NCHRP

Web-Only Document 174:

Performance Measurement and Evaluation of Tolling and Congestion Pricing Projects

Parsons Brinckerhoff, Inc.
New York, NY

Contractor's Final Report for NCHRP Project 08-75
Submitted March 2011

National Cooperative Highway Research Program
TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

ACKNOWLEDGMENT

This work was sponsored by the American Association of State Highway and Transportation Officials (AASHTO), in cooperation with the Federal Highway Administration, and was conducted in the National Cooperative Highway Research Program (NCHRP), which is administered by the Transportation Research Board (TRB) of the National Academies.

THE NATIONAL ACADEMIES

Advisers to the Nation on Science, Engineering, and Medicine

The **National Academy of Sciences** is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. On the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Ralph J. Cicerone is president of the National Academy of Sciences.

The **National Academy of Engineering** was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. Charles M. Vest is president of the National Academy of Engineering.

The **Institute of Medicine** was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, on its own initiative, to identify issues of medical care, research, and education. Dr. Harvey V. Fineberg is president of the Institute of Medicine.

The **National Research Council** was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both Academies and the Institute of Medicine. Dr. Ralph J. Cicerone and Dr. Charles M. Vest are chair and vice chair, respectively, of the National Research Council.

The **Transportation Research Board** is one of six major divisions of the National Research Council. The mission of the Transportation Research Board is to provide leadership in transportation innovation and progress through research and information exchange, conducted within a setting that is objective, interdisciplinary, and multimodal. The Board's varied activities annually engage about 7,000 engineers, scientists, and other transportation researchers and practitioners from the public and private sectors and academia, all of whom contribute their expertise in the public interest. The program is supported by state transportation departments, federal agencies including the component administrations of the U.S. Department of Transportation, and other organizations and individuals interested in the development of transportation. **www.TRB.org**

www.national-academies.org

Table of Contents

Tables

Figure

Key Terms

Term	Definition
Build Scenario	A scenario that assumes a specified transportation improvement will be built
Congestion Pricing	The application of variable fees or tolls on roadways to manage available capacity and user demand
Cordon and Area Pricing	Traffic management strategies designed to mitigate traffic congestion in dense urban environments—generally city centers and the corridors providing access to them—by charging vehicles during peak periods, either each time they pass a set boundary (cordon) or once during a set period (e.g., 24 hours) as they enter (or travel within) a specified zone (area)
Dynamic Pricing	Variably priced tolls where toll rates vary in real time based on detected traffic conditions
Farebox	Term used to refer to transit fares collected from passengers
Fixed Variable Pricing	Variably priced tolls set according to a fixed schedule that may be determined by such variables as hour of the day, direction of travel, and day of the week
General Purpose Lanes	Limited access highway lanes available to all vehicles without occupancy restrictions or imposition of a toll or fee
Greenfield Toll Facility	A new toll highway built in a corridor that was previously without such a facility
HOV2+	A policy defining vehicles with two or more passengers as HOVs
HOV3+	A policy defining vehicles with three or more passengers as HOVs
Level of Service (LOS)	A scale ranking (A to F) of the performance of highway facilities calculated by comparing actual traffic volumes to the theoretical carrying capacity of the roadway
Managed Lanes	Limited access highway lanes where tools such as occupancy requirements, fixed or variably-priced tolls, the use of ETC technology, and physical barriers and striping are used to manage the flow of vehicles in order to achieve a desired level of traffic service
Maximum Optimal Capacity	The maximum number of vehicles that a managed lane can carry while providing the desired traffic service level measured in vehicles per hour
Mode Share	The percentage of trips made in a specified travelshed or corridor by a given travel mode (i.e. passenger car, taxi, bus, rail transit, ferry, bicycle, etc.)
No Build Scenario	A scenario that assumes a given transportation improvement is not built
Park-and-Ride	A bus or rail station providing parking where drivers may leave their vehicles and continue their journeys by public transit
Particulates	Solid airborne pollutants

Key Terms
(continued)

Term	Definition
Peak Period	Travel periods with the highest traffic volumes usually occurring during weekday mornings and late afternoons
Performance Evaluation	An assessment of a facility or scheme's operation relative to expectation or a set of prescribed parameters; a performance evaluation can be used to make set adjustments to a facility or scheme's operation (e.g. based on an established algorithm) or used to make operational adjustments based on judgment and the weighing of present factors (e.g. costs, benefits, or risks)
Performance Measure or Metric	Used interchangeably, a quantitative or qualitative characterization of a facility or scheme's operational properties; performance measures inform a performance evaluation
Performance Monitoring	The ongoing, structured process of compiling performance measure data; performance monitoring results can be reported and/or retained for historical purposes; performance monitoring is also required to undertake a performance evaluation
Sponsoring Agency	An agency responsible for developing a transportation improvement
Stakeholder Agency	A public agency with a vested interest in the development of a transportation improvement required to comment on projects as they are developed, most notably as part of the environmental review process
Travelshed	An area where trips tend to cluster in a linear pattern with feeder routes leading to larger linear alignments providing access into a metropolitan area
Variably Priced Managed Lanes	Managed lanes that use variable pricing as a tool to maintain desired traffic service levels

Acronyms

ADT	Average Daily Traffic
ALG	Association of London Government
ALS	Area Licensing System
AVO	Average Vehicle Occupancy
BRT	Bus Rapid Transit
CBD	Central Business District
CDOT	Colorado Department of Transportation
CPTC	California Private Transportation Company
CRD	Congestion Reduction Demonstration
CTE	Colorado Tolling Enterprise
CUTR	Center for Urban Transportation Research
DOT	Department of Transportation
DRCOG	Denver Regional Council of Governments
EPA	(U.S.) Environmental Protection Agency
ERP	Electronic Road Pricing
ETC	Electronic Toll Collection
ETCC	Electronic Transaction Consultants
ETL	Express Toll Lanes
FDOT	Florida Department of Transportation
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
FTE	Florida's Turnpike Enterprise
GHG	Greenhouse Gas
GPS	Global Positioning System
HCTRA	Harris County Toll Road Authority
HOT Lane	High Occupancy Toll
HOV Lane	High Occupancy Vehicle
HPTE	High Performance Transportation Enterprise
ICM	Integrated Corridor Management
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITS	Intelligent Transportation System
LOS	Level of Service
LTA	Land Transport Authority of Singapore
MDT	Miami Dade Transit
METRO	Metropolitan Transit Authority of Harris County
Mn/DOT	Minnesota Department of Transportation

Acronyms
(continued)

MPO	Metropolitan Planning Organization
MTO	Ministry of Transportation Ontario
NAAQS	National Ambient Air Quality Standards
O&M	Operations and Maintenance
OCTA	Orange County Transportation Authority
O-D	Origin-Destination
PANYNJ	Port Authority of New York and New Jersey
$PMAP^3$	Performance Monitoring and Pricing Pilot Program
RPS	Road Pricing System
RTD	Regional Transportation District (Denver's transit authority)
RZ	Restricted Zone
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
SANDAG	San Diego Association of Governments
SCOOT	Split Cycle and Offset Optimization Technique
SOV	Single Occupancy Vehicle
SPSL	A private retail analysis firm
SR	State Route
TfL	Transport for London
TRB	Transportation Research Board
TxDOT	Texas Department of Transportation
UPA	Urban Partnership Agreement
USDOT	United States Department of Transportation
VHT	Vehicle Hours Traveled
VKT	Vehicle Kilometers Traveled
VMT	Vehicle Miles Traveled
VOC	Volatile Organic Compound
Vph	Vehicles Per Hour
VPHPL	Vehicles Per Hour Per Lane
WSDOT	Washington State Department of Transportation

Foreword

This Final Report for NCHRP 08-75, Guidelines for Evaluation and Performance Measurement of Congestion Pricing Projects, provides an overview of the project's purpose, scope, and methodology, and most importantly a complete compilation of the project's work products. The main product of this project is a set of Guidelines (produced as a separate document but also contained herein) that distills the findings of its research and makes recommendations on the performance evaluation and measurement of congestion pricing projects.

The research behind this project included a literature review, an identification of gaps in understanding, the development of a Work Plan (methodology) to fill the identified gaps, and its execution. This final report is organized into seven chapters and an appendix.

This Final Report contains within it the Guidelines in their entirety. As such, the real-life anecdotes that appear inside text boxes interspersed throughout the Guidelines are retained in this Final Report in Chapters 1, 4, 5, 6, and 7. They offer additional context on the material presented, taken directly from operational examples of and issues surrounding today's congestion pricing projects.

Chapter 1 appears as the first chapter of the Guidelines. It introduces the impetus for the Guidelines and the problem statement behind the research for NCHRP 08-75. It defines the three forms of congestion pricing (variably priced managed lanes, toll facilities with variable pricing, and cordon or area pricing) around which the Guidelines' recommendations are organized. The chapter also presents a detailed context in which the application of congestion pricing and its performance evaluation and measurement takes place. Planning, design and construction, and operations are considered.

Chapter 2 presents the literature review conducted as Task 1 of the project. The literature review was completed in early 2009 and represents research reports, studies, and documentation available at that time. Although not reflected in the review, as additional resources were made available subsequently during the ongoing research, they were incorporated into the research findings and the Guidelines as appropriate.

Chapter 3 describes the information gaps in existing knowledge of performance monitoring for congestion pricing project. Gaps were identified based on the literature review and comprised Task 2 of the project.

Chapter 4 outlines the Work Plan developed to address the information gaps identified in Chapter 3. It includes the methodology as proposed and a description of the underlying research ultimately carried out as a result. The main focus of that research was the conduction of 12 case studies for active congestion pricing projects. This chapter also discusses how the case studies were synthesized into the Guidelines and examines the context for the future of congestion pricing projects and their performance evaluation.

Chapters 5, 6, and 7 are extracted directly from the Guidelines and represent the remaining work products of this research. Chapter 5 presents specific recommendations on developing performance evaluation programs and selecting specific performance measures each tailored to the three forms of congestion pricing. Chapter 6 provides detailed information and recommendations about integrating performance evaluation and measurement with public outreach, including advantages and disadvantages of doing so, and specific recommendations on market research tools and constituency building. Chapter 7 is a synthesis of the primary findings of the Guidelines.

Chapter 1 Introduction

1.1 Background and Problem Statement

Major metropolitan regions across the United States today face a variety of mobility challenges from deteriorating travel reliability to increased peak-period congestion, lengthening durations of peak travel periods, and underutilization of existing capacity during off-peak periods.

Key Definitions

- **Congestion Pricing** – the application of variable fees or tolls on roadways to manage available capacity and user demand
- **Performance Measure or Metric** – used interchangeably, a quantitative or qualitative characterization of a facility or scheme's operational properties; performance measures inform a performance evaluation
- **Performance Monitoring** – the ongoing, structured process of compiling performance measure data; performance monitoring results can be reported and/or retained for historical purposes; performance monitoring is also required to undertake a performance evaluation
- **Performance Evaluation** – an assessment of a facility or scheme's operation relative to expectation or a set of prescribed parameters; a performance evaluation can be used to make set adjustments to a facility or scheme's operation (e.g. based on an established algorithm) or used to make operational adjustments based on judgment and the weighing of present factors (e.g. costs, benefits, or risks)

Note: because performance monitoring data is a direct input to a performance evaluation, the two

There is growing national momentum within government transportation agencies to use congestion pricing—a strategy that combines both physical and operational improvements—as a tool to address these challenges and also generate new revenue sources which can be used to fund transportation improvements. In late 2010, there were 11 operating high occupancy toll (HOT) lane facilities in the United States and a much larger number in different stages of development, including extensive regional networks in some cases. In addition, a small number of toll authorities have introduced variable pricing on existing toll facilities, while some new facilities have begun operations featuring time-of-day pricing. Finally, two major metropolitan areas are or have considered the possible implementation of cordon or area pricing schemes. These schemes require motorists to pay a fee to enter a designated urban zone, typically a city center, during congested peak periods. Similar systems are currently operating in Singapore, London, and Stockholm.

The use of congestion pricing and congestion management techniques has received further attention with the passage of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) in 2005. This legislation provides state departments of transportation (DOTs) the flexibility to convert existing high occupancy vehicle (HOV) lanes to HOT operation and also encourages the use of other congestion pricing strategies. Subsequently, the United States Department of Transportation (U.S. DOT) established two one-time initiatives—the Urban Partnership Agreement (UPA) and Congestion Reduction Demonstration (CRD) programs—to demonstrate how a variety of pricing concepts can be used together with other strategies to reduce congestion and tap into new sources of revenue. These programs are funding projects combining different forms of congestion pricing with transit enhancements, parking strategies, telecommuting, intelligent transportation system (ITS) applications, and operational improvements as tools to reduce congestion. Together they represent a Federal investment of over $700 million.

With widespread interest in using congestion pricing to manage congestion and generate new revenue streams, there is a need to document the performance of existing priced facilities. This is particularly important because congestion pricing strategies often face considerable political and public pressures and are not widely known or appreciated by the public at large. Moreover, with a relatively small number of congestion pricing facilities operating in the United States, there is lack of comprehensive information for developing overall performance evaluation programs for pricing project, identifying appropriate performance measures, and implementing public outreach efforts for these projects.

Performance monitoring for congestion pricing projects accomplishes three important and interrelated purposes:

1. To ensure that they are functioning as efficiently as possible and make adjustments to operational policies if they are not;
2. To quantify and validate the different benefits these facilities deliver; and
3. To document the successful application of congestion pricing in support of their expanded use.

These guidelines are designed to help agencies understand how and when to put evaluation and performance measurement programs in place, and how to identify and develop appropriate performance measures, collect the necessary data, evaluate performance and adjust management procedures to ensure performance standards are being met, and communicate the results.

While these guidelines attempt to identify as broad a range of goals and performance measures as possible, it is also important to recognize that the resources available to transportation agencies to support performance evaluation are often constrained. The Guidelines offers recommendations on which measures are particularly effective in the management

An Early Glut of HOV Performance Data Followed by a Dearth

When HOV lanes were first being introduced in selected cities, often under the auspices of demonstration project status, considerable scrutiny was given to the performance of each project. There was keen interest in whether a dedicated lane would successfully induce mode and spatial shifts and meet stated goals. Accordingly, data was often collected on users, traffic demand on the corridor and parallel routes, travel times, crash and violation rates, before and after trip characteristics, and a wide range of other factors. Some locales issued initial status reports on a weekly or monthly basis. This investment left practitioners with a rich set of resources from which to later understand what worked and what didn't. While most demonstrations tracked these measures rigorously, follow-on projects also tracked performance-related safety, air quality, modal shifts, public attitudes and in some cases even land use values in the respective corridor.

As these projects proved themselves and became accepted by sponsoring agencies and users, there was less need evidenced in most places to invest as rigorously in performance monitoring. With some regional exceptions, as findings from performance monitoring informed best practices in designing and operating preferential lanes, standards of practice and guidance emerged. These became accepted at a corridor, regional/state, and national level on such topics as buffer separation width, hours of operation, enforcement area treatment, access and occupancy restrictions, to name a few. Many areas have held to these standards of practice since they are understood by local motorists and participating agencies, and have, by most anecdotal accounts, worked satisfactorily.

Accepted HOV practices have inadvertently led to less and less investment in performance monitoring and reporting by respective sponsoring agencies. While many areas continue to monitor basic information related to the number and operation of such HOV projects within their jurisdiction, few have budget resources to regularly track and report on such measures as safety and enforcement, performance by mode, design efficacy, or constituent attitudes. So they are often ill-prepared for sudden inquiries that question whether the lanes are continuing to respond to their stated goals and objectives. Exceptions arise when extraordinary events or public or political scrutiny require responses to specific questions or changes in operation. In these instances data is collected and evaluated to respond specifically to the issue of an inquiry or design/operational change. In summary, if the HOV lanes are working satisfactorily, only monitoring of a few measures is typically conducted on a regular basis.

The advent of pricing on HOV lanes has renewed interest in performance monitoring on at least the first projects in each locale, primarily to gain an understanding of how this new tool works. If history is any indication, lessons learned from these early pricing projects will also set forth commonly accepted practices, which may in turn, result in lessening interest and investment in performance monitoring. Conversely, having a customer/business proposition that requires continuing and real-time management oversight and a revenue stream that can be utilized to underwrite monitoring activities offers the opportunity to assure an ongoing commitment to this needed resource.

of priced facilities and conveying the effects of congestion pricing projects to the public when funds for more extensive monitoring programs are not available.

1.2 Types of Congestion Pricing

As these guidelines are being written, congestion pricing projects currently in operation in the United States and abroad can be categorized into three basic types:

1. Variably priced managed lanes;
2. Toll facilities with variable pricing; and
3. Cordon and area pricing.

These guidelines provide tailored recommendations on performance monitoring for each of these pricing forms. The following descriptions provide further information on these three types of congestion pricing.[1]

1.2.1 Variably Priced Managed Lanes

Managed lanes are designated highway lanes that are operated to provide improved travel conditions to eligible users. The most common form of managed lanes is HOV lanes, which use vehicle occupancy to meter traffic. In certain cases, tolls may be used as an additional or stand-alone criterion to meter the flow of traffic on the managed lanes. Following from this, highway facilities with *variably priced managed lanes* feature "partial facility" pricing, whereby one or more lanes in one or both directions on a roadway facility are priced and operate in conjunction with adjacent, un-priced, general purpose lane capacity. These facilities comprise two forms:

1. HOT (or express) lanes, which combine variable pricing for lower occupancy vehicles with free travel for higher occupancy vehicles; and
2. Express Toll Lanes, which charge the same variable toll for all vehicles or a variable toll for lower occupancy vehicles with a discounted toll for higher occupancy vehicles.

As with toll facilities with variable pricing, variable toll rates can be fixed or dynamic.

The use of variably priced managed lanes is exclusive to the U.S. Nearly all—11 facilities operational as of late-2010—are HOT lanes, converted from prior HOV lanes. Exceptions include the 91 Express Lanes in Orange County, California, which were constructed in the corridor's median as a privately developed expansion project and operate as ETL in the eastbound direction weekdays between 4 p.m. and 6 p.m. Also, portions of the UPA-grant funded I-35W HOT lanes in Minneapolis, which combine HOV lane conversion with corridor widening and shoulder lane conversion.

Common goals of these facilities include providing a reliable alternative to frequently congested general purpose lane capacity along a corridor. The fixed variable or dynamically variable pricing schedule is designed to maintain a certain level of service, flow rate, or travel time, removing the uncertainty and variability in travel on the un-priced lanes. Often, other goals for these facilities are a desire not to degrade certain levels of safety or create inequities in availability to users, such as those with lower incomes that may be less able to pay the toll charged. Finally, revenue is often a consideration to help

[1] Definitions and descriptions have been adapted from the Federal Highway Administration's Office of Innovative Program Delivery – Road Pricing Revenue website (http://www.fhwa.dot.gov/ipd/revenue/road_pricing/index.htm).

pay for maintenance and operations or maintain a certain debt coverage ratio, but is typically secondary to maximizing system efficiency and reliability.

1.2.2 Toll Facilities with Variable Pricing

Toll facilities with variable pricing involve “full facility” pricing, where all lanes of a facility are tolled at variably-priced rates in response to time of day and travel demand. Toll facilities with variable pricing can involve new or existing highways or bridges and tunnel crossings. They may involve the introduction of a variably-priced toll structure on legacy facilities that previously featured fixed toll rates, or the use of variably-priced toll rates on new facilities.

Toll rates on these facilities vary by time of day or congestion level such that peak period travel is more expensive than off-peak travel, encouraging some motorists to move their trips to off-peak periods or utilize other travel modes, such as transit. In this manner, the duration of peak-period congestion is reduced or eliminated, increasing the reliability of a user's trip and allowing for more efficient use of system capacity from a time-of-day and physical (lane-mile) standpoint. Variable toll rates can be fixed on a particular schedule or vary dynamically based on real time traffic conditions. Electronic toll collection is critical to these systems' efficient operation.

In the U.S., toll facilities with variable pricing include the Port Authority of New York and New Jersey’s bridge and tunnel crossings between New Jersey and New York City; the New Jersey Turnpike; the Midpoint and Cape Coral Bridges in Lee County, Florida; and the San Joaquin and Foothill/Eastern toll roads in Orange County, California operated by Transportation Corridor Agencies. Outside the U.S., the 407 ETR in Toronto, Canada uses variable pricing. Other facilities include Autoroute A1 from Lille to Paris that charges a peak toll on Sunday afternoons, the Harbour Bridge in Sydney, and toll roads in Japan on a pilot basis. Because these facilities operate as “traditional” toll facilities—i.e., tolls are collected to support their operation, maintenance, and possible expansion—revenue generation often remains the primary goal. On a secondary basis, reducing congestion, increasing reliability, and encouraging off-peak or alternate mode (e.g., public transit) travel are also goals of these facilities.

1.2.3 Cordon and Area Pricing

Cordon and area pricing is a strategy designed to mitigate traffic congestion in dense urban environments—generally city centers and the corridors providing access to them—by charging vehicles during peak periods, either each time they pass a set boundary (cordon) or once during a set period (e.g., 24 hours) as they enter (or travel within) a specified zone (area). In addition, a wide range of other charging options exist for both these schemes, including varying charges by time-of-day, by vehicle, and by entry point. The charge can be fixed on a particular schedule or vary dynamically based on real time traffic conditions.

The application of cordon or area pricing has occurred only internationally to date. The three most extensive uses (based on geographic extent and population served) are located in London, England; Stockholm, Sweden; and Singapore. Common goals are to reduce congestion within urban centers often limited by finite roadway capacity, to improve access to urban destinations (central business districts, commercial establishments, cultural and civic institutions, etc.), to encourage the use of alternate forms of transportation (especially public transit), and to improve natural and urban environments (quality of life).

1.3 Context for Congestion Pricing Projects and Their Evaluation

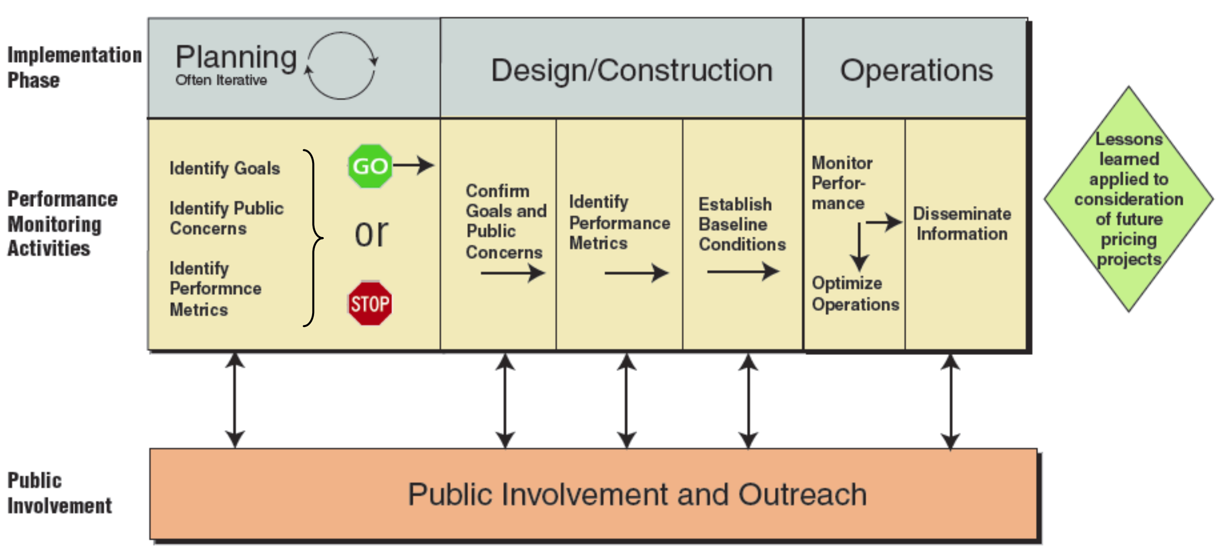
Evaluation and performance measurement programs for congestion pricing projects are most effective when their development extends across the overall planning, implementation, and operation lifecycle of the projects they assess. In an ideal scenario, this approach happens naturally: a congestion pricing project is identified, planned, and executed along an uninterrupted timeline, with consistent agency sponsorship, such that the project's goals and objectives are clear throughout the process and a consistent approach to measuring and evaluating the project's outcomes can be applied to assess its ability to meet them. However, more often evaluation and performance measurement programs for congestion pricing projects are discrete efforts, especially if there has been a break in time between the planning and design and construction phases of the implementation process, or if these activities were completed by different agencies or teams.

The relationship between project implementation and performance evaluation and measurement is shown in Figure 1-1. As with other types of transportation improvements, the implementation of a congestion pricing project involves the following major phases:

- Planning;
- Design and construction; and
- Operations.

Each of these phases is underpinned by an ongoing public involvement process to obtain input and feedback from local stakeholder groups, which is used to shape the transportation project that emerges from the process. The public involvement process also enhances awareness, education and marketing/promotion for the project. The following discussions provide further information on the different steps and the overall context involved in formulating and implementing evaluation and performance measurement programs for congestion pricing projects.

FIGURE 1-1: PERFORMANCE EVALUATION AND MEASUREMENT CONTEXT AND ACTIVITIES THROUGHOUT THE PROJECT DEVELOPMENT PROCESS



1.3.1 Planning Studies and the Development of Preliminary Evaluation and Performance Measures

The first step in the implementation of a congestion pricing project is the completion of planning studies that result in either a pricing project being advanced into design and construction, or a decision not to continue. The planning process is essentially a decision-making framework through which regional goals are established and different improvement options are assessed for their ability to meet those needs.[2] Ideally, it should include a preliminary identification of performance measures that demonstrate the extent to which the project meets its goals and addresses public and other stakeholder concerns. More often, however, planning studies for capacity expansion and operational enhancements, including congestion pricing projects, extend over several years and focus on need and feasibility, and less on ultimate execution. Other issues including securing funding and approvals for the project and the possible need to gain local or state legislative authority and/or Federal agreements to collect tolls add further time and complexity to the planning process. As the transition to construction occurs, circumstances may have changed since the initial planning study—agency, institutional (legal, regulatory), or stakeholder priorities may have shifted—often making it more appropriate to wait until implementation is imminent to finalize the details of the evaluation program.

1.3.2 Project Design and Construction and the Review or Development of Evaluation and Performance Measures

Although the development of performance measures and an evaluation program to assess them may not have been considered during the planning process, these needs become more critical during project design and construction. Comprehensive baseline data documenting conditions prior to the opening of the congestion pricing facility is essential to determine the incremental effects of pricing once it becomes operational.

At the very least, as a project enters its design and construction phase, its goals should be confirmed in conjunction with either the refinement of selected preliminary performance measures from the planning process or the development of an initial set (see the following section). If resources allow, it is helpful to use the public consultation process already established for the project to confirm regional goals and obtain an understanding of public and other stakeholder attitudes toward the pricing project and any subsequent issues that may have arisen since the completion of the planning process. Public involvement at this stage should educate the public on the project's purpose and benefits to make the case for its implementation. Specific performance measures can be identified that would best communicate the realization of these benefits and confirm that the project is meeting its intended goals.

Performance evaluation programs will also need to include specific measures that may be legislatively mandated and any others that the project sponsor may have committed to during the approval process. Such commitments may be made to obtain stakeholder buy-in and increase support for the project. Examples might include commitments to monitor transit travel times to indicate improvements or absence of degradation in service, or a commitment to measure effects on low income users for those concerned with economic equity. By addressing these obligations, credibility and confidence in project execution is built. Overall, performance measures selected to build the case for public acceptance, respond to stakeholder input, and meet legislative requirements are those that will *validate* the project.

[2] Volume 1 of NCHRP 08-57 *Improved Framework and Tools for Highway Pricing Decisions* provides extensive analysis and case studies illuminating decision-making frameworks for tolling and pricing projects.

The other primary function of performance measurement is to manage facility or pricing scheme *operations*. It is critical to identify performance measures that will provide a reliable and consistent means to manage a facility's ongoing operations and define when changes in operation are necessary. For example, performance measures for operations often derive directly from the facility's toll policy. Thresholds for toll adjustments are informed by assessing ongoing performance measure data, such as hourly traffic volumes or travel times between selected route points. Changes in facility policies (such as vehicle occupancy requirements or the specification of peak period operation) may also arise as a result of a performance evaluation program.

Facility operations also require its equipment and service providers meet established performance standards. Such standards would be likely to include the accuracy of ETC transactions and billings, the opening of new ETC accounts, wait times and overall satisfaction with services provided by a customer call center, and incident response times. Performance measures to assess whether these standards will be met should also be identified and specified at this stage.

Finally, as part of the design phase, all equipment needed to collect performance measurement data should be identified, followed by the preparation of either detailed specifications or designs. Equipment used for performance monitoring purposes could include loop detectors, automated toll collection systems, and still and video cameras.

Whether a performance measure's intended purpose is to validate the project or manage its operation (or both), it should also be structured to utilize any previously compiled data or statistics on facility performance and its users' behavior and attitudes. Making the case for achieving project goals and benefits can be enhanced by comparisons to past performance data and prior (likely worsening) trends. Growing peak period traffic volumes or travel times and attendant impacts on economic or environmental impacts are good examples of these types of data. The collection of similar data once the pricing project is operational

The Challenges of Determining Before-and-After Effects amid Ongoing Construction

Due to the constraints of completing construction work within active highway rights-of-way, construction periods for large HOT lane projects can extend for periods of several years, with the new improvements brought on-line on a rolling basis as they are completed. Similarly, other unrelated construction project in the corridor or adjacent areas before or after the completion of the HOT lane could also skew traffic data and other performance parameters. Both situations complicate the ability of project sponsors to obtain useful before-and-after benchmarking data needed to assess the performance of these projects in terms of traffic operations and user perception. When this is the case, sponsors may have to wait several years to gain a complete understanding of the effects of congestion pricing in their regions. The following findings from the Miami, Minneapolis and San Diego project profiles presented in the appendix provide further detail on how ongoing construction activity has effected performance monitoring in three of the seven managed lane projects assessed in NCHRP 08-75.

- *Miami*: One recurring challenge with the opening of the 95 Express was tracking the performance of a facility that was being opened in phases, which meant that monitoring would begin when the facility was only partly opened and still undergoing impacts from ongoing construction.
- *Minneapolis*: Assembling meaningful before-and-after data on the I-35W corridor was complicated by the fact that the MnPASS improvements opened on a rolling basis and that they were impacted by ongoing project construction and the replacement of the Mississippi River crossing near downtown Minneapolis. These factors resulted in a substantial time gap between comparable before-and-after conditions.
- *San Diego*: The San Diego Association of Government's (SANDAG) expansion of the I-15 Express Lanes is being completed over a five-year period. As these Guidelines are being written the eight-mile, reversible flow, two-lane segment continues to operate as it has for the past 14 years, and a new much more complex five-lane segment has opened to the north. At the same time, extensive construction activities in the I-15 corridor continue, impacting the operation of the general purpose and managed lanes alike. Together these conditions have led to a lull in normal performance monitoring activities in the I-15 corridor while SANDAG addresses constantly changing maintenance of traffic issues during the construction period and gears up for full operations of the completed facility. Similarly, subsequent survey work after the opening of the first segment of the expansion has been postponed because of the extensive construction activities in the corridor. However, no one has questioned whether the facility is providing benefit to the region.

would be most useful if it can be compared on an even basis with past collected results.

After the preliminary performance measures have been reviewed, revised, or an initial set compiled for the first time, it is essential to establish pre-existing baseline conditions prior to opening of the new congestion pricing project. The baseline conditions will provide the reference point for documenting changes in the facility's performance. They will likely require the ongoing collection of objective data such as traffic parameters (volumes, speeds, vehicle occupancies, etc.), transit utilization, safety statistics, and others. It is also expected that one-time, specially designed surveys will be required to collect subjective data, such as public perceptions.

Ideally, baseline data collection should extend for one full year prior to the opening of the congestion pricing facility so that recurring patterns are well documented and the quantity of data is robust enough to make comparisons with those collected after operations begin. External factors, such as other construction projects, economic trends, and even weather events may skew the baseline data. Additional baseline collection time, data, or the use of a control corridor/facility/region may be necessary.

These factors can greatly affect the previously made strategic decisions regarding agreed upon project goals. Accordingly, specific performance measures included in a performance evaluation program would be best selected at least 18 months prior to project construction completion so that the measurement of adequate baseline data can be accommodated and carried out. Consideration must be given to making these baseline measurements during construction and the potential phased schedule for opening the project to operations. Protocols for ongoing performance measure reporting should also be agreed upon prior to the opening of the congestion pricing facility.

The Unanticipated Benefits of a "Soft" Opening in Houston

While travel demand modeling output provides a reasonable estimate of utilization levels for HOT lanes, there is always some uncertainty regarding actual utilization prior to opening. Before opening the new 12-mile, four-lane Katy Freeway Managed Lanes, its operator, the Harris County Toll Road Authority (HCTRA), did not know what the overall utilization levels would be. While HCTRA's initial intent was to open the facility simultaneously to HOV and paying SOV motorists, as a result of delays in completing the ETC installation for the reconstructed HOT lanes, the facility was opened in a phased sequence—first to HOVs only and then later to paying vehicles.

In retrospect HCTRA found that this decision was extremely helpful on a number of fronts. Most importantly, it provided the Authority with an excellent understanding of HOV utilization in the corridor, which was higher than expected at 1,400 vehicles during the peak hour, and the opportunity to determine whether any operational issues could be enhanced. The soft launch period also gave the public time to become accustomed to the lanes and for HCTRA to conduct outreach activities. With local elections following the soft opening by one month in November 2008, a county judge who was up for election came out in support of the lanes and later assisted HCTRA in the development of television commercials for the new facility. While they cite the soft launch as "dumb luck" necessitated by delays in implementing toll collection equipment in the corridor, HCTRA staff believe a phased opening might be beneficial to other operators launching new congestion pricing facilities.

1.3.3 Performance Measurement and Evaluation during Project Operation

When a congestion pricing project goes into operation, project sponsors should anticipate that local stakeholders, elected officials, and the media will want performance data to be available almost immediately. Making this data available provides project sponsors with the opportunity to demonstrate their responsiveness and gain the confidence of the congestion pricing project's stakeholders. Managing expectations is equally important, since many project settings may be targeted for longer-term benefits not readily seen on opening day. Moreover, it provides the opportunity to share quantifiable project performance data that validates the benefits of the project and demonstrates how its performance is meeting its goals, as well as any specific community concerns that may have arisen during the implementation process.

While a relatively limited number of performance measures will be used to manage the ongoing operation of the pricing facility, these measures will be critical to the success of the project, especially at the beginning of its service life. The monitoring process will have to determine whether critical thresholds identified by supporting sponsors at the federal, state or local levels are being met. These may include peak period travel speeds or hourly vehicle volume thresholds, public support, safety, modal changes, compliance/violation rates, financial and revenue performance, or a host of other locally significant measures. In the event that they are not, operating requirements such as price levels or occupancy requirements will need to be adjusted until system performance meets the required benchmarks.

In terms of data used to validate the project, project sponsors should also anticipate generating regular monthly or weekly reports driven by electronically collected data on an ongoing basis, as well as press releases, individual milestone reports upon the completion of major user survey efforts, or annual or biannual reports—which may also be a legislative requirement.

There are also ongoing public involvement opportunities for information reporting during the operation of the congestion pricing facility. Stakeholders and the public are anxious to learn of the performance evaluation findings due to their involvement in developing goals during the planning and/or design and construction phases. Information reporting should target these and other newer interests if the project is demonstrating success. For example, the outcome of an air quality measure can be highlighted at a local meeting of the Sierra Club, or an outcome of enforcement elements can be highlighted through law enforcement channels. Project sponsors should continue performance reporting to all existing stakeholder groups with whom they have interacted during the implementation of the congestion pricing project, as well as to any newly identified stakeholders. One ultimate measure of success is to have built support for the continued or expanded use of congestion pricing through a project's performance evaluation and measurement.

Chapter 2 Literature Review

A comprehensive literature review on the evaluation and performance measurement of congestion pricing projects was undertaken as an initial task (Task 1) in this research. Its main purpose was to provide a thorough survey of existing information to inform the next tasks in the research, namely the identification and analysis of commonalities and information gaps across existing congestion pricing monitoring efforts and the development of a set of guidelines for the evaluation and performance measurement of congestion pricing projects.

The main sources of literature reviewed for this project derived from existing roadway facilities with a congestion pricing component including evaluation studies, periodic reports, and planned monitoring programs for facilities currently undergoing implementation. Most documents are readily found on publicly available websites, either those of the project sponsor or entities acting on behalf of the project sponsor. These sources of information were supplemented with additional documentation obtained by contacting knowledgeable representatives of the facility/project sponsor or those acting on its behalf.

Congestion pricing projects have come online in the U.S. over the past 15 years. Many of them have been the subject of one-time comprehensive technical, and in some cases, attitudinal studies assessing a broad range of evaluation and performance measures. Primary goals such as congestion reduction and public acceptance were carefully monitored, as congestion pricing remained a new and untested concept for providing and managing roadway capacity. Such comprehensive studies, which often evaluated performance metrics on a "before-and-after" basis, were typically one-time in nature and may or may not have been followed by readily-documented, ongoing performance monitoring.

As a new wave of congestion pricing projects are beginning to come online under USDOT's Urban Partnership Agreement (UPA) and Congestion Reduction Demonstration (CRD) programs, performance monitoring is taking on a new focus with a nationally-led evaluation strategy to compare the success of each of the projects.

Finally, this literature review covers both domestic (U.S.) and foreign projects. Domestic projects consist of HOT or express toll lane facilities and variably-priced toll crossings (bridges and tunnels). Foreign projects comprise those using cordon or area pricing, and in one case, cordon pricing combined with road pricing.

2.1 General Literature

Very little scholarly research on monitoring or the performance evaluation of congestion pricing projects exists to date. Most relevant documentation pertains to specific congestion pricing projects' monitoring and evaluation programs or studies performed by or on behalf of the project sponsor. A search of primary peer-reviewed journals and transportation databases yielded one study relevant to this literature review.

Carson, Jodi L. *Monitoring and Evaluating Managed Lane Facility Performance*. Texas Transportation Institute. (Sept. 2005). http://tti.tamu.edu/documents/0-4160-23.pdf.

This study attempts to fill some of the gaps in the state of practice of highway performance monitoring and evaluation that has almost exclusively focused on general highway facilities and has lacked specificity for managed lane facilities. The abstract states:

> "Managed lane facilities are unique, typically requiring a higher degree of active (sometimes real-time) management, addressing goals and objectives that are inconsistent with the general freeway facility (i.e., revenue generation, person throughput), and accessing an exclusive set of management tools (i.e., gate closures). To address these potential differences between facilities, this investigation was conducted to isolate and document the best performance monitoring and evaluation practices and principles explicitly for managed lane facilities."

The report concludes that there was some general consistency in practice with respect to performance monitoring and evaluation, "despite the novelty of managed lanes as a traffic management strategy, the diversity of managed lane facility types, and the breadth of motivating factors for managed lane implementation." It notes that:

> "Common goals, objectives, and performance measures were observed across similar facility types. Significant differences were also observed across similar facility types with respect to observed performance outcomes and evaluation methodologies. Differences in observed performance outcomes are likely explained by the variety in facility design (i.e., length of facility, accessibility, etc.) and operation (i.e., eligibility requirements, toll rates, etc.), even within a similar facility type. Differences in the evaluation methodologies used to arrive at these observed performance outcomes are likely reflective of the available resources for analysis at the time of evaluation and the evolving state of analysis methodologies."

The report begins by summarizing various managed lane facilities of which priced lane facilities are a subset. Subsequently, it concludes that six indistinct and overlapping steps are present in successful performance and monitoring programs:

1. Setting goals and objectives that reflect the program or system's desired performance, consistent with agency or regional priorities
2. Identifying appropriate performance measures to accurately evaluate attainment of the goals and objectives
3. Identifying data and sources to support calculation of the performance measures
4. Defining appropriate evaluation methods within the constraints of data availability and staff training
5. Defining an appropriate schedule for ongoing, periodic system monitoring
6. Reporting the results in a usable and easily understood format

The remainder of the report is devoted to a comprehensive compilation of guidelines for performance monitoring of general highways and to managed lane facilities, including value-priced and HOT lane facilities. Highlights from this compilation are summarized below.

For general highway facilities, *Freeway Management and Operations Handbook* (Neudorff, et al., 2003) is an authoritative source on performance goals and objectives and principles for performance measurement. A set of minimum recommended performance measures is presented, derived from *Performance Measures of Operational Effectiveness for Highway Segments and Systems* (NCHRP Synthesis 311 – Shaw, 2003) and from the National Transportation Operations Coalition *Performance Measure Initiative* (2005). Performance measures specific to ITS, the collection and processing of data, and reporting are also covered. For monitoring and evaluation, important considerations include frequency (ongoing monitoring, before-and-after, etc.), and what is being measured (dynamic performance measures like violation rates, continuously collected data like speed and volumes, and infrequent occurrences like accidents).

Managed lane facilities evaluated in the report include HOV, value-priced, and HOT lanes; exclusive lanes; mixed-flow separation/bypass lanes; lane restrictions; and dual facilities. Most of this information was collected from site-specific evaluation studies. Of all managed lane facilities, the best coverage existed for HOV lanes, with two prior summaries being Turnbull et al. (1991) and Bracewell et al. (1999). This report augmented those two studies with site-specific evaluations not previously considered.

The report finds that, "little documentation in the form of collective guidelines for monitoring and evaluation [of] the performance of value-priced and high occupancy toll lanes was uncovered." Nonetheless, it does present a summary table for the performance monitoring and evaluation of value-priced and HOT lane facilities compiled from several theoretical or project-specific value pricing studies/evaluations. The table is reproduced below.

Table 37. Value-priced and High Occupancy Toll Lane Performance Monitoring and Evaluation Summary.

	GOALS/ OBJECTIVES	PERFORMANCE MEASURES: MEASURES	PERFORMANCE MEASURES: OBSERVED PERFORMANCE/ TARGETS	DATA COLLECTION: Continuous Automated: volumes/classifications	speeds/travel times	density/lane occupancy	Sampled, Manual: travel times	vehicle occupancy	violation rates	Customer Surveys: origin-destination	perceived time savings	ridership/mode use	satisfaction	Agency Surveys: vehicle productivity	on-time performance	operating costs	capital costs	accidents	enforcement levels	toll revenue	EVALUATION/ MONITORING: descriptive statistics	inferential statistics	capacity analysis	simulation	before and after analysis	alternatives analysis
MOBILITY/CONGESTION	Increase overall mobility during recurring and nonrecurring congestion while maintaining accessibility																									
	Increase throughput	• Daily, hourly volume on HOV facilities (vehicle, person) • Total, daily, and hourly facility volume (HOV, GP) • Total, daily, and hourly facility volume (vehicle, person)	[3] 7% (off peak) to 35% (p.m. peak) use lane (range 24,000–33,000 vpd) [6] 50–90 vpd, a.m. peak 40–50 vpd, p.m. peak 0.89 avg. uses per week [4] 2.5%–17.2% increase in PPUF (range 45.1%–65.7%)	P				P	S												M Q A	M Q A	Q A	A	O	O
		• Vehicle occupancy (per/veh)						P													M Q A	M Q A	Q A	A	O	O
		• Temporal shift	[4] -7.6%–12.0% increase in PPDF (range 60.9%–80.3%) [6] 10% (a.m.) and 3.6% (p.m.) are HOV-2 paying toll to move to peak out of shoulders [7] 70%–101% (a.m.) and 20%–67% (p.m.) decrease in ADT 89%–94% (a.m.) and 50%–70% (p.m.) increase in ADT during discounted periods [8] 71% changed time of travel 1+ times/week	P				P	S												M Q A	M Q A	Q A	A	O	O
		• Mode shift	[3] HOV-3+ increased 4%–40% [6] 51% (a.m.) and 58% (p.m.) drove alone 11% (a.m.) and 5% (p.m.) changed from bus to carpool									P									M Q A	M Q A	Q A	A	O	O

P = primary, S = secondary, M = monthly, Q = quarterly, A = annually.

[1] DeCorla-Souza (2002), [2] Berg (1999), [3] Sullivan (2000), [4] Supernak et al. (2003a), [5] Supernak et al. (2003b), [6] Hickman et al. (2000), [7] Swenson et al. (1999), [8] Burris and Swenson (2001), [9] He et al. (2001), [10] PBQD (2005), [11] DeCorla-Souza (2002).

Table 37. Value-priced and High Occupancy Toll Lane Performance Monitoring and Evaluation Summary (Continued).

	GOALS/ OBJECTIVES	PERFORMANCE MEASURES: MEASURES	PERFORMANCE MEASURES: OBSERVED PERFORMANCE/ TARGETS	DATA COLLECTION: Continuous Automated			Sampled, Manual			Customer Surveys				Agency Surveys							EVALUATION/ MONITORING					
				volumes/classifications	speeds/travel times	density/lane occupancy	travel times	vehicle occupancy	violation rates	origin-destination	perceived time savings	ridership/mode use	satisfaction	vehicle productivity	on-time performance	operating costs	capital costs	accidents	enforcement levels	toll revenue	descriptive statistics	inferential statistics	capacity analysis	simulation	before and after analysis	alternatives analysis
MOBILITY/CONGESTION (Cont.)	Increase overall mobility during recurring and nonrecurring congestion while maintaining accessibility (Cont.)																									
MOBILITY/CONGESTION (Cont.)	Increase average travel speeds	• Average lane (HOV, GP) and facility speed	[6] 40–63 mph HOV, 12–45 mph GP, a.m. peak (not exclusive of HOV lane effects) 54–75 mph HOV, 15–34 mph GP, a.m. peak (not exclusive of HOV lane effects)		P		S														M Q A	M Q A	Q A	A	O	O
MOBILITY/CONGESTION (Cont.)	Decrease average travel times	• Travel time savings (min) • Travel time savings ($/mile) • Annual travel-time savings ($)	[2] 12–13 min/trip [5] 20 min/trip [6] 19.3 min/trip, a.m. peak (range 5–51 min) 21.4 min/trip, p.m. peak (range 9–39 min) [10] 7–29 min/trip, p.m. peak, simulated 2030		P		S														M Q A	M Q A	Q A	A	O	O
MOBILITY/CONGESTION (Cont.)	Decrease average travel times	• Customer perceptions on travel time									P										A	A				
MOBILITY/CONGESTION (Cont.)	Decrease delay	• Average delay (per day, annually) • Average delay (vehicle, person)	[11] 360.42 hours/day, p.m. peak	P	P		S	S	S												M Q A	M Q A	Q A	A	O	O
MOBILITY/CONGESTION (Cont.)	Decrease violators	• Managed lane compliance						S	P										S		M Q A	M Q A	Q A	A	O	O
RELIABILITY	Increase reliability during recurring and nonrecurring congestion																									
RELIABILITY	Decrease travel time variation	• Std. deviation (travel time, speed) • Variance (coefficient of variation) (travel time, speed)			P		S														M Q A	M Q A	Q A	A	O	O
RELIABILITY	Decrease travel time variation	• Customer perceptions on reliability									P										A	A				
RELIABILITY	Increase "on-time" performance	• Buffer index (95th percentile travel time by corridor and trip) • Percent of trips that arrive in acceptable time window			P		S								S						M Q A	M Q A	Q A	A	O	O

P = primary, S = secondary, M = monthly, Q = quarterly, A = annually.
[1] DeCorla-Souza (2002), [2] Berg (1999), [3] Sullivan (2000), [4] Supernak et al. (2003a), [5] Supernak et al. (2003b), [6] Hickman et al. (2000), [7] Swenson et al. (1999), [8] Burris and Swenson (2001), [9] He et al. (2001), [10] PBQD (2005), [11] DeCorla-Souza (2002).

Table 37. Value-priced and High Occupancy Toll Lane Performance Monitoring and Evaluation Summary (Continued).

	GOALS/ OBJECTIVES	PERFORMANCE MEASURES: MEASURES	PERFORMANCE MEASURES: OBSERVED PERFORMANCE/ TARGETS	DATA COLLECTION: Continuous Automated			Sampled, Manual			Customer Surveys				Agency Surveys							EVALUATION/ MONITORING					
				volumes/classifications	speeds/travel times	density/lane occupancy	travel times	vehicle occupancy	violation rates	origin-destination	perceived time savings	ridership/mode use	satisfaction	vehicle productivity	on-time performance	operating costs	capital costs	accidents	enforcement levels	toll revenue	descriptive statistics	inferential statistics	capacity analysis	simulation	before and after analysis	alternatives analysis
SAFETY	Increase overall safety levels																									
SAFETY	Decrease incident frequency and severity	• Number of incidents (type, location) • Incident severity																P	S		Q A	Q A		A	O	O
ENVIRONMENT	Decrease overall impacts to the environment and resources																									
ENVIRONMENT	Decrease fuel consumption	• Fuel consumption (per VMT, PMT)		P	P	S	S	S													Q A	Q A		A	O	O
ENVIRONMENT	Increase air quality/ decrease pollutants	• Tons of pollutants • Days in air quality non-compliance	[3] -18%–3.7% [11] -72.43 tons/year, HC -273.82 tons/year, CO 133.60 tons/year, NOx	P	P	S	S	S													Q A	Q A		A	O	O
ORGAN. EFFICIENCY	Increase productivity without compromising public's expectations for efficient and effective travel																									
ORGAN. EFFICIENCY	Increase customer satisfaction	• Percentage rated good to excellent • Qualitative customer comments	[3] 50%–75% approve toll lanes 30%–75% approve variable tolls 45%–75% approve selling capacity to SOVs [9] 53% report willingness to pay toll <$2.00										P								A	A				
ORGAN. EFFICIENCY	Minimize costs	• Cost for construction (per lane-mile, VMT, PMT)	[11] $2 mil annually, direct connector ramps	P				P	S								P				A O				O	O
ORGAN. EFFICIENCY	Minimize costs	• Vehicle operating costs (per lane-mile, VMT, PMT)	[11] $4 mil annually, toll/credit transaction costs	P				P	S							P			S		Q A				O	O
ORGAN. EFFICIENCY	Minimize costs	• Cost-benefit measures	[1] 8.2–11.9 B/C [11] 5.6 B/C	P	P		S									P	P	S	S		A				O	O
ORGAN. EFFICIENCY	Maximize revenue	• Toll revenue	[11] $13.79 mil annually																	P	M Q A			A	O	O

P = primary, S = secondary, M = monthly, Q = quarterly, A = annually.
[1] DeCorla-Souza (2002), [2] Berg (1999), [3] Sullivan (2000), [4] Supernak et al. (2003a), [5] Supernak et al. (2003b), [6] Hickman et al. (2000), [7] Swenson et al. (1999), [8] Burris and Swenson (2000), [9] He et al. (2001), [10] PBQD (2005), [11] DeCorla-Souza (2002).

The report concludes that with respect to the performance monitoring of managed lane facilities, little information was available to support recommendations for the frequency of monitoring required. In the studies examined, before-and-after or feasibility studies were dominant, and a focus on changes over time after initial observations was lacking. The report also cautioned against applying the summarized managed lane performance measures to future applications, as a wide variation in facility design and operation makes applying a uniform set of performance metrics problematic.

Specific to value-priced and HOT lanes, the report concludes from the studies compiled in the table above that they generally:

> "…present unique opportunities for toll revenue, capitalizing on the time savings benefit with less emphasis on encouraging mode shift. Safety and environmental effects are of secondary interest, primarily reported to confirm no adverse impacts from implementation of a managed lane facility. Accidents generally occur infrequently and, hence, require a lengthy evaluation period. Environmental effects are loosely estimated as a function of travel speeds."

2.2 Domestic Facility Documentation

2.2.1 Colorado Department of Transportation I-25 Express Lanes

Opened in June 2006, the I-25 Express Lanes operate over a 7-mile stretch of the interstate between Downtown Denver and US 36 north of the city. The facility involved the conversion of existing HOV lanes and operates as two lanes in each direction, although express lane users must enter the facility through the "toll" lane to distinguish themselves from HOVs. Toll rates are variable on a fixed, time-of-day rate schedule. Express bus travel times are a key metric for the corridor and may trigger a toll adjustment if there is a measured degradation. Additionally, the facility's peak hour toll cannot be less than express bus fare for that route.

I-25 Express Lanes Monthly Progress Report, Colorado Tolling Enterprise. Mar. 2009 http://www.dot.state.co.us/cte/expresslanes/Mar2009MonthlyReport.pdf.

I-25 Express Lanes Monthly Progress Report, Colorado Tolling Enterprise. Mar. 2008 http://www.dot.state.co.us/cte/expresslanes/March2008MonthlyReport.pdf.

I-25 Express Lanes Monthly Progress Report, Colorado Tolling Enterprise. Mar. 2007 http://www.dot.state.co.us/cte/expresslanes/MarchMonthly2007.pdf.

I-25 Express Lanes Monthly Progress Report, Colorado Tolling Enterprise. June 2006 http://www.dot.state.co.us/cte/expresslanes/June2006MonthlyReport.pdf.

These monthly reports (selected above on an annual basis) on the performance of the I-25 Express Lanes have been published since the facility opened in June 2006. Monitored performance metrics in the March 2009 report included:

- Traffic volume (monthly, maximum daily, average daily, average weekday AM and PM peak hour and peak periods)
  - Presented for express users, HOV users, violators, and license plate tolling users (introduced in January 2009 for SOVs without a transponder)

  - Evaluations include year-over year comparisons, a table of daily counts, monthly average peak hour usage, and peak period 15-minute counts monitored the first week of every month at one particular exit
- Bus travel times
- Revenues and expenditures (estimated vs. actual and year-over-year comparisons)
- Incidents
- Enforcement (state patrol manual citation counts)
- Operational issues

HOV/Express Lanes User Survey. PowerPoint Presentation. Corona Research. 16 Oct. 2008 http://www.dot.state.co.us/cte/expresslanes/WorkshopCoronaResearchPresentation.pdf.

This presentation, available on CDOT's website, highlights the following attitudinal evaluation metrics for users of the I-25 Express Lanes:

- Socioeconomic and geographic characteristic of users
- Usage characteristics (frequency, purpose, demographics/use patterns)
- Levels of satisfaction
- Opinions on free access for hybrid vehicle users

2.2.2 Florida Department of Transportation 95 Express

The 95 Express Managed Lanes on I-95 between Fort Lauderdale and Miami is an USDOT Urban Partnership Agreement (UPA) project. It began operation in December 2008 with a 7-mile northbound stretch (Phase 1A) from SR 112 to the Golden Glades Interchange. Phase 1B is expected to open in late 2009 and consists of the corresponding southbound direction of Phase 1A and the north and southbound directions between SR 112 and I-395 near Miami. Phase 2, expected to be competed in 2011, extends the facility to Fort Lauderdale from the Golden Glades Interchange to I-595 in both directions. The project involves the conversion of existing HOV lanes and the addition of one new lane in each direction. The HOV occupancy requirement for free use of the facility rises from HOV2+ to HOV3+. Free HOV3+ (as well as hybrid vehicle) users must be registered. Tolls vary dynamically. Expanded BRT service will also utilize the express lanes.

Evaluation Plan Framework for 95 Express Managed Lanes. Cambridge Systematics, Inc. 30 Mar. 2009.

This document presents the evaluation framework for monitoring the 95 Express Managed Lanes (ML) in Miami. Although the performance evaluation of the facility is being done in cooperation with the national USDOT-required evaluation of UPA and Congestion Reduction Demonstration (CRD) program projects, it is being performed independently of that coordinated, national effort. Accordingly, the evaluation measures and performance metrics summarized in the table below will provide input to evaluating how the project meets both a set of objectives formulated by Miami/FDOT in its UPA application to USDOT and a set of national evaluation objectives developed for all UPA/CRD projects.

The success of the 95 Express Lanes will be measured on a before-an-after basis by comparing historical HOV reference data (before) to current express lane data (after) for both the managed and general purpose lanes. The monitoring effort is summarized in the following table, taken from the evaluation plan framework.

Evaluation Measures	Performance Metrics	Miami/FDOT Objectives	USDOT UPA/CRD Objectives
Corridor Performance Impacts (mobility improvements) and Utilization			
• Traffic – ML vs. GP lanes	Per lane group: • Traffic volume • Avg. speed • Travel time savings • LOS • Peak period distribution (VPHPL) • Vehicle classification (types) • Avg. vehicle occupancy • Vehicle and person throughput	• ML optimization • Congestion relief in ML • Congestion relief in GP lanes • Maintain free flow • Express bus service	• Congestion • Tolling • Transit • Goods movement
• Transit (BRT)	• Ridership • Service load factors (passengers per bus) • Travel time measures (max/min, min/mile, pull-out time, door-to-door) • Reliability measures (running time, on-time)	• ML optimization • Congestion relief in GP lanes • Maintain free flow • Express bus service • Effective operations via technology	• Congestion • Tolling • Transit • Technology
• Other	• Daily toll usage • No. of HOV registrations • No. of hybrid registrations • Park-n-Ride utilization (lot counts) • Emissions, noise, fuel consumption • Mode split • Trip-making changes • Equity measures	• Congestion relief in ML • Congestion relief in GP lanes • Express bus service • Public acceptance/ satisfaction	• Congestion • Tolling • Transit • Telecommuting/ TDM • Equity • Environmental
Operations and Effectiveness (operational efficiency)			
• ML and GP lanes	• Toll revenue • No. of crashes, type, and severity • Incident frequency, response time, duration • No. of violation citations • No. of equipment malfunctions, time to fix • O&M related cost data • On-the-job injuries	• Facility and operational costs coverage • Maintain safety • Effective operations via technology	• Technology • Safety • Cost/Benefit
• Transit (BRT)	• Operating costs by route • Farebox revenue by route • No. of incidents, type		• Safety • Cost/Benefit
Acceptance and Satisfaction			
• ML and GP lanes	• Media coverage instances • User survey levels of acceptance and satisfaction • Public perceptions of project success • Business/employer impacts • Signage effectiveness	• Public acceptance/ satisfaction • Effective operations via technology	• Technology • Business impacts • Non-technical
• Transit (BRT)	• User survey levels of acceptance and satisfaction • Public perceptions of project success		• Non-technical

2.2.3 Harris County Toll Road Authority Katy Managed Lanes

As part of the five-year reconstruction of a 12-mile section of the Katy Freeway west of SH 6 to the I-10/610 interchange west of Houston, single contra-flow HOV lanes were converted to two express lanes in each direction within the median of the freeway. The managed lanes operate 24/7 on a fixed, variable toll schedule. HOV use is free during HOV hours, 5 AM to 11 AM and 2 PM to 8 PM both eastbound and westbound. SOV use of the managed lanes began on April 18, 2009. The Harris County Toll Road Authority (HCTRA) is responsible for the operation of the managed lanes in cooperation with TxDOT and the Metropolitan Transit Authority of Harris County (METRO), which operates buses on the managed lanes free of charge.

No published monitoring or evaluation plan was available at the time of this literature review, however, a conversation was held with the Katy Tollway Director of Operations. It was learned that no formal monitoring plan is currently in place, but certain system performance metrics related to these operational considerations are being monitored. With assistance from Wilbur Smith, HCTRA is currently in the process of documenting the results of this monitoring effort.

The initial operating plan for the Katy Tollway was to allow HOV3+ free use of the facility. HOV3+ users would be able to “self-declare” by passing though each tolling location (three tolling locations per direction) in a 3rd lane. In this manner, tolled users could use either travel lane, as HOV users would be able to distinguish themselves in this 3rd lane at each tolling location.

However, in summer 2008, a political decision (partially affected by gas prices) was made to operate the HOV lane as HOV2+. But, the 3rd lane at each tolling location would not have been able to handle the volume of expected HOV2+ users, and at the time, no practical transponder technology was available to allow users to distinguish themselves as HOV3+ users within the same lane as other users. Consequently, current operations dictate that during HOV hours, one lane is reserved for HOV2+ use, and the other for tolling operations.

Current monitoring is focused on the outcome of this operational change. That is, if HOV volumes become too large (>1800 vph), the rule may have to change from HOV2+ to HOV3+. Likewise, if the tolled lane becomes too congested, prices may require and upward adjustment. Prices are set to maintain at least LOS C for users, which include METRO buses. HCTRA’s website notes that:

> “This factor sets the Katy Tollway/Managed Lanes apart from other HCTRA facilities, in that the collection and enforcement of tolls will focus on optimizing and managing the use of the added capacity rather than revenue. While HCTRA still has a fiduciary responsibility to debt recovery, revenue generation is tertiary to traffic management and traffic safety within the I-10 corridor. … During peak travel times the occupancy requirements and toll pricing will be set to incentivize ridesharing. During non-peak travel times, the objective will be to make the greatest use of the available capacity by allowing motorists the option to pay for the assurance to drive at free flow speeds of at least 45 mph. Actual toll prices will be determined based on initial operations and the evaluation of daily commute patterns.”

2.2.4 Minnesota Department of Transportation MnPASS Lanes

Minnesota’s I-394 MnPASS Express Lanes, which opened in May 2005, is the state’s (and one of the country’s) first use of HOT lanes. The dynamically variable priced, 9-mile facility involved the conversion of existing HOV lanes along I-394 between I-94 in downtown Minneapolis and I-494 west of the city. Between I-94 and MN-100, it consists of a two-lane, barrier separated reversible flow facility, and between MN-100 and I-494, it consists of a single, striped lane section in each direction (diamond lanes). Mn/DOT's MnPASS website reports: "...the I-394 MnPASS project is functioning well and achieving its planned objectives for performance and public satisfaction."

MnPASS System Study Final Report, Cambridge Systematics, Inc. 7 Apr. 2005 http://www.mnpass.org/pdfs/050407mnpass_system_finalreport.pdf.

This report analyzes a future MnPASS system for the Minneapolis-St. Paul Twin Cities region, including HOV-to-HOT lane conversions and new tolled (except for transit) highway capacity. Pricing of these facilities would vary by demand. The overall objective was to identify facility segments within a system of priced lanes and estimate its costs as well as operational, revenue, and system implications. At the time of the study, HOT lanes on I-394 were under construction and in the planning stages for I-35W.

The report includes a section on Evaluation Criteria for comparing the tolled scenario to Future Base Conditions for 2010 and 2030 on a proposed 2013 network. Evaluations were conducted for the entire Twin Cities regional network, a system of MnPASS express lanes, and individual MnPASS segments. The following characteristics were analyzed:

- *Transportation Performance* – Measures for the regional network and MnPASS system included VMT, VHT, and average speed (VMT/VHT) for the AM and PM peak periods and nonpeak period. For specific segments, a comparison of travel times on tolled lanes to travel times on non-tolled lanes during different times of day were made using segment length, travel time (in minutes) and vehicle hours, and travel time savings.
- *Financial Performance* – Conducted for each MnPASS segment, the following estimates were made:

  For 2030 only: estimated annual debt service on a 30-year bond, annual operating cost (assumed at 10 cents per toll transaction), annual gross toll revenue, annual net revenue, and ratio of annual net revenue to annualized capital cost

  For 2010 and 2030: comparison of the present value of a stream of revenues to a stream of costs to develop a cost recovery ratio (the present value of the net revenue stream divided by the present value of the capital cost stream) and a funding gap (the difference between the present value of net revenue and the present value of the capital cost)

MnPASS Technical Evaluation Final Report, Cambridge Systematics, Inc. (Nov. 2006). http://www.mnpass.org/pdfs/394mnpass_tech_eval.pdf.

This report was prepared following the implementation of the MnPASS Express Lanes on I-394. It represents the technical side of a two-part evaluation of the I-394 MnPASS. (An attitudinal evaluation is summarized in the next entry.) The technical evaluation of the I-394 MnPASS Express Lanes was conducted according to guidelines specified in a Technical Evaluation Test Plan formulated in March 2003. Evaluation objectives included assessing before and after conditions through simple documentation of issues, as well as the testing of specified hypotheses.

This report summarizes an Evaluation Approach, the Corridor Impact Findings, and the System Performance Findings. Primary data used derived from automated data sources and were supplemented by field collection. Before-and-after data were collected on the converted I-394 HOV lanes as well as on I-35W HOV lanes as a control. The following table summarizes the data collected, the corridor impact findings, and the system performance findings.

Data Collected	Corridor Evaluation Metrics	System Performance Metrics
• vehicle volumes (vehicle detector stations) – factored in day-of-week, days of inclement weather, and incidents • vehicle speeds (vehicle detector stations) • vehicle occupancy (manual field collection) • crash occurrence (Dept. of Public Safety database) • incident occurrence (RTMC incident log) • noise impacts (Office of Enviro. Service) • emissions impacts (Office of Enviro. Service) • enforcement data (highway patrol) • system performance (contracted administrator) – e.g. system down-time, errors o number of transponders o usage statistics o prices charged o number of valid transponder reads • revenue – (contracted administrator) – daily, weekly, quarterly • transit operational impacts (subjective information from transit operators)	• volume/ throughput • speed and travel time • vehicle occupancy • violation rates • crash occurrence • speed differential (GP lanes vs. MnPASS lanes) • noise levels • emissions	• use and revenue • enforcement • transit performance

The report identifies a number of evaluation challenges: unpredictable factors affected travel conditions; tolls were dynamic; MnPASS subscribers increased over time; operational hours were modified one month after opening; toll rate scales were modified (the range was unchanged, but the average became slightly higher); and changes occurred external to the MnPASS system (e.g. construction outside the system and high gas prices – these were captured through the use of the I-35W HOV lanes as a control).

The report concluded that results were mainly presented as lessons learned for Minnesota stakeholders considering the expansion of the MnPASS system to other state corridors, although it noted that, "the continuous and sustained monitoring and evaluation of corridor conditions following deployment of I-394 was key to identifying minor problems in the system before they had the opportunity to balloon into more serious issues."

MnPASS Evaluation Attitudinal Panel Survey Wave 3, Humphrey Institute of Public Affairs, University of Minnesota. Aug. 2006 http://www.mnpass.org/pdfs/MnPassFinalReport%2027NOV06.pdf.

This report presents the findings of the attitudinal component of the two-part evaluation of the I-394 MnPASS Express Lanes. This Wave 3 Survey, conducted during May and June 2006, occurred six months after a second wave and about one year after the facility's implementation. Over 1,200 interviews were conducted, of which nearly 350 were with panel members (i.e., interviewed in the baseline, Wave 2, and Wave 3 surveys). These data were collected to evaluate the attitudinal and behavioral impacts of allowing solo drivers to pay to use carpool lanes. The following characteristics were the focus of the interviews:

- attitudes
- travel behavior (satisfaction, experience)
- users (usage, trip characteristics, satisfaction)
- subscribers (socioeconomic characteristics, perceived value, satisfaction)

1. *I-394 HOV Report including MnPASS Data* (Mn/DOT) – quarterly

2. *MnPASS Express Lanes Annual Report* (Cofiroute USA)

3. Crash Statistics

4. Enforcement Statistics

(*Not publicly available*)

Current Mn/DOT monitoring of the I-394 Express Lanes is based on four main sources of data, which are not publicly available on the internet. The quarterly HOV report (1) for I-394 takes data from one set of loop detectors in the reversible flow section (across all lanes in both directions) and from loop detectors in the standard diamond lane section (across all lanes at separate locations for each direction). Directional data presented depends on the peak period (AM or PM). Data specific to the Express Lanes presented in the annual report (2) is obtained from facility operations and transponder use. Crash data (3) and enforcement statistics (4) are also tracked by Mn/DOT and are considered more significant compared to toll revenue. Combined, these four sources of data represent current monitoring of the I-394 Express Lanes. The table below summarizes the evaluation measures and performance metrics captured in these documents.

Evaluation Measures	Performance Metrics	Source
Traffic volumes and speeds	• Trips by peak hour • Trips by day of week • Total managed trips • Daily average speed	2
	• Vehicles moved • People moved (by type and peak hour – Express Lanes and GP lanes) • Percent of total people moved (by peak hour – Express Lanes and GP lanes • Auto/Bus occupancy rate • Daily average speed	1
Revenue	• Toll revenue per week • Average toll • Fee revenue	2
Accounts	• Open and closed accounts • Active accounts • Active transponders • Transponder status • Transponder distribution	2
Customer service • Call center performance	• Average talk time • Abandoned calls • Average speed of answer • Emails • Chats	2
• Call activity	• Customer service representative answered • Interactive voice response answered • Types of calls • Dialer success rate (to customers)	2

Evaluation Measures	Performance Metrics	Source
Network and systems	• Server uptime • System incidents • Google website analysis • System security audit	2
Enforcement	• HOV violations • Crossing double white lines • Speeding • Seat belts • Accident/stalled assistance	4
Safety	• Annual crashes	3

2.2.5 Orange County Transportation Authority 91 Express Lanes

The SR-91 Express Lanes opened in December 1995 as a new 10-mile, four lane express toll lane facility within the median of the east-west SR 91 in Orange County, California between SR 55 near Anaheim and the Orange/Riverside County line. Tolls vary by direction, time-of-day, and day-of-week on a fixed schedule, which is periodically updated based on monitored traffic conditions. For the first two years of operation, HOV3+ users were permitted to use the facility free of charge. This policy was subsequently changed in early 1998 for Monday through Friday in the eastbound direction from 4pm to 6pm, when they are required to pay 50 percent of the published toll.

Sullivan, Edward. *Evaluating the Impacts of the SR 91 Variable-Toll Express Lane Facility*.

Final Report. Cal Poly State University, Department of Civil and Environmental Engineering, Applied Research and Development Facility. May 1998.

Sullivan, Edward. *Continuation Study to Evaluate the Impacts of the SR 91 Value-Priced Express Lanes*. Final Report. Cal Poly State University, Department of Civil and Environmental Engineering, Applied Research and Development Facility. Dec.
2000 http://www.vta.org/expresslanes/pdf/cal_poly_exp_lanes_sr91_2.pdf.

The December 2000 report on the SR 91 Express Lanes documents more than five years of field observations—including about a year-and-a-half of observations to establish baseline conditions before the facility opened—to identify the impacts of implementing the first application of congestion (value) pricing in the U.S. The December 2000 report contains findings through mid-1999, supplementing a previous “final report” issued May 1998, which presents impacts through June 1997.

The report is a very detailed examination of data collected, which includes traffic measurements, vehicle occupancy counts, transit ridership data, and comprehensive travel surveys with current and former commuters. Data analysis includes calibration of models of the route (toll/non-toll), vehicle occupancy, transponder acquisition, and time-of-day choices of commuters; as well as estimation of air pollution emissions. Notable changes in the system for which monitoring results were recorded include a change in policy in early 1998 to charge HOV3+ users 50 percent of the toll weekdays from 4pm to 6pm in the eastbound direction.

Performance Monitoring and Pricing Pilot Program: Application for Participation in the FHWA Value Pricing Pilot Program. Orange County Transportation Authority. 14 Mar. 2005 http://knowledge.fhwa.dot.gov/cops/hcx.nsf/All+Documents/1470E6E1703C1FF5852570FA0057A36E/$FILE/7%20CA%20OCTA%20SR91%20Exp%20Lanes.pdf.

This application to FHWA's Value Pricing Program proposes the deployment of dynamic pricing on the SR 91 Express Lanes that incorporates continuous, real-time monitoring of traffic conditions on the Express Lanes and adjacent main lanes. A nearly $600,000 grant was awarded by FHWA in January 2006. Implementation of the project is pending.

The project is called the Performance Monitoring and Pricing Pilot Program (PMAP^3). The project application states that the primary elements will include: an operational simulation to develop the dynamic pricing algorithm including preparation and testing; data collection; microsimulation; post-testing and adjustments; installation of the network; software development; operational testing including offline testing, off-hour testing, and operational testing; monitoring and evaluation; and transition to operational status. This project will potentially lead to the implementation of dynamic pricing on SR-91, increase the knowledge base in the area of dynamic pricing applications, and provide transferability to other projects nationally.

A monitoring and evaluation plan will be prepared as part of the project. "Before" data will be collected once the necessary sensor system is in place and until operational testing commences, after which "after" data will be collected. Once operational, surveys and focus groups will be conducted to gauge impacts and perceptions of the dynamic pricing and be compared to previous surveys and socioeconomic studies. The application presents project objectives and measures designed to determine if objectives will be met, as summarized in the following table.

Objectives	Measures
Ensure required revenue level through reliable service and revenue neutral or positive approaches to dynamic pricing schemes	Actual toll revenue vs. anticipated revenue
Maximize efficiency and vehicle throughput of the Express Lanes and main lanes during peak commute hours	VPHPL and average speeds over period of time
Improve reliability and consistency of travel time	End to end travel time over period of time
Provide enhanced and accurate speed and travel time data for the Express Lanes	Comparison of existing and future speed and travel time data over period of time
Provide enhanced and accurate speed and travel time data for the main lanes	Comparison of existing and future speed and travel time data over period of time
Establish a pricing scheme that takes into account conditions on the main lanes in addition to the Express Lanes	Implementation of pricing scheme including main lane speed information
Provide a visible and easily understandable link between the toll and travel time and speed	Customer feedback

In addition, the monitoring and evaluation component of the project will examine the following evaluation measures:

- Technical performance (compared to existing operations)

- *Systems* – Do systems provide very high levels of reliability in terms of:
  - Accurately measuring and recording traffic conditions on the 91 Express Lanes and adjoining main lanes;
  - Reverting to default mode automatically in the event of system failures or manual intervention;
  - Effectively adjusting toll rates at the required regular intervals; and
  - Properly displaying accurate toll rates?
- *Operations* – How are operations impacted in terms of:
  - Safe and reliable operations on the 91 Express Lanes;
  - Safe and reliable operations on the adjoining main lanes;
  - Ease or difficulty of enforcement; and
  - Demands on TOC operators?
- *Travel Times/Speeds* – What impacts does PMAP^3 and dynamic pricing have in terms of:
  - Providing more reliable travel times for customers;
  - Improving travel times on the 91 Express Lanes and adjoining main lanes; and
  - Improving speeds on the 91 Express Lanes and adjoining main lanes?
- *Usage* – How does PMAP^3 impact the number of customers who use the 91 Express Lanes on a regular basis, and does it help attract new customers? Does it impact the number of violations?
- *Tolls* – How does the implementation of PMAP^3 impact toll rates by time of day and under traffic conditions? How does it impact the median and mean toll rates experienced by 91 Express Lane customers?

- Customer Perceptions – A portion of the evaluation will focus on customer reactions and views which are extremely important to OCTA. Techniques will focus on surveys of existing customers and focus groups, consistent with OCTA's current practices.
- Traffic/Revenue Forecasts – Evaluating the near- and long-term impacts to traffic volume and revenues for the 91 Express Lanes is critical to OCTA. For PMAP^3 to be successful it must meet both the operational and policy goals set for it while remaining largely revenue neutral under existing and forecast conditions.

Orange County Transportation Authority. *91 Express Lanes. Congestion Management Pricing*. http://www.octa.net/toll_policy.aspx.

Orange County Transportation Authority. *91 Express Lanes Toll Policy*. 28 June 2005. http://www.91expresslanes.com/generalinfo/tollpolicy.asp.

Currently, OCTA's SR 91 monitoring program is a critical part of the facility's formal toll policy. The policy is explained on the authority's websites noted above.

Traffic volumes comprise the focal point of the SR-91 monitoring program: hourly, daily, and directional traffic volumes on a rolling 12 consecutive week period. Certain sustained volume levels can lead to adjustments of the "super-peak" hour rates up to once every 6 months. Tolls may be adjusted upward when traffic volumes consistently reach a trigger point (92 percent or more of Maximum Optimal Capacity, which is 3,128+ vehicles per hour, per day, per direction) where traffic flow can become unstable. Conversely, if volumes consistently fall below a threshold of 2720 vehicles per hour, day, and direction, the rate can be adjusted downward. Non super-peak toll prices are adjusted annually by inflation. The toll policy goals are to:

- Provide customers a safe, reliable, predictable commute
- Optimize throughput at free-flow speeds
- Increase average vehicle occupancy
- Balance capacity and demand, thereby serving both full-pay customers and carpoolers with three or more people who are offered discounted tolls
- Generate sufficient revenue to sustain the financial viability of the 91 Express Lanes

Other performance evaluation measures, including those previously studied in the Cal Poly State University December 2000 impacts report are not currently actively monitored by OCTA. Enforcement, such as toll violations, is under the purview of the California Highway Patrol, which is contracted to police the facility.

2.2.6 The Port Authority of New York and New Jersey Congestion Pricing Program

In March 2001, the Port Authority of New York and New Jersey (PANYNJ) instituted a new payment structure at its four bridges and two tunnels that connect the two states. Tolls vary according to time of day and payment technology, with discounts for off-peak travel and ETC transponder use (E-ZPass).

Muriello, Mark F. and Danny Jiji. *The Value Pricing Toll Program at The Port Authority of New York & New Jersey: Revenue for Transportation Investment and Incentives for Traffic Management*. The Port Authority of New York and New Jersey. (Summer 2003). http://knowledge.fhwa.dot.gov/cops/hcx.nsf/All+Documents/F28934FF571FF3C685256DB10063E81B/$FILE/Hudson%20River%20Crossings%20Draft%20Report.pdf.

This paper discusses the genesis of the value pricing toll program as a revenue enhancement to finance an aggressive new intermodal capital investment program. It also explores the traffic management benefits of the program, as well as its effectiveness in addressing five key policy objectives established for the effort:

1. Encourage shifts to less congested off-peak travel periods
2. Increase the E-ZPass electronic toll collection market share
3. Encourage use of mass transit in corridors with transit alternatives
4. Create commercial traffic management incentives
5. Eliminate the frequency-based commuter discount program

Effectiveness of the program was measured by:

- Revenue generation
  - Estimated through E-ZPass participation rates from price elasticities generated from mid-1990s stated preference surveys
  - An upgrade to the revenue-generating forecasting tools using econometric methods was recently performed

- Shift to off-peak period
  - Measurement of vehicular demand prior to, immediately after, and one and two years after value pricing
  - A successful shift out of the 6-9am peak period to 5-6am was realized, but not so much to 9-10am
- E-ZPass market share
  - Measurement of E-ZPass usage

Holguín-Veras, José, Kaan Ozbay, and Allison de Cerreño. *Evaluation Study of The Port Authority of New York and New Jersey's Value Pricing Initiative*. New Jersey Department of Transportation. (March 2005). http://knowledge.fhwa.dot.gov/cops/hcx.nsf/All+Documents/F28934FF571FF3C685256DB10063E81B/$FILE/PANYNJ%20Final%20Report.pdf.

The main objective of this project summarized in this paper was to monitor the impacts of the PANYNJ value pricing initiative, both at the system-wide level and at the user level. The three main focuses of this study were 1) aggregate impacts on traffic and transit use, 2) disaggregate behavioral impacts, and 3) public reaction to the time-of-day pricing initiative.

This 2005 study was somewhat different in its approach than the 2003 study above, which evaluated the effectiveness of the program on three well-defined criteria significant to PANYNJ business operations (revenue, peak period traffic shift, and E-ZPass market share). In this 2005 study, traffic conditions and patterns were again examined but also included transit and goods movement usage. A comprehensive data set with traffic counts at the various PANYNJ toll facilities, classified by type of vehicle and hour of the day, were used to quantify the impact of time-of-day pricing on overall traffic patterns, E-ZPass usage, and time of day traffic changes. Additionally, behavioral changes produced by the time of day pricing initiative were examined. For this, focus group studies and surveys were conducted with both passenger car users and truck dispatchers. Finally, public reaction and opinion of the process followed, and the implementation of the time of day pricing initiative was studied.

The report states that:

> "The results indicated that 7.4 percent of passenger trips and 20.2 percent of truck trips (including those that increased shipping charges or switched to E-ZPass) changed behavior because of time of day pricing. The time of day pricing resulted in an increase on the percent share of peak shoulder traffic for both trucks and cars during weekdays, and short term pre-peak elasticities are higher than post-peak elasticities during both AM and PM periods on weekdays for almost all of crossings."

However, "unanswered questions still remain about how the time of day pricing initiative impacted the receivers of goods and services. These questions must be the target of future research."

Key data and information sources used in the study included:

- Traffic data (hourly, daily, weekly, monthly, on weekdays and weekends, by facility type and vehicle type, and by method of payment) – used to measure price elasticities
- Transit ridership data (rail, bus, ferry)
- Focus group findings (auto users, truck dispatchers, truckers)
- Passenger surveys

- Attitudinal factors from trucking company usage
- Carrier data (dispatcher surveys)
- Media and decision-makers' reactions
- Public opinion polling (passengers and commercial sector)

Wolff, Carolyn and Pierre Vilain. *Congestion Pricing as a Traffic Management Tool: Evaluating the Impacts at New York City's Interstate Crossings*. TRB 86th Annual Meeting Compendium of Papers CD-ROM. (2007). http://pubsindex.trb.org/document/view/default.asp?record=802207.

The focus of this examination was to determine if the shift in peak and off-peak traffic shares since the PANYNJ value pricing program started was due to the pricing incentives or changes in congestion itself. By controlling for time indifferent unobserved variables and peak-spreading, the analysis concluded that the absence of peak spreading indicated that the shift in observed travel time choices was due to the congestion pricing program.

2.2.7 San Diego Association of Governments I-15 Express Lanes

Express Lanes on I-15 in San Diego County have been operational since December 1996. The initial segment from SR 163 to SR 56 northeast of San Diego is an 8-mile, two-lane reversible HOV-to-HOT conversion. From December 1996 through March 1998, it operated as the ExpressPass program where SOVs could pay a monthly fee for unlimited use. Subsequently, the FasTrak system was introduced with ETC and dynamically variable tolls. The I-15 Express Lanes are currently undergoing an expansion to four lanes with movable barriers for maximum flexibility and a total length of 20 miles from SR 163 to SR 78. The middle segment—a northward, 8.3-mile extension from the existing lanes—opened in two phases in September 2008 and March 2009. Continued northward expansion 3.7 miles to SR 78 is scheduled to open in 2011, and an expansion and upgrade of the original lanes is scheduled for 2012. Also since March 2009, the toll has become distance-based, levied per-mile depending upon entry point, and remains dynamically variable.

Supernak, Janusz, et al. *I-15 Congestion Pricing Project Monitoring and Evaluation Services: Task 13 – Phase II Year Three Overall Report*. San Diego State University, Department of Civil and Environmental Engineering. 24 Sept.
2001 http://ops.fhwa.dot.gov/tolling_pricing/value_pricing/pubs_reports/projectreports/pdfs/interst15_congestion.pdf.

This report summarizes a three-year evaluation of the I-15 Express Lanes from inception through December 1999 while it operated under FHWA's Congestion Pricing Pilot Program introduced in ISTEA. For more than two-thirds of this report's study period, the Express Lanes operated under the ExpressPass Program (Phase I) with a monthly fee for SOV usage of the corridor's HOV lanes. The Express Lanes have operated under the FasTrak ETC system (Phase II) since April 1998. The project's Phase II stated goals were to maximize the use of the Express Lanes, to fund new transit and HOV improvements along the corridor, to see if solo drivers using HOV lanes could reduce congestion, and to use a market-based approach to set tolls. A segment of I-8 in southern San Diego County was used as a control corridor.

Baseline data collected before project implementation included traffic volumes, vehicle classification and occupancy, and violation data. New data was gathered on both a macroscopic (aggregate) and microscopic (disaggregate) level for the studies performed, as summarized in the following table.

Macroscopic Studies	Microscopic Studies
Traffic Study • traffic volumes • modal split • maintenance of LOS C • changes in volume distribution across time-of-day • changes in vehicle occupancy • changes in travel time/delay	**Attitudinal Panel Study** • changes in demographic characteristics • FasTrak use and mode split • departure times and time-savings • satisfaction with and perceptions of travel conditions • pricing and price sensitivity • awareness and attitudes towards the pricing project
Cost of Delay Study • value of time	**Business Impact Study** • level of awareness from local business community to evaluate whether they considered program important to their employees, customers, and operations
Air Quality Study • emissions levels for VOCs, NO_x, PM_{10}, and CO	
Park-and-Ride Study • lot occupancy	**Land Use Study** • housing decisions
Bus Study • ridership levels	

Other issues covered in this study include stakeholder opinions on the implementation of the I-15 pricing project, enforcement effectiveness and violation assessment, and a discussion of media relations and coverage, marketing, and public response.

I-15 Managed Lanes Value Pricing Project Planning Study: Volume 3 Monitoring and Evaluation Plan, Wilbur Smith Associates. May 2002 http://www.sandag.cog.ca.us/index.asp?publicationid=1198&fuseaction=publications.detail.

This report was published as plans for expanding the I-15 Express Lanes were underway. It recommends a monitoring and evaluation plan similar to the one summarized above for the Congestion Pricing Pilot Program. However, some differences would have to be taken into account for the expansion, such as the addition of BRT and the use of movable barriers. It also recommends foregoing the business and land use studies, since their expected findings would be mostly the same as those in the original study. A four-tiered evaluation approach was recommended as summarized in the table.

Recommended Evaluation Measures	Performance Metrics
System impacts • *Data*: historical "before" data including for at least one year prior to opening on the same schedule as planned "after" data collection • Traffic volumes and speeds • Vehicle occupancy and classification • Modal split • Emissions **Utilization** • *Data*: sourced from counts of various user groups based on account information and surveys • Level and frequency of use on monthly basis **Acceptance** • *Data*: panel surveys (1 "before" wave and 2 "after" waves over one year), stakeholder interviews • Acceptance • Equity • Public perception of success **Operations** • *Data*: violation rates and safety data, technical and revenue data • Reliability • User perceptions • Costs • Revenue generation • Enforcement	• LOS – time of day, week, month • Changes in delay, travel time, speed • Toll user volumes – time of day, week, month • Changes in mode split – SOV, carpooling, vanpooling, existing bus, new BRT; measured by panel or before-and-after survey • Changes in vehicle occupancy • Changes in vehicle classification • Changes in trip-making – time, frequency, length, route; measured for all users/nonusers by panel or before-and-after survey • Changes in park-and-ride use – lot counts • Changes in emissions – based on modes and speeds

2.2.8 Washington Department of Transportation SR 167 HOT Lanes

Washington State's first-ever HOT lanes opened to traffic in May 2008 as a four-year pilot project. The project involved the conversion of a 9-mile stretch of existing HOV lanes on SR 167, one in each direction, between Renton and Auburn in southern King County. Tolls vary dynamically.

Eight-Month Performance Summary of SR 167 High Occupancy Toll (HOT Lanes Pilot Project), Washington State Department of Transportation. 7 Jan. 2008 http://www.wsdot.wa.gov/NR/rdonlyres/962C3A05-FCF2-483F-884A-1569059A0346/0/SR167HOTLns8MnthFinal.pdf.

WSDOT has issued 3-, 6-, and 8-month performance reports for the SR 167 HOT Lanes. Performance reporting was mandated by the state legislature as outlined by state statute authorizing the pilot project (Revised Code of Washington 47.56.403 – HOT Lane pilot project legislation). The following excerpt from the state code describes the requirement:

> "The department shall monitor the state route 167 high occupancy toll lane pilot project and shall annually report to the transportation commission and the legislature on operations and findings. At a minimum, the department shall provide facility use data and review the impacts on:

> (a) Freeway efficiency and safety;
>
> (b) Effectiveness for transit;
>
> (c) Person and vehicle movements by mode;
>
> (d) Ability to finance improvements and transportation services through tolls; and
>
> (e) The impacts on all highway users.
>
> The department shall analyze aggregate use data and conduct, as needed, separate surveys to assess usage of the facility in relation to geographic, socioeconomic, and demographic information within the corridor in order to ascertain actual and perceived questions of equitable use of the facility."

Performance measurements included in the 8-month report are:

- Traffic volumes
  - ADT year-over-year for May-December 2007 and 2008
  - ADT by month, lane (toll, HOV, and GP lanes), and peak-hour
- Travel times
- Maintenance of free-flow speed criteria
- Collision data (presented as preliminary only; WSDOT's recommendation is to examine at least two years of crash data)
- Corridor performance
  - Toll customer share
  - Transit and carpool speeds
  - The pricing algorithm performance is currently under evaluation
- Use patterns
- Make of customer cars
- Customer service usage
- Revenue
- Transit performance (i.e. buses along the corridor)
- Enforcement
- Incident response
- Citizen correspondence (feedback, comments, and complaints)

SR 167 HOT Lanes January 2009 Focus Groups Final Report, EnviroIssues. 4 Mar. 2009 http://www.wsdot.wa.gov/NR/rdonlyres/2F77F039-7397-4E69-9443-5E86DD49457D/0/SR167_Focus_Group_Report_FINAL_v4.pdf.

This report summarizes the findings from WSDOT-led focus groups in January 2009 as part of the SR 167 HOT Lanes Pilot Project. This round, consisting of two focus groups (typical and low-income drivers), was designed to complete the work WSDOT began in 2006 when six focus groups were conducted to gauge initial perceptions of the SR 167 HOT Lanes and to compare responses given in both rounds. The primary purpose of the overall study was to assess attitudes of low-income drivers relative to typical drivers, with the January 2009 round focusing on how the operation of the new HOT lanes was affecting both sets of users of the roadway. Socioeconomic conditions, commute characteristics, familiarity with and perceptions of the concept (especially equity), and operational understanding are documented.

2.3 Foreign Facility Documentation

2.3.1 Central London Congestion Charging

Congestion charging (cordon pricing) was instituted in London in February 2003 for the 8-square-mile CBD. The charge has been substantially reinvested in expanded public transportation, especially bus. The flat rate, per-day charge is levied to enter the zone weekdays from 7 AM to 6 PM. In July 2005, the rate was increased from £5 to £8. The charging zone was subsequently expanded westward in February 2007, doubling the zone by incorporating Westminster and Kensington & Chelsea. An uncharged through-route bisects the two zones. Comprehensive annual reports on impacts monitoring is published by Transport for London (TfL) and are available on its website. The first and the most recent reports are presented here.

Impacts Monitoring: First Annual Report. Transport for London. (June 2003).

http://www.tfl.gov.uk/assets/downloads/Impacts-monitoring-report1.pdf.

Central London Congestion Charging Impacts Monitoring: Sixth Annual Report. Transport for London. (July 2008).

http://www.tfl.gov.uk/assets/downloads/sixth-annual-impacts-monitoring-report-2008-07.pdf.

The first annual report describes the monitoring program, summarizes the conditions prior to congestion charging, and presents the range of indicators and issues being monitored. Data was derived from over 100 specially designed surveys and studies, as well as existing surveys and data sources. Sources included:

- Data generated from traffic management and scheme operation functions
- Moving car observer surveys
- The use of monitoring and enforcement cameras
- A wide range of traffic counts across a variety of areas, sites, screenlines and cordons
- Various counts of buses and bus passengers, plus data from other public transport providers
- Trip diaries, a wide range of travel surveys, as well as data from parking providers, the Public Carriage Office (taxi licensing), and the London Accident Analysis Unit (part of TfL)
- Business surveys, economic case study work, plus data on a range of key environmental indicators

The most recent annual report discusses in great depth seven broad categories that comprise the monitoring program, which are summarized in the table below. The 2008 annual report notes that TfL's monitoring program was significantly expanded in 2005 and 2006 to collect comprehensive baseline "before" data in advance of the western zone expansion in 2007. Data gathered during its implementation was them compared to this baseline, and an approach was developed to assess the impacts of the expanded scheme.

Evaluation Category	Measures
Congestion (monthly reporting, annual changes) • Inside the original central zone • On the inner ring road (free passage route between the two zones and eastern section around original central zone) • On approaching radial routes • Inside the western extension zone • On the western extension boundary route • On main routes to the western extension • Within Inner London (outside the charging zone)	• Excess travel rate (min/km) – the difference between the travel rates in the early hours of the morning (uncongested) and those during charging • SCOOT indices measured at traffic signals (SCOOT automatically and dynamically adjust signal timings according to traffic)
Traffic patterns (hourly, weekly, annual changes – central zone and western extension) • Traffic entering and leaving the zone • Interaction between central and western zones • Traffic circulating in the zone • Traffic on the inner ring road • Radial traffic approaching the zone • Traffic on select roads	• Volume • Vehicle classification • Vehicle-kilometers driven
Public transportation, accidents, and air quality • Bus patronage in the western extension • Bus patronage in central zone	• Bus passengers counts (total, per bus) • Passenger-km • Bus-km • Average occupancy
• Bus network speeds	• Journey speeds
• Bus network reliability	• Excess waiting time
• Underground patronage • National rail patronage	• Underground passengers counts • National rail passenger counts
• Accidents within central zone and western extension	• Accident counts (with personal injury [pedestrian/non-pedestrian], severity [fatal, serious, slight], vehicle type involved)
• Emissions from road traffic (NO_x, PM_{10}, CO_2) • Air quality	• Emission change attributable to traffic volume and composition, to speed, to vehicle stock • Annual mean concentration ($\mu g/m^3$)
Travel behavior • Roadside interview surveys – western and central zones	• O-D of trips • Journey purpose • Industry sector of business trips • Length of trip
• Survey of response to charging before western extension	• O-D of trips • Journey purpose
• Survey of western extension residents registered for residents' discount	• Before and after travel • Anticipated vs. actual impact
• Survey of charge-paying western extension drivers	• Trips taken

Evaluation Category	Measures
	• Consideration of car alternatives • Attitudes towards affordability
Social impacts (before and after surveys) • Western extension users survey • Londoners (in general) survey	• Travel behavior change (mode, purpose, alternatives used/changes made) • Access to services (destination by frequency, destination by mode, anticipated vs. actual change in frequency by destination) • Affordability and overall impacts • Perception of transport provision and environment • Impacts on interaction with friends and family • Impacts on parents and children
Social impacts (continued) • Key workers (public service) supplementary survey • Shift workers supplementary survey • Disabled people and caretakers supplementary survey	• Travel patterns • Affordability • Employment • Activities • Benefits • Travel behavior change • Activities (western extension) • Impact on travel (western extension) • Travel patterns (by car, by public transportation) • Social contact with friends and family
Business and employees • Business modeling • Dun and Bradstreet business database analysis • Annual Business Inquiry • VAT Registrations data • TfL Congestion Charge Business Survey	• Number of enterprises, survival rates, openings and closings • Turnover and profits • Employee numbers and business units • Numbers of business registrations and deregistrations • Business reactions and attitudes
Retail • SPSL retail traffic data • London Retail Sales Monitor • TfL western extension visitors survey • TfL western extension shoppers exit survey	• Changes in retail traffic • Shoppers/diners/boundary business users' behavior • Exit survey and shopper counts
Tourism • GLM tourism analysis	• Visitor trends
Property • Investment Property Databank • Land Registry analysis of residential property prices	• Commercial property prices and rental yields • Residential property prices and sales volume
Operation, compliance, enforcement, and revenues • Service provider performance	

Evaluation Category	Measures
	• 52 performance indicators
• Payments	• Number, type
• Service quality	• Satisfaction survey results
• Enforcement	• [Described in previous annual reports] • Penalty charge notices issued • Penalty charge notices paid • Penalty charge notices challenged • Appeals
• Operating costs and revenue	

Congestion Charging: A First Review. London Assembly. (Feb. 2004) http://www.london.gov.uk/assembly/reports/transport/congestion_charging_feb04.pdf.

Prior to the implementation of congestion charging, the London Assembly (an elected body that scrutinizes the activities of the Mayor of London—together the Mayor and the London Assembly comprise the Greater London Authority) recommended eight criteria on which to judge the London Congestion Charge; it:

- Must deliver a real and sustained reduction in congestion
- Must not have an adverse impact on the areas outside the charging zone
- Must not disadvantage Londoners (particularly low-income groups)
- Must deliver a real improvement to bus journeys in London
- Should not have an adverse effect on London's economy or services
- Should not have an adverse effect on London's environment
- Should not penalize "innocent" drivers
- Should deliver net revenue to fund transport initiatives

This report evaluates the extent to which each criterion had been met 10 months into the scheme's implementation through results from a focus group, TfL data, and various surveys. Through mostly qualitative discussions, the report summarized:

- Impacts on congestion within central London and outside the charging zone
- Impacts on Londoners, especially low-income groups
- Effects on public transportation, especially buses
- Impacts on the economy and the environment
- Remarks on customer service and enforcement
- Net revenue to fund transportation initiatives

The report concluded with a number of recommendations for further monitoring and policy considerations for TfL. Although the report makes multiple mentions of future monitoring by the London Assembly, no further reports specifically on the congestion charge monitoring were published.

Study to Produce an Independent Assessment of the Central London Congestion Charging Scheme. London Councils (ALG). 20 Mar. 2008. http://www.londoncouncils.gov.uk/London%20Councils/Transport/Transport%20Publications/ProjectOvervie.pdf.

This document summarizes a congestion charging monitoring study commissioned by the Association of London Government (ALG)—renamed the London Councils in October 2006—and performed by Ove Arup & Partners. The London Councils is a local government association comprising representatives from the 32 London Boroughs and the City of London Corporation as well as the police authority and fire brigade. This review by the London Councils has acted as an independent audit of the congestion charging scheme, as its primary monitoring is being performed by TfL, the agency responsible for administering and collecting the charge.

When first commissioned in 2002, London Councils felt that TfL's planned five-year monitoring program had several shortcomings including: the scope and scale of its coverage; TfL's objectivity; a need to carefully examine behavior as well as hard numbers such as traffic counts; carefully attributing results to the charge or to other initiatives; and the absence of a "No Build" comparison to the congestion charge's "Build" scenario. Five study elements were selected as a focus of the monitoring program, and data was gathered and analyzed before and after the scheme's implementation in 2002 and 2003, respectively:

- An independent assessment of the impact of the congestion charging scheme on traffic levels inside and immediately outside the zone
- An independent assessment of any traffic diversion to parallel routes around the charging zone
- An examination of the impacts of the scheme on parking usage and revenue in and around the congestion charging zone
- An examination of the effect of the scheme on parking around stations in outer London
- An examination of bus occupancy levels following the introduction of the scheme

Evaluation measures and performance metrics incorporated in this effort are summarized in the table below.

Evaluation Measures	Performance Metrics
Traffic levels • Inside and outside the zone • Along the cordon • Diverted to parallel routes around the zone	• VKT
Parking activity • Inside and outside the zone • Around rail stations (on-street)	• No. of parking events • Cost of parking/parking revenue • No. of resident permits/permit cost • No. of violations/violation revenue • No. of parking enforcement shifts
Bus occupancy/overcrowding (10 routes, morning peak)	• Manual (videotaped) counts

2.3.2 Singapore Electronic Road Pricing

A manual cordon pricing scheme—the Area Licensing System (ALS)—was put into operation within Singapore's CBD in 1975. An area license had to be purchased and displayed for entry into the CBD's Restricted Zone (RZ). In the 1990s, a similar scheme—the Road Pricing System (RPS)—was progressively introduced along three major expressways leading to the RZ to complement the ALS. In September 1998, the manual ALS and RPS were replaced by the Electronic Road Pricing (ERP) system. ERP utilizes overhead gantries with antennae that communicate with vehicles' In-vehicle Units, which utilize reusable credit card-like CashCards and deduct an appropriate ERP charge. The ERP charge is generally levied for entry into the RZ weekdays between 7:30 AM and 7:00 PM. Also, within a major shopping district in the RZ, the charge is levied on Saturdays from 12:00 to 8:00 PM. Along the major expressways and arterials approaching the RZ, the charge is generally levied weekdays from 7:30 to 9:30 AM. Overall, the charge varies by vehicle type (passenger car/taxi, motorcycle, heavy and very heavy goods vehicles), by gantry, and per ½-hour on a fixed schedule with adjustments possible every three months to maintain smooth traffic flow. The "85^{th} percentile" criterion is applied in making this adjustment, whereby 85 percent of roadway users must perceive improved conditions (LOS/speed) following the adjustment.

The ERP program is administered by Singapore's Land Transport Authority (LTA). Performance monitoring documentation from the authority is not publicly available. However, from a personal communication with the Deputy Director of the ERP program, the following information was obtained.

The underlying performance characteristics of ERP that are measured and tracked carefully by LTA include an array of standard traffic theory and traffic engineering metrics/techniques specifically focused on the speed of traffic. For example, speed-flow analyses are performed for all travel routes (expressways, major arterials, and minor arterials) to examine congestion levels relative to target LOS. Formerly, an optimal range of speeds was assigned to specific road types, and if monitored performance below this set speed envelope was observed, a pricing policy correction could be initiated. However, it was found that not all roadway users perceived these speed ranges as correlative with satisfactory service for the price paid. Consequently in 2008, the criterion was changed to the "85^{th} percentile" measurement as described previously.

Performance measurement data is taken from five sources. An integrated data processing platform handles each of the inputs.

- A fleet of roughly 7,000 taxis, equipped with GPS, and acting as floating cars—proxies—for the speeds of all roadway users
- ERP gantries capable of roughly measuring point speeds
- Expressway traffic cameras (currently under expansion to arterials) located on average 500 meters apart that collectively can compute mean-space speeds
- Loop detectors
- On-site origin-destination surveys

Aside from traffic theory applications and critical speed-flow and mean-spaces speed calculations, other higher-level metrics are monitored and tracked for use by senior management. These include time to travel from benchmark locations throughout Singapore (this applies to public transport as well as roadways), system availability, and the quantification of delay into economic loss. Environmental effects and safety are not directly monitored, as these aspects are thought to correlate positively with the successful application of the ERP program and congestion reduction. Finally, when communicating system performance and policy decisions with the public, traffic speed is used as simple, easy-to-comprehend metric with which to characterize system operation, rather than presenting the full detail of traffic theory computations.

2.3.3 Stockholm Congestion Tax (Trängselskatt)

From January 3 through July 31, 2006, the City of Stockholm underwent a cordon pricing trial period (The Stockholm Trials) by charging a congestion tax to enter the city's center. Goals of charging the tax were to reduce congestion and improve the environment. Following an October 2006 referendum in which Stockholm Municipality voted to implement the charge permanently, while 14 other surrounding municipalities in Stockholm County voted against it, the Swedish parliament voted to make it permanent in June 2007. The permanent charge (Trängselskatt) went into effect August 1, 2007. A variable charge is levied to enter the 13.8-square-mile city center on weekdays between 6:30 AM and 6:30 PM. No charge is levied during the month of July.

The Stockholm City Traffic Administration, in cooperation with Stockholm Transport and the Stockholm Region of the National Road Administration, is responsible for the congestion tax's monitoring and evaluation. However, summarizing the documentation of these efforts was complicated by the lack of publications in English. A comprehensive evaluation of the trial period was published in English and summarized below. Other documents referenced here are summarized using Google translations. These include several reports issued shortly after the permanent charge's implementation in August, October, and November 2007.

Additionally, it is stated on the Stockholm City Traffic Administration's website that quarterly monitoring would take place throughout 2008 to examine the congestion tax's impact on trade, economy, road safety and the environment (http://www.stockholm.se/Fristaende-webbplatser/Fackforvaltningssajter/Trafikkontoret/Trangselskatt/Program-for-uppfoljning-/?oversatt=). However, only one quarterly report, summarized below, was available on the website.

In addition to these resources, the National Road Administration maintains monthly usage statistics on its website: http://www.transportstyrelsen.se/sv/Vag/Trangselskatt/Statistik-trangselskatt2/.

Facts and Results from the Stockholm Trials. City of Stockholm. (Dec. 2006). http://www.stockholmsforsoket.se/upload/Sammanfattningar/English/Final%20Report_The%20Stockholm%20Trial.pdf.

This document summarizes the results of the Stockholm Trials—the congestion tax's trial period. A significant number of performance metrics were evaluated with respect to the objectives of reducing congestion, improving the natural environment, and improving the perceived environment of the city. It was concluded the these objectives were met, with an even greater-than-expected reduction in congestion, improved levels of CO_2 and PM, and an improved city environment, at least with respect to those changes that could be measured and quantified.

Importantly, this report also discusses what could be changed about the charge if it were made permanent. The report acknowledges that a simple, flat fare structure and fixed boundary achieved the goals uniformly. However, if a more complex fare structure were adopted, varying the charge level during the year to account for seasonable changes in traffic levels would be preferable.

Evaluation measures (before and after implementation) and performance metrics are summarized in the following table.

Evaluation Measures	Performance Metrics
Road traffic	• Weekday traffic volumes distributions (veh/hr) • Vehicle kilometers traveled (VKT) – in the charge zone and along approach roads • Vehicle classification (manual counts)
Congestion	• Congestion coefficient (prolongation of journey time in percent, compared with the corresponding journey when traffic is flowing freely) – in the charge zone and along approach roads • Traffic queue length (median, maximum)
Transit	• Ridership (bus and rail – service extended by 7% in 2005 prior to charge) • Travel card (fare) sales • Bus travel speeds • Service quality (biannual survey)
Pedestrians/bicycles	• Traffic counts (manual) • Experience (interviews)
Parking	• Park-n-Ride lots – outside the charge zone (counts, occupancy) • Public garages – in the charge zone (counts, occupancy)
Travel patterns	• Mode split (car, bike, pedestrian, transit) • Trip purpose
Road safety	• Collisions, injuries, fatalities
Environment (natural)	• Air quality/emissions (NO_x, NO_2, CO_2, PM_{10}) • Noise
Urban Environment	• Survey of urban experience • Interviews regarding effect on children's sports activity
Trade	• Retail sales volume • Impacts on laborers • Impacts on driving schools • Taxis/courier service/elderly and disable special transportation service • Regular commuters to businesses inside and outside the charge zone
Economy	• Effects on the gross regional product, incomes, costs and prices • Effects on the attractiveness of various areas in the region • Effects on the location of residential premises and places of work • Cost-Benefit analysis
Equity	• General analysis
Awareness	• Business and employee surveys

Baradaran, Siamak (City of Stockholm) and Leif Carlsson (Swedish National Road Administration). *Fordonstrafiken in i och ut ur Stockholms innerstad – före, under och efter trängselskatteförsöket samt efter trängselskattens införande 1 augusti 2007*. 23 Nov. 2007 http://www.stockholm.se/PageFiles/86806/TK_trafikanalys20november202007.pdf.

Several reports issued in 2007 subsequent to the implementation of the permanent congestion tax are available on the City of Stockholm's website. Brief reports for one day (August 2, 2007) and for one week (August 10, 2007) simply highlight the change in traffic counts monitored at the congestion zone's cordon where vehicles must pay the charge. An annual report (October 2007) presenting analysis of traffic measurements, including monitoring of the congestion tax's effects is also posted, but could not be translated. Finally, the brief report noted above from November 23, 2007 presents further detail on the permanent congestion tax since its implementation and a comparison to the conditions experienced during its trial period. The report concludes that the permanent congestion tax had approximately the same effect on traffic reduction within the charging zone as was experienced during the trial period.

Baradaran, Siamak (City of Stockholm). *Trafik till, från och inom trängselskattesnittet Lägesrapport, kvartal 1-2008*. 13 May 2008 http://www.stockholm.se/PageFiles/119772/l%c3%a4gesrappor_kvartal1_080609.pdf.

This document constitutes the first quarter progress report for 2008 on the permanent congestion tax. It is the only one available on the City of Stockholm's website, despite a statement that monitoring reports on the charge would be made quarterly. However, an October 2008 progress report on vehicle volumes entering the congestion zone is available. The 2008 first quarter progress report summarizes traffic volumes into the charging zone from 2005 through the first quarter of 2008, which covers the pre-charge period, the trial charge, a period of no charge before its permanent implementation, and the permanent charge. The report also summarizes public transportation ridership, the results of a mobility analysis examining travel times, and the proportion of exempt vehicles entering the zone.

Chapter 3 Identification of Information Gaps

3.1 Background: Current State of the Practice in which Gaps Have Occurred

The Task 1 Literature Review relied primarily on the publications and documentation associated with existing road facilities operating with a congestion pricing component. Evaluation studies, periodic reports, and monitoring program documentation for these facilities comprised nearly all the available information on evaluation monitoring and performance measurement. Only one general study pertaining to the evaluation of congestion pricing facilities was found among the scholarly research investigated in the literature review.

The obvious explanation for the limited documentation available on performance measurement is the number of congestion-priced facilities and their relatively brief operational histories. Among the 11 facilities identified in the literature review, only four were operating in the 1990s—although one has since been thoroughly redesigned—while five (six counting this redesign) have been open for less than five years. Accordingly, there is limited collective experience in developing a full understanding of facility performance measurement and evaluation specific to congestion pricing.

Information gaps can be grouped into three primary areas:

1. An incomplete understanding of why performance evaluation takes place and why certain metrics are tracked;
2. An incomplete understanding of how the information collected is used in practice and what changes have taken place as a result; and
3. A need to resolve the challenge of compiling guidelines that encompass a broad set of congestion pricing projects, varying across a wide range of characteristics, but applicable to any individual facility's goals and circumstances.

What the Task 1 literature review does reveal, however, is that there is no lack of actual performance metrics used in practice to cover a broad range of performance evaluation categories. These include an expansive number of metrics covering system impacts, system utilization, system operations, environmental impacts, economic impacts, land use impacts, impacts to related transit services, and public perception.

However, it does not lead to an understanding of the reasons for and outcomes of having measured this wide range of information or the establishment of best practices. In the absence of this knowledge, it is postulated that:

- Optimal measurement and validation of congestion-priced facility goals would not necessarily be achieved;
- New implementation of congestion-priced facilities might suffer the inefficiencies of not drawing upon proven best practices; and
- The continued proven capabilities of congestion-priced facilities would not be as well demonstrated or communicated, hindering the ongoing adoption of these promising techniques for transportation facility operation and management.

A work plan for closing these gaps will be developed in Task 3 and will lead to the establishment of guidelines for the evaluation and performance measurement of congestion pricing projects. Establishing these best practices will help allay the obstacles outlined above.

3.2 Primary Areas with Information Gaps

3.2.1 Why is the data collected?

The first step in addressing information gaps is to identify why the performance of congestion pricing projects is monitored and evaluated. Articulating the specific reasons why particular data are collected is a good starting point in the pursuit of creating guidelines with functional utility and broad-based applicability.

The Task 1 Literature Review revealed that from the relatively small pool of operational variable toll crossing, priced managed lane, and cordon priced facilities, there is a voluminous array of evaluation measures spanning a broad range of evaluation categories. Examples include:

- System impacts evaluated by using measures such as volume and throughput, speeds and travel times, and vehicle occupancy;
- System operations evaluated by using measures such as finance, enforcement, and safety; and
- Public perception evaluated by using measures such as awareness, acceptance, satisfaction, and media coverage.

These evaluation measures can be quantified using individual or several different performance metrics, some unique to a particular facility, others commonly used by multiple facilities. For example metrics for traffic volume and throughput include average daily traffic (ADT), traffic volumes measured over other time periods, traffic volume distributions, person volumes, and vehicle miles traveled (VMT), among others. Looking across all evaluation categories, the literature review revealed that there is no shortage of ways in which to evaluate and quantify the performance of congestion pricing projects… But why are these data being collected?

Several answers to this question can be surmised from the literature review and knowledge of industry practice. However they would benefit from further exploration. Requirements range from the general—and potentially even arbitrary—to the specific and goal-oriented. The relative weights of their significance would vary from facility to facility depending upon their locations, time in service, jurisdictional and institutional considerations, and other factors.

- Of primary significance to a facility provider are specific operational objectives that maximize its utility. Utility could apply, for example, to a single priced lane, all lanes along an entire corridor, or multiple corridors serving the same region, depending upon the priorities of its provider. These objectives differ from broader program goals in that their focus is facility- or corridor-specific. Maximizing system throughput or meeting set levels of service are notable instances in practice (e.g. the SR 91 Express Lanes in Orange County or Singapore's Electronic Road Pricing, respectively). Here, these operating objectives are often monitored on a rigorous basis requiring specific metrics that likely feed into an established algorithm for adjusting pricing levels.
- Monitoring may also be employed to measure achievement of broad program goals set by an agency or facility operator. Program goals could be as simple as meeting the demands of an agency's customers; as broad as reducing congestion or providing more reliable alternatives on heavily congested corridors where roadway expansion is not viable; or more specific, such as meeting target

reductions in criteria pollutants. Program goals are often applied strategically, as opposed to technical objectives (noted above) that are applied operationally.

- Data collection and reporting can also stem from a political process or prescriptive legislative requirements beyond an agency or operator's purview. The need to undertake performance evaluation and reporting may be more attributable to this supposition because of acceptance issues associated with pricing and congestion pricing projects' specialized characteristics or objectives. Direct legislative authorization (e.g. the SR 167 HOT lanes near Seattle) or reporting otherwise commissioned by a governmental body (e.g. London's congestion charging) may necessitate particular evaluation measures and performance metrics to be monitored and reported—at least once or with some established frequency. FHWA's Urban Partnership Agreement (UPA) and Congestion Reduction Demonstration (CRD) programs provide another example of monitoring programs imposed to ascertain how the projects fare at meeting FHWA's objectives.
- Another significant reason to collect performance data is to gain user acceptance and to facilitate communication with the public and stakeholders. Particular evaluation measures may be prescribed in a formal public outreach plan. The literature review revealed that pricing often draws public skepticism and that new projects often benefit from—and perhaps even necessitate—a strong public outreach component that relies on communicating its benefits through evidence of actual performance. For example, concerns that pricing roadway capacity may be a regressive policy and is detrimental to low-income motorists have been largely dispelled through actual usage experience as reported by careful monitoring.
- Finally, transportation agencies often collect data that are the most easily accessible or involve a bureaucratic legacy that can be traced to the agency itself or the specific facility involved. However, this conjecture may be less applicable for congestion pricing projects than for non-priced facilities again because their acceptance issues related to pricing and operation necessitate more demanding requirements for performance reporting.

Using this framework that describes why certain data are monitored, it will next be necessary to understand how the collected information is used. This process in turn will facilitate the identification of which measures and metrics are most relevant to a particular facility and it will enable the analysis of trends in their application to formulate this research's guidelines and best practices.

3.2.2 How is the collected information used?

Once performance data is collected, a full understanding of how it is used in practice represents the second major gap in existing knowledge. Although the answer to this question can be partially answered by understanding the reasons *why* the data are collected, as discussed above, their actual application is not necessarily articulated through the literature review findings. Typically, monitoring efforts were presented simply as the data themselves—either quantitatively or descriptively—or on a final outcome basis, for example the characterization of observed impacts or the success or failure of achieving particular objectives. What is less clear are the inner mechanics of this process; that is, how are evaluation criteria or the monitored metrics used to arrive at these conclusions, and more importantly, how do they result in operational adjustments or improvements to the priced facilities themselves. It is also necessary to ensure that the correct data is being collected at the outset, so that it is qualified to answer the questions asked or objectives posed. Areas to explore include:

- What data/information is collected?
- What results from past monitoring or operating experiences influenced the selection of an evaluation measurement strategy or use of particular performance metrics?

- What monitoring results are used to make adjustments to operating parameters (e.g. price, hours of operation, enforcement strategies, etc.) for the pricing application and what is the process for making those adjustments?
- How have the monitoring results been applied to a public outreach/public relations strategy?
- Do monitoring parameters respond to specific legislative requirements?
- Have any significant operational or physical changes occurred as a result of monitoring?
- Which evaluation measures have proven to be the most critical?
- What were the results of monitoring a control corridor/facility, if so chosen?
- Do operators desire additional operational, evaluation, or monitoring measurements?

3.2.3 What are the effects of differences in facility characteristics on evaluation and performance measurement?

The final area of exploration focuses on the many differences in facility characteristics found among the field of potential congestion pricing projects and the challenge associated with reconciling these differences to create a unified set of guidelines for their monitoring and evaluation. Because nearly all available literature is specific to particular facilities, there is little, if any consideration—or need—to explore the effects of how the monitored results might pertain or compare to other facilities,[3] starting with the operational differences among the three facility types identified in the review—variably priced managed lanes, toll facilities with variable pricing, and area or cordon pricing.

Although all seek to manage congestion through pricing, the application of this strategy and the physical and operational circumstances for doing so vary among the three facility types represented in the literature review.

The effects of these differences on performance evaluation and monitoring are not apparent from the literature review and represent a knowledge gap to be explored.

Beyond the intrinsic differences among the three facility types in providing for and managing roadway capacity, other more specific characteristics can vary from facility-to-facility and require consideration.

- Historical characteristics
  - The maturity of congestion pricing facilities varies from less than one year of operation to nearly 35 years.
  - In some cases congestion pricing was implemented at the facility's inception or in others it was added later.
- Location characteristics
  - Facility location can be impacted by geography, topography, the built environment (urban vs. suburban), and other regional characteristics that may be difficult to quantify.
- Data collection
  - Available baseline data and collection technology varies by facility.
  - Some impacts (which may not apply to every facility) have data collection challenges associated with them, including: 1) identifying exogenous variables/factors other than pricing, access, or

[3] In at least two cases in the literature review, control corridors were monitored to identify and control for potential exogenous factors that could skew the results of monitoring the congestion-priced facility, but it was not clear if these corridors were also used to make explicit comparisons between priced and un-priced facilities. Nonetheless, consideration generally was not given to making comparisons between priced facilities in different regions.

technology controls that impacted the facility operation or performance measurement process; and 2) measuring system-wide benefits when pricing is deployed on a single corridor.

Overall, information learned by filling the gaps in the first two identified areas—why the data is collected and how it is used—will facilitate a trend analysis of various applications of performance evaluation and measurement. It will be necessary to determine which metrics are universal in nature, which are specific to certain facility types or facility characteristics, and which are potentially unique in their application.

Chapter 4 Development of the Work Plan

This chapter discusses the Work Plan for executing the remainder of the project's research subsequent to the literature review and the identification of information gaps in the understanding of congestion pricing performance evaluation and measurement. It includes the methodology as proposed and a description of the underlying research ultimately carried out as a result. The main focus of that research was the conduction of 12 case studies for active congestion pricing projects.

4.1 Information Gaps Summary

As outlined in Chapter 3, information gaps within the current understanding and application of performance evaluation and monitoring of congestion pricing project were identified in Task 2. These information gaps derive from the current state of the practice as defined by the products of the Task 1 Literature Review. Grouped into three primary areas, these gaps are:

1. An incomplete understanding of why performance evaluation takes place and why certain metrics are tracked;
2. An incomplete understanding of how the information collected is used in practice and what changes have taken place as a result; and
3. A need to resolve the challenge of compiling a usable set of guidelines applicable to a broad set of congestion pricing projects that vary across a wide range of characteristics, i.e. the need to reconcile site-specific monitoring applications with multi-facility benchmarking efforts.

4.2 Methodology to Address Information Gaps

To fill these information gaps in a systematic and thorough manner, an initial methodology was developed. As prepared for Task 3, it stated:

1. All or a majority subset of the facilities reviewed in the Task 1 Literature Review will be selected for further exploration.
2. Knowledgeable individuals currently or formerly working for or on behalf of the facility owners and operators will be identified. Individuals contacted as a part of Task 1 will serve as a first point of identification.
3. A checklist of questions and issues to explore will be prepared to use in interviews conducted with the identified individuals.
    a. The questions will first explore how a facility's monitoring and data collection align with the five postulated reasons for why performance evaluation takes place. The significance of each performance metric will be characterized and the reason for having collected it will be identified as: 1) meeting operational objectives; 2) meeting program goals; 3) satisfying legislative or other prescribed requirements; 4) facilitating user acceptance and public communication; and/or 5) because of agency/facility legacy or unspecified reasons.
    b. The questions will explore how each evaluation measure and performance metric is used in practice. Of critical importance is gaining an understanding of how they result in operational adjustments or improvements to the priced facility itself. Important questions include those identified in Task 2:
        – What data/information is collected?

- What results from past monitoring or operating experiences influenced the selection of an evaluation measurement strategy or use of particular performance metrics?
- What monitoring results are used to make adjustments to operating parameters (e.g. price, hours of operation, enforcement strategies, etc.) for the pricing application and what is the process for making those adjustments?
- How have the monitoring results been applied to a public outreach/public relations strategy?
- Do monitoring parameters respond to specific legislative requirements?
- Have any significant operational or physical changes occurred as a result of monitoring?
- Which evaluation measures have proven to be the most critical?
- What were the results of monitoring a control corridor/facility, if so chosen?
- Do operators desire additional operational, evaluation, or monitoring measurements?

c. Attributes specific to the facility in question will be explored, beginning with the type of congestion pricing employed (variable toll crossing, priced managed lane, or cordon/area priced facilities).

d. Additional facility characteristics will be identified and explored, helping to further delineate which measures and metrics align with facility-specific evaluation and which can be applied in a broader, multi-facility benchmarking framework. As identified in Task 2, these are:

- Historical characteristics
  1. How does the lifetime duration of a congestion pricing facility's operation affect the need and specifics of a monitoring program? Existing facilities vary in operational existence from less than one year of operation to nearly 35 years. The needs and requirements of a monitoring program may evolve as time passes; for example the effects of increasing demand over time and increasing user acceptance may need to be reflected in an evaluation strategy.
  2. When did the facility begin operating a congestion pricing component? In some cases congestion pricing was implemented at a facility's inception and in others, it was added later. These considerations also may impact the reasons why monitoring would take place and the metrics and strategies employed.
- Location characteristics
  1. What is the effect of geography? Unique characteristics of a facility's location (e.g. population or weather) should be considered relative to the details of a monitoring program.
  2. What is the effect of topography? Topographical restrictions (e.g. the location of the SR 91 Express Lanes within the Santa Ana Canyon) may impact the operations of a facility and in turn, its monitoring priorities.
  3. What is the relationship of the facility to the built environment? Facilities located in dense urban environments where chronic traffic congestion is the norm may seek a marginal reduction in congestion relative to that of a less dense, suburban region.
  4. What are the effects of other regional—and perhaps unique—aspects of the facility that may be difficult to quantify? Potential factors include regional demographics, average commute lengths, gas prices, and parking costs at major destinations.

– Data collection

1. What are the available baseline data and data collection technologies and/or methodologies? The ability to monitor certain metrics will be enabled or limited by these considerations.
2. What other data collection challenges are associated with the facility? Potential issues could include: 1) identifying exogenous variables/factors other than pricing, access, or technology controls that impacted the facility operation or performance measurement process; and 2) measuring system-wide benefits when pricing is deployed on a single corridor.

e. Finally, interviewees will be asked their thoughts on best practices and how their evaluation and performance measurement strategies may be helpful to others.

4. Interviews will be carried out and additional source materials on facility performance evaluation and monitoring will be sought to supplement those from the literature review and to support the interviews' findings.

It is believed that the information gathered through this process with be sufficient to fill the identified research gaps and facilitate the creation of a unified and usable set of guidelines on congestion pricing facilities' performance evaluation and measurement.

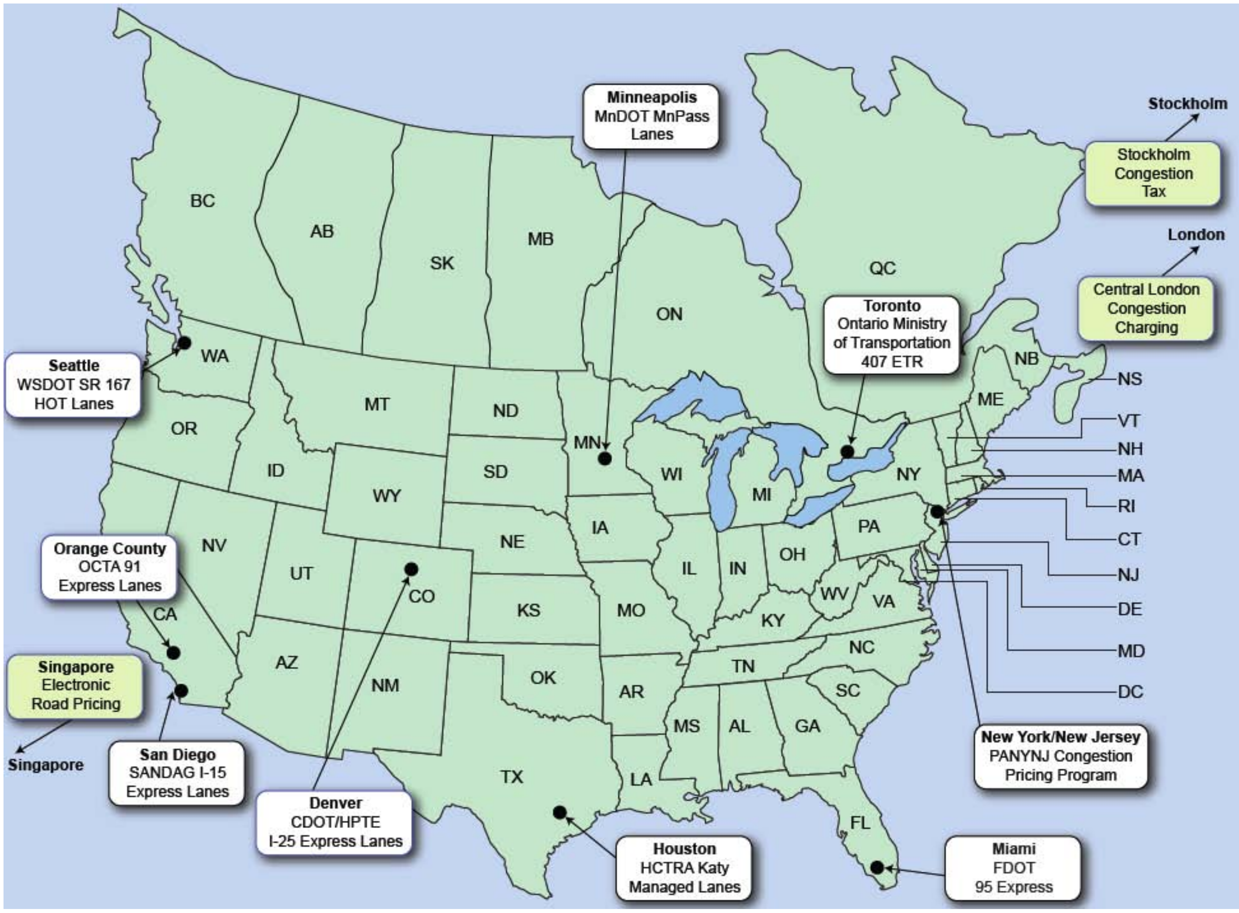
4.3 Underlying Research

Execution of the methodology outlined in the previous section focused on a comprehensive examination of 12 active national and international congestion pricing projects listed in Table 4-1 and organized into the three types of pricing defined in Chapter 1. These projects were selected for detailed study based on size of population served, possession of unique attributes, ease of obtaining relevant information within the constraints of the project, and general level of awareness in the transportation community. Their locations are shown on the map in Figure 4-1.

TABLE 4-1: CASE STUDY CONGESTION PRICING PROJECTS BY TYPE

Variably Priced Managed Lanes	Colorado Department of Transportation I-25 Express Lanes
	Florida Department of Transportation 95 Express
	Harris County Toll Road Authority Katy Managed Lanes
	Minnesota Department of Transportation MnPASS Lanes
	Orange County Transportation Authority 91 Express Lanes
	San Diego Association of Governments I-15 Express Lanes
	Washington Department of Transportation SR 167 HOT Lanes
Toll Facilities with Variable Pricing	Ontario Ministry of Transportation Highway 407 Express Toll Route
	The Port Authority of New York and New Jersey Congestion Pricing Program
Cordon and Area Pricing	Central London Congestion Charging
	Singapore Electronic Road Pricing
	Stockholm Congestion Tax

FIGURE 4-1: CASE STUDY CONGESTION PRICING PROJECTS BY LOCATION



4.3.1 Case Studies

Detailed case studies were prepared for each of the 12 projects selected for examination. This work was completed in two phases. Initially internet-based research was conducted to identify germane reports and other documentation available on performance measurement activities associated with these active congestion pricing projects. Reports and other publicly available materials were identified describing the methodologies used and the results of these performance evaluation programs. Following this initial effort, telephone and in-person interviews were conducted with staff from most of the sponsoring agencies of the 12 pricing projects to better understand each facility's goals and performance evaluation programs, what they measure and why, what they wish they would or could have measured and why, any challenges associated with project or evaluation program implementation, and other lessons learned in the context of guideline development—following the methodology outlined in the previous section.

The 12 project case studies are included as an appendix to this Final Report. They are generally organized by providing:

- An overview of the agency sponsoring the congestion pricing project
- A review of the agency's congestion pricing program
- A discussion of the different measures used to monitor agency's congestion pricing project performance

- Identification of other data collection efforts associated with the agency's congestion pricing project's implementation
- A review of why performance evaluation takes place and how the agency uses the performance monitoring data it collects
- A review of lessons learned and discussion of additional data or information that would be helpful to the sponsor or other agencies considering the use of congestion pricing

Each case study is accompanied by a detailed Facility Performance Monitoring Summary Matrix providing a comprehensive record of all current, known measures used to monitor performance on the facility, organized by evaluation area. (Evaluation areas, which can be related directly to specific project goals, are explained further in Chapter 5). Evaluation areas in each matrix consist of:

- Traffic
- Public Perception
- Users
- System Operations
- Environment
- Transit
- Economics
- Land Use

In addition, the matrices provide the following information for each individual measure:

- Frequency of collection
- Purpose
- A simple indication of overall importance
- Characterizations of the metric that relate back to agency or facility goals
- Sources of information
- Other related notes

4.3.2 Guideline Synthesis

The project case studies described in the previous section are the heart of this project's research and provide the underlying foundation to the Guidelines. Each facility's performance monitoring program and suite of performance measures used in practice were synthesized to provide the Guideline recommendations, as presented in Chapters 5, 6, and 7. For each of the three types of congestion pricing, the best practices and lessons learned were culled from among the subsets of respective projects. A primary component of this synthesis involved developing summary matrices of performance measures used in practice for each congestion pricing type. These matrices form the basis for distinguishing between the "must-have" measures and the "nice-to-have" measures (as well as those that may provide little value). Importantly though, the Guidelines do not simply repeat verbatim the performance measures identified in this manner, but by applying the case studies' findings on what facility operators wish they had done in retrospect and overall conclusions from the research, the Guidelines seek to make the best set of recommendations for future performance evaluation program implementation.

Given that each congestion priced facility is unique and that performance evaluation programs must be tailored to varying sets of goals, contexts, and available resources, the 12 project case studies are also provided as an Appendix to the Guidelines—and likewise is included as an appendix to this Final Report. In this manner, the reader may find that the information contained in a specific case study can augment the Guidelines' recommendations or serve to better illustrate a particular application in detail. For example, in considering the implementation of a simple HOV-to-HOT conversion along a 3 by 3 lane corridor with one non-barrier separated HOV lane and two general purpose lanes in each direction, the Washington State Department of Transportation's experience doing just that along SR 167 in southern Kings County may useful to study in detail—in addition to the recommendations for variably priced managed lanes.

4.4 State of the Practice and Beyond

The current collection of operational congestion priced facilities from which the Guidelines draw upon highlight two important points. One, the application of congestion pricing—and thus evaluating and measuring its performance—is a relatively new concept, but one that is expected to continue growing. The second point, which, despite the expected increase in operational facilities, will likely remain true, is that no two facilities are the same. It follows from this that no two facilities have the same performance measurement requirements. It is with this understanding that the approach to these Guidelines has been to synthesize what has been used in practice and apply that which has been found to provide the best value.

4.4.1 The Expanding Future of Congestion Pricing

The trend of applying congestion pricing solutions to transportation needs in the U.S. (and abroad) is growing. With limited resources with which to make improvements and a need to manage increased demand from a growing population seeking greater mobility, congestion pricing is a natural, and many would argue, necessary solution. And to continue to make appropriate justifications for investing in congestion pricing solutions, as well as to ensure their intended and optimal operation, performance evaluation and measurement must play a significant role in their application.

The current scope of congestion pricing in the U.S. is shown in Table 4-2 alongside expected future projects that are in the "pipeline." These pipeline projects are currently in design or construction, or have a good chance of moving ahead from their ongoing planning processes. Those that are operational today have opened only within the last 15 years. Many of the projects in the pipeline can be expected to open in less than half that time, greatly increasing their presence across the country and the number of sponsoring agencies responsible for their implementation. The number of users (and potentially skeptical observers) will also grow, making the need to validate and manage facility operation more pervasive. This project's Guidelines are designed to facilitate that need.

TABLE 4-2: OPERATING AND PIPELINE CONGESTION PRICING PROJECTS IN THE U.S.

OPERATING	PIPELINE	
Variably Priced Managed Lanes	**Variably Priced Managed Lanes**	
Alameda County, CA I-680 Denver I-25 Houston I-10 Katy Freeway Houston Northwest Freeway Miami I-95 Minneapolis I-394 Minneapolis I-35W Orange County, CA SR 91 San Diego I-15 Seattle SR 167 Salt Lake City I-15	Austin Loop 1 Baltimore I-95 Bay Area, CA I-580 Bay Area, CA I-80 Bay Area, CA U.S. 101 Charlotte I-77 Dallas DFW Connector Dallas I-30 Tom Landry Dallas I-35 Thornton Dallas I-35E Stemmons Dallas I-635/LBJ Dallas NTE (I-820/SH 121) Denver U.S. 36 Fort Lauderdale I-595 Georgia GA 400 Georgia I-75/I-575 Georgia I-85 Houston area reversible lanes except I-10 Katy Las Vegas I-15	Los Angeles I-10 Los Angeles I-110 Orange County, CA I-405 Provo I-15 San Antonio Loop 1604 San Bernardino/Riverside Counties, CA I-10 San Bernardino/Riverside Counties, CA I-15 San Bernardino/Riverside Counties, CA SR-91 San Diego I-15 San Diego I-5 San Diego I-805 San Diego SR 52 San Jose SR 237/I-880 San Jose SR 85 San Jose U.S. 101 Seattle I-405 St. Paul I-35E Virginia I-395/I-95 Virginia I-495 Capital Beltway
Toll Facilities with Variable Pricing	**Toll Facilities with Variable Pricing**	
Lee County, Florida Bridges New Jersey Turnpike Orange County, California San Joaquin Hills (73) and Foothill/Eastern (241, 261, 133) Toll Roads Delaware Route 1 San Francisco-Oakland Bay Bridge The Port Authority of New York and New Jersey Bridges and Tunnels Virginia Dulles Greenway	Maryland Intercounty Connector Seattle Alaskan Way Seattle SR-520	
Cordon and Area Pricing	**Cordon and Area Pricing**	
None	San Francisco	

4.4.2 Every Congestion Priced Facility Is Unique

The research that underpins these Guidelines has shown a predictable result—that no two congestion priced facilities are the same. Numerous factors that influence the decision to implement such a facility contribute to the uniqueness of each: overarching goals, sponsoring agency, regional roadway network configuration, available alternate modes, land use patterns, user population and demographics, experience level with tolling and managed lanes, available resources—the list goes on. A user of the Guidelines will likely be confronted with this situation, seeking guidance and recommendations for a facility's implementation that presents its own unique attributes and challenges. For this reason, the Guidelines' approach has been to identify a wide range of recommendations on establishing a performance evaluation program and selecting specific performance measures. The Guidelines represent a synthesis of best practice, but at the same time, remain accessible to readers seeking direction on components of a performance monitoring program that may not be the most commonly applied in practice. Ultimately, a user of the Guidelines may pick and choose among the recommendations as appropriate based on applicable context.

Chapter 5 Guidelines for Evaluation and Performance Measurement of Congestion Pricing Projects

This Chapter provides detailed recommendations and key considerations on initiating performance evaluation programs and selecting specific performance measures for congestion pricing projects. Section 5.1 discusses important considerations common to the three forms of congestion pricing when establishing a performance evaluation program. These include:

- Issues of coordination and timing (such as who will perform the data collection and when, and what are the available resources to do so)
- Confirming goals set for a facility and expected service standards
- Identifying measures for evaluating and managing project performance
- Performance measures used in practice

Sections 5.2, 5.3, and 5.4 are devoted to performance measurement and the selection of performance measures for the three forms of congestion pricing: variably priced managed lanes, toll facilities with variable pricing, and cordon or area pricing, respectively. Each of these sections focuses on their distinguishing characteristics and presents detailed recommendations on selecting the most relevant, cost-effective measures based on goals, identified constraints, and other factors—organized by eight evaluation areas.

5.1 Initiating Performance Measurement Programs

5.1.1 Coordination and Timing

Once the decision has been made to move forward with implementation of a congestion pricing project, project sponsors should also formulate plans to evaluate and measure the performance of the project. These plans should involve input from a multidisciplinary team of technical experts within the public agency responsible for such areas as project outreach, traffic engineering, transit, planning and environment, and environmental justice—together with other stakeholder agencies involved in supporting the project. Stakeholder agencies would depend on local institutional structures but could likely include the local transit authority, state or local law enforcement, and municipal governments.

Once the membership of the performance monitoring team has been established, it should convene and discuss performance monitoring needs for the project, with the expectation that different agencies and technical disciplines are likely to have their own unique needs and interests in terms of performance goals and measures. The discussion should identify the universe of issues task members are interested in tracking and rationalize them with the overall goals established for the congestion pricing project and the funds available to support the performance monitoring program. The discussion should also focus on existing data including surveys, counts, and automated reports that could be used to establish baseline conditions and provide a good precedent for ongoing performance monitoring.

As different measures are discussed, the team should consider the following issues:

- How is the measure collected—with real-time detection equipment, regular counts or surveys, one-time surveys?
- Is the data already collected, or would a new effort be needed to do so?

- Which agency is best placed to collect the data?
- What is the cost of collecting the data?
- Should the data be collected internally or by an outside vendor or contractor?
- What is the benefit of having the data?
- How would the data be used?
- What level of resources is available to support collecting the data?
- Are cooperating agencies able to provide data within their existing budgets or would they require additional funding to be able to do so?
- Will construction activities or other externalities be likely to skew or otherwise influence the data collected during the baseline period, and, if so, how should this be reconciled?

By considering these issues, the team will develop and understanding of which potential performance measures are “have-to-have” items that will deliver essential information for the management and validation of the congestion pricing facility and which of them are “nice-to-have” items that do not necessarily provide the same level of utility. If new information will be needed, it should be collected in the most efficient manner possible. Responsibility for any data that could be gathered electronically should be delegated to the system operator responsible for toll collection or captured by existing ITS installations and included in automated reports. Responsibility for manual counts and surveys should be kept in-house if the sponsoring agency has the capability and staff availability to collect the information. Otherwise it is normally more efficient to outsource more specialized data collection needs such as stated preference surveys or aerial photography to private vendors or firms specializing in those areas.

The performance monitoring team’s deliberations should then be summarized by a smaller subset of its members or a consultant into a Draft Performance Evaluation Plan, which could be reviewed and approved by the larger group. The draft plan could also be circulated to other agencies or vetted through the project’s ongoing public consultation efforts to obtain input and buy-in from as large a cross section of the local community as possible. When completed, the plan could be posted to the project website in order to enhance transparency and awareness of the performance monitoring efforts.

As discussed in Chapter 1, baseline data collection should extend for one full year prior to the opening of the congestion pricing facility. Having a full 12 months of traffic data and other information allows the sponsor to document normal seasonal trends, as well as the effects of external events such as a large, prolonged snowfall, a spike in the price of gasoline, or changes in transit fares or service. It should also be recognized that the construction of the pricing facility is likely to pose an externality in and of itself, with the potential to degrade travel conditions and divert traffic to other corridors. If this is the case, then the baseline data may need to include historic traffic data prior to construction or possibly involve collecting similar information in a control corridor elsewhere in the region.

Accordingly, planning for performance monitoring must be completed far enough in advance of the 12-month baseline period to be able to procure and install any detection equipment that may be required. Similarly, it is also likely that one-time attitudinal surveys will be completed prior to the activation of the congestion pricing project. Planning for these efforts must also be completed far enough in advance to undertake them during the baseline period. While scheduling specifics will differ from project to project, it would be best for project sponsors to complete their performance monitoring plans two years prior to the opening of the project. This would allow a full 12 months to prepare for the beginning of monitoring activities during the 12-month baseline period prior to the project’s opening.

5.1.2 Goal Confirmation and Identification of Service Standards

As described above, one of the performance monitoring team's first activities should be to confirm the goals established for the congestion pricing project. Goal confirmation could also involve revisiting particular needs or concerns that may have arisen from the public consultation process. Primary project goals for congestion pricing projects are likely to include congestion reduction and/or revenue generation. Other likely goals may include system utilization targets, strengthening transit service, and maintaining or improving safety. In certain cases, goals for congestion pricing projects may also extend to the environment, local economic conditions, and even land use. As they summarize and confirm the project goals, the performance monitoring team should recognize that different stakeholder groups are likely to be interested in different goals. As such, the group should seek to agree upon a broad set of goals that will resonate with the widest possible constituency.

At the same time, the performance monitoring team should also identify a comprehensive set of service standards established for the project. These will include system performance requirements established for installation of ETC equipment and for a system operator, if chosen to run them. These requirements would be identified in the procurement documents prepared for these functions. Other service standards would involve standard maintenance activities such as snow removal, sweeping, or guardrail repair, and would likely be established by the maintenance or operations division of the agency sponsoring the project. Still others would likely involve incident management, which normally falls under the purview of the local police or state highway patrol.

The team, or a smaller subset thereof, should identify the various performance standards that have been identified for all relevant aspects of the congestion pricing project's operation, together with existing protocols for tracking them. It should then identify which of those standards should be included in the performance monitoring program for the congestion pricing project, which agency would be best placed to monitor them, and whether new procedures would be required to do so.

5.1.3 Identifying Performance Measures and Their Use

Once the performance monitoring team has identified project goals and areas with performance specifications, it should proceed with the identification of individual performance metrics to be utilized in the performance monitoring plan. The optimal set of metrics will enable the project sponsor to have a clear understanding of how well the congestion pricing project is performing and to what extent it is meeting its various goals and standards without being overly costly or requiring an inordinate amount of staff or consultant time to collect.

The performance monitoring team should consider each project goal individually and then identify the different performance measures that would be useful in quantifying the extent to which it is being met. As they do so, the team should identify how the data for each metric would be collected, the frequency of collection, the ease of collection and overall cost. They should also determine whether or not the data is already collected or if it duplicates any new information that will be collected through the monitoring program. If the data is not duplicative, then the team should assess the costs of collecting the metric against the overall utility of having the information. In order to make the most effective decisions, the team should review all candidate metrics associated with a given goal concurrently to identify the optimal subset of measures that will meet its needs. Project sponsors should track the performance of a large enough complement of metrics to have a full understanding of the overall performance of their priced facilities. This is particularly helpful if certain measures indicate notably different performance trends. Sponsors also will need to be intelligent about the conclusions they draw from their monitoring data and look into any changes in performance that the data reveal.

The overall scale of the performance monitoring program should also be commensurate with the scale of the pricing application it is tracking. Individual factors influencing the performance monitoring needs for the three forms of congestion pricing are discussed in later sections of this chapter. For example, performance measurement for cordon and area pricing applications should be done at a regional level. This is accomplished by monitoring conditions at strategic locations and then extrapolating the findings to the regional level.

The influence that pricing on individual lanes or facilities has at the regional level will depend on the size of the region, the scope and scale of the regional highway network, and the proportion of it that is actually priced. As regions move from implementing individual priced facilities to developing regional networks of priced lanes—as is currently envisioned in the Bay Area, San Diego, Minneapolis, Dallas and Atlanta—there will be an increasing need to monitor the performance of these systems at a regional level. It will be many years before such regional systems are in place, and performance monitoring and evaluation for regional pricing systems will likely warrant additional research in the future.

5.1.4 Social Equity and Congestion Pricing

The use of congestion pricing often raises concerns regarding effects on different elements of society, particularly low income individuals and other marginal groups. Equity is a broad topic subject to many interpretations. Economists often group people based on income levels or where they live and work, while urban planners often use broader categories such as age, disability, gender or language abilities to identify populations that may be disadvantaged in some way by transportation facilities and services.[4]

Equity analysis seeks to address how facilities affect marginal groups. Rather than involving unique performance metrics, it focuses on how outcomes among marginal populations compare to other user groups and the public at large across a standard set of measures including utilization, acceptance, affordability and overall satisfaction. The findings of equity analyses depend upon how equity is measured, the way in which user groups are defined, the specifics of different locations, and to what congestion pricing is compared.[5]

Priced managed lanes are likely to generate fewer equity concerns compared to other pricing forms since they provide drivers with a new priced travel option without taking away the free parallel lanes; they may also involve transit improvements. With respect to toll facilities with variable pricing or the use of cordon or area pricing, equity impacts largely will be driven by where lower income people live and work and the extent to which people have no choice but to drive on priced routes or are forced to forgo certain trips because they are too expensive.

In all cases, the differences in the direct benefits and costs between income groups are fairly small. Regardless of one's economic status, the time saved by using a priced facility will be the same. However, while the absolute cost of using the facility does not change by income, the relative cost compared to an individual's budget does vary widely. Therefore, when considering the issues of equity, it is important to monitor how different groups benefit from the use of the revenues, rather than just the use of the facility. Whether any discounts or exemptions are available for target populations should also be considered. When revenues are used to support new or enhanced services that benefit target populations, pricing can be found to be progressive. However, if regions use the revenues in ways that benefit all individuals equally, such a policy could be considered regressive.

[4] Liisa Ecola and Thomas Light; *Equity and Congestion Pricing: A Review of the Evidence*, Rand Corporation, Santa Monica, CA: 2009, pp 8-9. http://www.rand.org/pubs/technical_reports/TR680.html

[5] *Ibid*, pp 11-12.

Revenue use actions likely to have positive equity impacts could include:

- Increased transit service
  - New transit routes serving low income neighborhoods
  - Additional platform hours dedicated to existing runs serving low income neighborhoods
  - Additional seats on existing transit runs serving low income neighborhoods
- Reduced fares on selected transit routes
- Rebates or credits for trips made by members of target groups
- New or improved security at existing park-and-ride lots
- Additional spaces at existing park-and-ride lots
- New park-and-ride lots

Equity assessments for pricing projects generally begin during the planning phase with the identification of populations with potential equity concerns. This is usually done through consultation with local community boards and neighborhood groups as part of the public outreach process. Target populations could include low income residents, residents of a specified geographic areas or neighborhoods, transit riders on given services, or possibly speakers of certain languages.

Once the target populations have been identified, potential impacts are vetted through discussions with local planners and community and advocacy groups, together with possible strategies for mitigating them. Ultimately these strategies—which are likely to be combinations of the actions in the bulleted list above—are incorporated as part of the pricing project and assessed in the environmental approval process.

Performance monitoring efforts for congestion pricing projects should be designed to track equity impacts and the efficacy of the programs developed to mitigate them. This is accomplished by distinguishing disadvantaged populations from other travelers and then comparing their overall utilization and satisfaction rates to users at large. This can be accomplished in different ways ranging from tracking trip and travel behavior of transponder account holders residing in target zip codes or those who self identify as being a member of a target group. Surveys are normally designed to capture income information and other demographic and socioeconomic data that can be used to identify respondents from target groups, thereby facilitating comparative analysis. Additionally, follow-on meetings or focus groups with members of target populations including residents of given neighborhoods, members of community groups, transit riders, and people enrolled in project-related credit or rebate programs may be held, enabling project sponsors to gain additional feedback from these groups and measurement of the overall performance of any equity mitigation programs. Ideally this information can be used to promote equitable outcomes in measurable terms and garner support for congestion pricing from the public and elected officials.[6]

5.1.5 Performance Measures Identified in Practice

The following sections of Chapter 3 present tailored analyses of the particular performance measures identified by the research supporting these Guidelines. Section 5.2 examines performance measurement for variably priced managed lanes, Section 5.3 looks at toll facilities with variable pricing, and Section 5.4 evaluates cordon and area pricing. The full set of performance measures identified among the supporting research's 12 project case studies and used in these analyses is shown in Table 5-1, organized by evaluation area. Evaluation areas represent a logical means of organizing the vast gamut of measures found among operating facilities. Importantly, they relate directly to goals established for a particular facility; that is goals can be framed within the context of an evaluation area.

[6] *Ibid*, p. 33.

TABLE 5-1: CONGESTION PRICING PERFORMANCE MEASURES IDENTIFIED IN PRACTICE

Evaluation Area	Performance Measures	
Traffic Performance	*Speed & Travel Time*	LOS
		Speeds/ average speed
		Speed differential (GP vs. HOT lanes)
		Travel times
		Travel time savings
		Cost of delay/ VOT
	Volume	Vehicle volume (hourly/daily/weekly/monthly)
		Person volume (hourly/daily/weekly/monthly)
		Tolled trips/ untolled trips
	VMT/VKT	VMT/ VKT
	Congestion	Delay/ wait times
		Congestion coefficient
		Queue length
	Mode Share	Mode share (SOV, HOV, transit)
	Occupancy	Avg. vehicle occupancy (auto)
	Bike/Ped	Bike/ped traffic counts
	Parking	Park-n-ride activity (lot counts)
		Off-street parking activity (counts/occupancy)
		On-street parking activity (counts/occupancy)
		Violations/ revenue
Public Perception	*Awareness*	Of the facility/general/how much?
		Specific features
		Toll adjustments
		Future plans
	Acceptance	General/fairness/equity
		Specific questions
	Satisfaction	General/perceived value/how well?
		Traffic conditions/ reliability
		Perceived time savings
		Perceived safety
		Agency performance/ customer service
		Enforcement
	Effectiveness	Congestion reduction
	Social Impacts	Specific activities/populations
	Media Coverage	No. of articles/ reports (positive or negative)
Facility Users	*Transaction Method*	Transponder/video/by-mail/cash
	Accounts	Total, open/closed
		No. of transponders issued
	User Characteristics	Vehicle classification
		Vehicle make
		Vehicle registrations (HOV, vanpool, hybrid)
		Home zip code
		Demographics/ socioeconomics
	Trip Characteristics	Frequency of use
		Time of day/ departure time
		O-D/ travelshed determination
		Toll spending/price paid (self-reported)
		Trip length
		Trip purpose

TABLE 5-1: CONGESTION PRICING PERFORMANCE MEASURES IDENTIFIED IN PRACTICE [CONTINUED]

Evaluation Area	Performance Measures	
System Operations	*Finance*	Total transactions
		Revenue (toll/ charge)
		Average toll/ highest toll
		Revenue (fee)
		O&M Cost
	Enforcement	Total traffic stops/ responses
		Violations/citations/fines
	Safety	Collisions/ accidents
		Incident response time/ duration
	Customer Service	Inquiry activity (call, email)
		Performance (quantitative measures)
	System Function	Incidents
		Facility availability
		Equipment availability
		Mean time to respond/ repair
Environment	*Air Quality*	NAAQS criteria pollutants/ VOCs
		GHG/ CO2
	Noise	Noise levels
Transit	*Performance*	Travel time/on-time/excess wait
		Average speed
	Occupancy	Ridership/ boardings
		Average vehicle occupancy
	Finance	Farebox revenue
		O&M Cost
	Service	Quality/satisfaction/reliability
Economics	*General*	Gross regional product/ economic indices
		Benefit-cost analysis
	Business Impacts	General performance/openings/closings
		Specific sectors/services/populations
		Business costs and prices
		Retail traffic & sales
		Tourists/ visitors
	Property	Residential sales/rentals/values
		Commercial sales/rentals/values
Land Use	*Residential*	Housing decisions
	Commercial	Business locations

Whenever possible, these assessments also identify which measures are used more frequently and those that are more spurious. While it is possible to identify trends in some cases, each congestion pricing project is unique and is advanced to address a unique set of goals. Moreover, local concerns, legislative requirements, institutional relationships, and performance monitoring precedents also vary from location to location and project to project. These unique dynamics are the driving force that will determine which particular performance metrics are used on different projects. So rather than prescribing particular metrics for particular situations, these Guidelines provide a framework for project sponsors to identify which set of performance measures are likely to meet their particular needs.

Performance Monitoring and the Management of Congestion Pricing Facilities

The metrics included in these Guidelines are used for two primary purposes: monitoring and managing the performance of congestion pricing projects. When a metric is used in a management capacity the performance of the project is assessed against performance standards and if it is found that the facility is not achieving desired standards, then management tools such as toll rates, vehicle occupancy requirements, and access locations are modified in order for the project to meet the desired performance levels. It should be noted that a relatively small subset of performance metrics identified among the 12 case study projects assessed for this study are used in this way. Among variably priced managed lanes, 22 out of 62 identified metrics are used to manage operations; for toll facilities with variable pricing, the share was four out of 17 metrics; and for cordon and area pricing projects, three out of 55 identified metrics were used directly for operations.

5.2 Performance Measurement for Variably Priced Managed Lanes

As described earlier, performance measurement for variably priced managed lanes is undertaken for two primary purposes. ***The first is to monitor traffic operations on the managed lanes and confirm that traffic service, speeds and reliability meet the standards established for the facility*** and, if they do not, to make adjustments to toll rates and other operational policies such as access treatments or vehicle occupancy rates so that they do. This process takes place in real time with dynamically-priced HOT lanes where travel conditions are monitored on an on-going basis and toll rates adjusted up or down in intervals as frequent as every five minutes. With HOT lanes ETLs using fixed variable pricing, traffic performance data is most often collected electronically using in-road sensors and is reviewed on a regular basis, in some cases as often as every three months.

The second is more complex. It involves documenting the performance of priced managed lanes to the public at large and thereby validating the use of congestion pricing. This is a process that involves interacting with a variety of different stakeholder groups, each of which will have their own particular areas of interest and concern. Their interests will also be influenced by whether or not the project involved:

- The conversion of an existing HOV lane to HOT operation;
- The expansion of an existing HOT lane facility;
- The construction of new highway capacity used as a priced managed lane; or,
- The implementation of a new priced managed lane that involves a combination of new construction and the conversion of existing HOV or general purpose lanes.

There are many different audiences with an interest in the performance of variably-price managed lanes are likely to include the following groups:

- HOV motorists, transit riders, and drivers of other qualified vehicles who used the managed lane prior to its conversion to HOT operation;

- SOV motorists who pay to use the managed lanes;
- The agency sponsoring the managed lane projects and other transportation agencies and organizations;
- Transit agencies providing service on the managed lanes;
- Safety and law enforcement agencies providing these services on the managed lane facility;
- State legislatures and other local government bodies who may have approved the use of managed lanes and who may be the recipients of legally mandated reports documenting the performance of the facility;
- Local governments;
- Community boards and neighborhood groups
- The media; and,
- Any number of local interest groups including chambers of commerce; trucking organizations, environmental organizations and the like.

While there is some local variation, the general concerns and interests of these different groups is relatively consistent. Chapter 4 of these Guidelines provides additional information on outreach issues associated with the use of variable pricing.

Performance monitoring programs for variably priced managed lane projects need to encompass all the metrics needed to operate these facilities within prescribed standards, as well as a collection of other measures that together will enable project sponsors to document and validate the performance of the facility. There is no single approach that can be prescribed for accomplishing the latter. With each project this should involve a thoughtful review and balancing of the resources available for performance monitoring together with the goals established for the project and the different concerns among the stakeholder groups with whom the project sponsors must interact.

The remainder of Section 3.2 synthesizes the existing experience in formulating performance monitoring programs for seven operating variably priced managed lane projects from around the country based on interviews and case studies prepared as part of NCHRP 08-75. Through this process, the research identifies those particular performance measures that are widely found to be effective in meeting the two main requirements for monitoring the performance of variably priced managed lane facilities and distinguishing them from other measures that have been used but not necessarily found to offer the same value. However, before embarking upon that discussion Section 5.2.1 identifies a number of distinguishing characteristics that have been found to influence performance monitoring programs for variably priced managed lanes.

5.2.1 Distinguishing Characteristics of Variably Priced Managed Lane Projects

In addition to the distinctions described above, there are a variety of factors that influence performance monitoring needs for managed lane projects.

Configuration

The physical configuration the nation's priced managed lane projects varies considerably from those with single points of access and egress and full barrier separation, to those without barrier separation and still others with lengths up to twenty miles, multiple lanes, dedicated park-and-ride facilities, multiple points of access and egress, and even movable barriers allowing the operators to provide an additional travel lane in the predominant peak flow direction. The level of complexity of the configuration of priced managed lane projects can be expected to be reflected in performance monitoring programs for them. This is true both in understanding traffic performance, as well as overall utilization, revenue generation, and customer satisfaction.

Presence of Other Toll Facilities

The presence of other toll facilities or the lack thereof is a fundamental factor influencing the development of variably priced managed lane projects and, to a lesser degree performance monitoring programs for them. If a region has other toll facilities, interoperability of the ETC systems will be a high priority and rather than reinventing the wheel it is more likely than not that the new managed lane facility will use the same back office accounting system as the existing facility. This can be expected to have an influence on utilization, as many potential customers will already have established ETC accounts. Outreach issues in regions with a culture of tolling are likely to be different than in those where tolling and variably price are new.

However, in certain circumstances the presence of other toll facilities could introduce new concerns such as the distribution of new transponders in travel sheds where motorists are likely to utilize the new managed lane facility, or possible modifications that will be required, as in Los Angeles where HOV motorists will need to obtain a new ETC tag outfitted with a toggle switch that will allow them to declare themselves as either an HOV or SOV. To the extent that any of these potential issues poses a major concern, performance monitoring programs may need to track them.

Sponsoring Agency

The performance monitoring programs established for variably priced managed lane projects can be expected to be developed based on the existing monitoring practices of the agencies that implement them. However, these projects are sponsored by a variety of sponsoring agencies around the United States, including DOTs, MPOs, transit agencies and toll authorities. While each of these types of agencies can be expected to have experience in performance monitoring, their particular areas of expertise in this area can be expected to vary greatly. For example DOTs responsible for operating highways are likely to have experience with monitoring highway operations, but not necessarily with toll collection or transit performance. Transit operators cannot be expected to have experience in monitoring highway safety. Performance monitoring programs for priced managed lane projects extend across multiple disciplines and often require inputs and cooperation with other local transportation agencies. These issues will have an influence on the performance monitoring programs put in place and should be considered early on when plans for implementing monitoring programs are first being formulated.

Level of Public Interest

The overall level of public interest in priced managed lane projects varies from region to region. Two of the primary factors driving the level of public interest are whether or not congestion pricing is new to the region and the level of utilization of existing managed lanes when HOV to HOT conversions are involved. If pricing and managed lanes are new to a region, this can be expected to ratchet up the level of public interest in the project. Similarly, if existing HOV facilities are already highly utilized, motorists and transit riders using those facilities will be concerned about possible impacts to travel conditions or occupancy requirements enabling motorists to use them at no cost. Conversely, if HOV lanes slated for HOT conversion are perceived as being underutilized, the level of public interest can be expected to be less intense. The same dynamic holds true when new priced lanes are added in a region that already has operating ETL or HOT lanes, or in instances where existing managed lane facilities are widened or extended. It is a fair rule of thumb that the level of public concern over the implementation of variability priced lanes should be reflected in performance monitoring programs for these facilities. In instances where there is a high level of public interest in pricing, project sponsors should anticipate developing more comprehensive monitoring programs in order to generate an adequate amount of information at a level of detail that will to satisfy the public.

5.2.2 Selection of Performance Measures for Variably Priced Managed Lanes

This section provides specific factors for consideration, summaries of past experience, and recommendations on the selection of performance measures for variably priced managed lanes. The section's organization follows the order of the eight areas of evaluation identified among the operational congestion pricing projects examined as part of the NCHRP 08-75 research that produced these Guidelines. These evaluation areas and the full set of identified performance measures were introduced in Table 5-1 in Section 5.1.5.

It is important to remember that these evaluation areas are tied directly to the goals of a project. Specific project goals can be formulated and measured by framing them within the context of the evaluation areas. In setting a specific goal of congestion reduction (for example), "traffic performance" will necessarily be evaluated. Within this evaluation area, 20 distinct performance measures have been identified in practice (although not all offer equal value and some are more significant than others). The number of distinct performance measures captured within each evaluation area is shown in Table 5-2. The table also indicates which of these measures are considered "more common" and "less common" among currently operational facilities. A total of seven operating facilities comprise those researched for these Guidelines.

TABLE 5-2: TOTAL PERFORMANCE MEASURES BY EVALUATION AREA

	Total Measures Identified	Most Common Measures (3+ out of 7 Facilities)	Less Common Measures (3+ out of 7 Facilities)
Traffic Performance	20	8	6
Public Perception	15	5	7
Facility Users	14	5	9
System Operations	15	13	2
Environment	3	0	1
Transit	7	2	4
Economics	9	0	0
Land Use	2	0	0

The full spectrum of the most common performance measures ranked by frequency of use in practice is shown in Table 5-3. In many cases, these measures represent the "have-to-haves" for facility sponsors and operators in formulating a performance evaluation program. Subsets of this table are provided for each evaluation area in the sections that follow.

Table 5-3 and its subsets also identify whether the measures are generally applied in an operations or validation capacity, and whether they play a key (primary) or secondary role in a typical performance evaluation program. Some performance measures that validate a project may also be used to make operational facility changes, and vice versa; operational measures may also help validate the project. Those marked as operations are the critical measures that are used on a day-to-day basis to maintain the proper function of a facility (such as an input to a toll policy algorithm), while validation measures, which may also be used operationally, are applied on a less immediate basis (such as increasing the number of enforcement patrols or cameras based on violation data).

Several important points should be noted about the performance measures in Table 5-3 and its following subsets by evaluation area. The tables are based on a relatively small (but growing) sample size—seven priced managed lane projects as of the development of these guidelines. Other performance measures could be significant or necessary to collect based on the goals set for a particular facility that were either not captured by these guidelines' research or remain relatively "new" among the projects surveyed and not widely applied to date. Also, it may not always be necessary to follow what has been done previously by others just because it *has* been done. Where appropriate in the discussion that follows, these considerations will be made. Also in many cases, issues discussed for each evaluation area can be applicable to those performance measures *not* identified.

TABLE 5-3: PERFORMANCE MEASURES IN PRACTICE – VARIABLY PRICED MANAGED LANES (*3+ OUT OF 7 FACILITIES EXAMINED*)

Evaluation Area	Performance Measures		What Measures Are Used	Purpose		Importance	
				Operations	*Validation*	*Key*	*Secondary*
Traffic Performance	*Volume*	Vehicle volume (hourly/daily/weekly/monthly)	**7**	5	3	5	2
System Operations	*Finance*	Revenue (toll/ charge)	**6**	3	4	5	1
System Operations	*Enforcement*	Violations/citations/fines	**6**	1	5		6
Traffic Performance	*Speed & Travel Time*	Speeds/ average speed	**5**	5	3	5	
Traffic Performance	*Mode Share*	Mode share (SOV, HOV, transit)	**5**	1	5	1	4
System Operations	*Finance*	Average toll/ highest toll	**5**	4	3	4	1
System Operations	*Finance*	O&M Cost	**5**	1	3	2	3
Traffic Performance	*Speed & Travel Time*	LOS	**4**	3	1	4	
Traffic Performance	*Speed & Travel Time*	Travel times	**4**	1	3	1	3
Public Perception	*Satisfaction*	General/perceived value/how well?	**4**		4		4
Facility Users	*User Characteristics*	Home zip code	**4**	1	2	1	2
Facility Users	*Trip Characteristics*	Frequency of use	**4**	1	4	1	3
Facility Users	*Trip Characteristics*	O-D/ travelshed determination	**4**		3		4
System Operations	*Finance*	Total transactions	**4**	2	2	1	3
System Operations	*Safety*	Collisions/ accidents	**4**		4		4
System Operations	*Safety*	Incident response time/ duration	**4**		4		4
System Operations	*Customer Service*	Inquiry activity (call, email)	**4**		4		4
System Operations	*System Function*	Equipment availability	**4**		4		4
Traffic Performance	*Speed & Travel Time*	Travel time savings	**3**		3		3
Traffic Performance	*Volume*	Tolled trips/ untolled trips	**3**		2		3
Traffic Performance	*Parking*	Park-n-ride activity (lot counts)	**3**		2		2
Public Perception	*Awareness*	Of the facility/general/how much?	**3**		3		3
Public Perception	*Satisfaction*	Traffic conditions/ reliability	**3**		3		3
Public Perception	*Satisfaction*	Perceived time savings	**3**		3		3
Public Perception	*Satisfaction*	Perceived safety	**3**		3		3
Facility Users	*Accounts*	No. of transponders issued	**3**		2	1	1
Facility Users	*User Characteristics*	Demographics/ socioeconomics	**3**		3		3
System Operations	*Finance*	Revenue (fee)	**3**	1	2	1	2
System Operations	*Enforcement*	Total traffic stops/ responses	**3**		2		3
System Operations	*System Function*	Incidents	**3**		3		3
System Operations	*System Function*	Mean time to respond/ repair	**3**		3		3
Transit	*Performance*	Travel time/on-time/excess wait	**3**	1	2	1	2
Transit	*Occupancy*	Ridership/ boardings	**3**		3		3

Note: Purpose columns can add to more than the number of facilities using a particular measure if the measure is used in both an operations and validation capacity.

Traffic Performance

Traffic performance describes the fundamental purpose of a roadway: its ability to provide mobility to people and goods. It is the most important of the eight areas of evaluation and measured through a variety of traffic engineering measures answering the how much/many?, how fast?, and by what mode? questions pertaining to the facility.

Representative Traffic Performance Goals

Variably priced managed lane goals that involve measures of *traffic performance* are the most common among all possible goals set for these facilities. Achieving congestion reduction is one prominent example. This goal, in turn though, may be further characterized on a more "measureable" basis or within a context that better resonates with facility users or those interested in improved performance. To that end, the goal of achieving congestion reduction could more specifically be stated as achieving a reduction in delay or increasing person-volume throughput. More generally, traffic congestion reduction goals often imply improved system efficiency or reliability. However, these guidelines' research has shown that these "goals" are often subjective, hard-to-define, and dependent on location-specific contexts. For example, one agency or region may define improved reliability simply as maintaining average speeds above 50 miles per hour, while another may characterize it as the ability to achieve a certain journey time 95 or more percent of the time.

What Are the Most Frequently Applied Traffic Performance Measures?

Measures of traffic, as indicated in Table 5-2, include vehicle and person volumes, speeds and travel times, mode share and vehicle occupancies, vehicle miles traveled, and indicators of congestion, such as delay, queue lengths, and specially developed coefficients comparing specific metrics during congested and uncongested conditions. Other measures that incorporate traffic include bicycle and pedestrian measures and parking, although these are uncommonly applied to variable priced managed lane facilities. Those measures that are deemed only the most broadly and beneficially applicable are discussed here, although others may certainly offer equal or better value depending on the context in which they are applied.

Research for these guidelines has shown that key performance measures of traffic for variably priced managed lanes include vehicle volumes and speeds (see Table 5-4). LOS—a prescribed traffic engineering metric characterizing the performance relationship between volume and speed—also factors frequently among key performance measures, but is, itself, derived from knowing volumes and speeds.

TABLE 5-4: MOST FREQUENTLY APPLIED PERFORMANCE MEASURES – TRAFFIC PERFORMANCE

Performance Measures	What Measures Are Used	Purpose		Importance	
		Operations	*Validation*	*Key*	*Secondary*
Vehicle volume (hourly/daily/weekly/monthly)	**7**	5	3	5	2
Speeds/ average speed	**5**	5	3	5	
Mode share (SOV, HOV, transit)	**5**	1	5	1	4
LOS	**4**	3	1	4	
Travel times	**4**	1	3	1	3
Travel time savings	**3**		3		3
Tolled trips/ untolled trips	**3**		2		3
Park-n-ride activity (lot counts)	**3**		2		2

The following two sections explain how these measures are used in both ongoing operations of the priced facility and making in the facility's case to the public and other interested parties.

Operations: Using Traffic Performance Measures in the Day-to-Day Operation of Variably Priced Managed Lanes

A relatively small subset of measures is used to ensure that a facility is operating as intended, and, if it is not, to make decisions about appropriate changes.

> **Example: Traffic Volumes**
>
> The 91 Express Lanes in Orange County, California uses volumes to trigger toll rate adjustments. If hourly volumes across both lanes of travel in one direction on any one particular day exceed 3,200 vehicles, then a toll increase is applied. Adjustments are made on a quarterly basis to the fixed toll schedule and held constant for at least six months.

From the perspective of facility operation, measures of volume and/or speed are must-haves; without them, quantifying operational performance is very difficult. Knowing speeds also imply calculation of travel times, given the distance traveled between two points of measurement. These basic measures are critical to measuring goal success tied to congestion reduction and the ability to formulate a toll rate policy. As experience shows, validating and communicating the outcomes of the pricing project's implementation are often also dependent on the ability to quantify the volume or speed of traffic. Indeed, across a wide range of goals—not just those tied to congestion reduction—without an understanding of the number of vehicles using a facility and the speeds at which they are able to travel, it is not possible to fully comprehend the context of other possible facility goals, such as improvements in safety, effects on the environment, or impacts to transit service.

> **Example: Travel Times**
>
> Along the seven-mile I-25 Express Lanes in Denver, maintaining on-time journey by express buses is critical. Onboard transponders allow for the monitoring of bus travel times along the priced corridor and consequently average speeds. A toll increase is warranted to the fixed schedule when average speeds fall below 45 mph to reduce the number of paying SOV users.

Volumes and speeds (as well as travel times and LOS) can be used as thresholds for making toll rate adjustments or other operational changes, and consequently they can act as a direct input into the formulation of a toll rate policy. Hourly or peak period traffic volumes would be appropriate measures for determining when a toll rate adjustment is necessary by establishing threshold parameters above which (or below which) a price increase (decrease) is warranted. Adjustments dictated by these measures could apply to a dynamic toll schedule, with changes as frequent as every few minutes, or to a fixed schedule, where adjustments may be reviewed with only occasional frequency, such as on a quarterly basis. Similarly, average speed thresholds can dictate a toll rate adjustment and can be tied to a particular class of vehicle such as HOV or transit.

Volume and speed data can be readily collected on a continuous, real time basis through ETC transaction equipment, including transponder readers positioned at toll booths or mounted on overhead gantries, as well as with cameras operated with vehicle identification or point speed detection software. Once up and running, the cost to operate the system is marginal and often contracted out to a toll operator that is obligated to maintain the equipment, collect data, and produce reports, in conjunction with managing the collection of the toll itself.

Complications arise, however, if not all vehicles are required to use a transponder, as with HOV users on some facilities. In this case, conventional loop detectors can be employed. Going one step further, to make comparisons with adjacent general purpose lane conditions, loop detectors would be required equipment on those lanes as well. To obtain a fully comparable set of volume or speed data between priced and general purpose lanes, it may be necessary to retrofit additional loop detectors in the general purpose lanes to obtain the necessary coverage and ensure no gaps occur in the data. The costs of adding this equipment must be weighed against the importance of being able to make a one-to-one comparison of volumes and speeds across all lanes, or calculating additional metrics such as speed differential between the sets of lanes. Several operators of existing variable priced managed lane facilities have noted that this data is something they wish they had had when retrospectively evaluating their performance evaluation programs. A stronger case for the benefit of priced lanes can be made when a throughput or speed comparison across both a corridor's priced and unpriced lanes is available.

Example: Travel Times and Travel Time Savings

WSDOT makes the case for and quantifies improved reliability on the SR 167 HOT Lanes in southern Kings County, Washington by comparing travel times across the corridor's lanes. Along the general purpose lanes, the average weekday northbound peak hour travel time was 19 minutes, with a 95th percentile travel time of 26 minutes; and the average southbound peak hour travel time was 12 minutes, with a 95th percentile travel time of 19 minutes. Northbound the length of the route is 11 miles, southbound nine miles. The average travel time savings by using the HOT lanes was eight minutes northbound (A.M. peak) and four minutes southbound (P.M. peak). These travel time savings are genuinely noticeable along those distances and the results have resonated with facility users.

Validation: Using Traffic Performance Measures to Validate Variably Priced Managed Lanes

As important as using traffic performance measures is for facility operations, they can also be powerful means to validate a project. Table 5-3 indicates that all commonly applied performance measures currently used in practice can help communicate the success and benefits of a priced project's implementation.

In addition to those measures discussed above in an operations capacity, mode share is often employed in a validation role. Mode share denotes how many of each vehicle type is using the facility—SOV, HOV2, HOV3, transit vehicle, etc. Given the common focus on maintaining unaffected service to HOV users when converting HOV lanes to HOT operation, it is important to know the share of qualified HOV users (HOV2+ or HOV3+) relative to paying users (SOV or HOV2 in the case of an HOV3+ requirement). Observers will be interested in this information to help understand the effect of allowing paying customers on to the facility; for example, what share do they represent?, and did HOV usage decline with the addition of HOT operation? Mode share can be challenging to measure in the absence of full coverage ETC transponder data that identifies vehicle occupancy. Means to overcome this obstacle include requiring a registration process for HOV users (and transponder usage by paying users), or manual vehicle count surveys, although they are often expensive and time consuming.

A second measure used commonly to validate the performance of priced managed lanes is travel time savings. By comparing travel times in the priced lanes with congested condition travel times prior to their existence or in the parallel general purpose lanes, travel time savings measures can be calculated. This performance measure is becoming a more commonly applied metric to characterize and validate the benefits of implementing congestion pricing. It also can be used to help indicate measures of reliability or efficiency.

Other measures of traffic applied in a validation capacity are more specialized, and the decision to use them rests upon context and goal specificity. As one example, priced corridors with transit service may require knowing park-n-ride lot usage to understand effects on transit ridership or carpool formation. In another example, measures of vehicle miles traveled may be helpful to demonstrate a more regional-scale reduction in travel, a possible goal in areas contemplating priced managed lane expansion to the network level.

Public Perception

Knowledge of a priced managed lane's existence and purpose, acceptance of it as a mobility option, and satisfaction with the service it provides are characterized qualitatively through public perception. Given priced managed lanes' relatively recent existence as an operational form of providing traditional roadway capacity and the skepticism or criticism that it can generate, measuring public perception is a critical component of a performance evaluation program.

Representative Public Perception Goals

Gauging *public perception* is at the heart of goals that seek to validate a variably priced managed lane project. Representative goals may include achieving or sustaining a prescribed level of satisfaction with the facility's operation. Specific targets of perception, such as travel time savings, safety, or equity can be established and tracked. In addition to its relation to public perception, the special case of equity is discussed in depth in Section 5.1.4.

In general, measuring public perception is an attitudinal exercise that requires an appropriate instrument such as survey, focus group, or interview. Clearly, public outreach becomes a prime factor in establishing these goals and measuring their achievement. A detailed discussion of integrating performance evaluation and public outreach, including means of collecting attitudinal information, is provided in Chapter 4 of these guidelines. Provided here are details of the most commonly used and relevant performance measures for capturing and quantifying public perception.

What Are the Most Frequently Applied Public Perception Measures?

Public perception measures (as itemized in Table 5-1) focus on awareness, acceptance, and satisfaction. Among all three of these measures, specificity can range from the very broad to the more explicit. For example, general awareness of a facility's existence as a travel option can be queried as easily as its specific features, such as pricing policy or hours of availability. Awareness of planned toll adjustments or future expansion may also be of interest. Similarly, acceptance and satisfaction measures can be general or specific. As shown through these guidelines' research, Table 5-5 summarizes the most commonly applied public perception performance measures, with the majority of them focusing on satisfaction. Apart from awareness, acceptance, and satisfaction, one public perception measure (not commonly used) is the tracking of media exposure, for example recording the number of positive and negative news reports about the facility.

TABLE 5-5: MOST FREQUENTLY APPLIED PERFORMANCE MEASURES – PUBLIC PERCEPTION

Performance Measures	What Measures Are Used	Purpose		Importance	
		Operations	*Validation*	*Key*	*Secondary*
Satisfaction: general/perceived value/how well?	**4**		4		4
Awareness: general/of the facility/how much?	**3**		3		3
Satisfaction: traffic conditions/reliability	**3**		3		3
Satisfaction: perceived time savings	**3**		3		3
Satisfaction: perceived safety	**3**		3		3

What is most difficult about gauging public perception, however, is that there are no "loop detectors" for measuring it. That is, to make measurement that are inherently qualitative or subjective, a different set of tools are required, those that capture attitudes, as detailed in Chapter 4. In addition, many measures are stakeholder group-specific and require them to be custom tailored to a specific issue of significance. Nonetheless, there are some measures considered to be of interest to those at large, as Table 5-5 attests.

The following two sections explain how these measures are used in both ongoing operations of the priced facility and making in the facility's case to the public and other interested parties.

Operations: Public Perception Measures as Indirect Inputs to Facility Operations

Measures of public perception are not generally used—at least in a direct sense—to manage the operations of a variably priced managed lane facility. Certainly, the feedback assembled by assessing public perception can influence operational decisions, but do not dictate the specific day-to-day procedures, policies, or business practices that apply to a facility's operation, such as toll adjustments or maintenance schedules.

Validation: Using Public Perception Performance Measures to Validate Variably Priced Managed Lanes

All public perception measures can be characterized as serving a validation capacity, as well as playing a secondary role to those measures that dictate a facility's operation—at least among operating facilities that have provided the foundation to these guidelines. It is possible, however, that an agency contemplating the implementation of a priced managed lane project may view certain public perception measures as key to their performance evaluation program if, for example, a particular issue, such as user equity, is expected to be highly visible. Additionally, results of public perception measures may dictate necessary changes to customer service functions or public communication policies.

Survey instruments, focus groups, or interviews are generally used to collect data for public perception measures. These tools are described in greater detail in Section 6.2, and their advantages and disadvantages along with estimated costs are provided in Table 6-2. Generally speaking, these measures are more demanding and costly to collect and synthesize because of the user-specific, manual collection process required of attitudinal information. Because of this, their collection is often done on either a "before-and-after" or periodic basis. Surveyed public perceptions can be collected prior to the opening of the priced facility, either once or in several waves, and compared with similar results after opening. Once operational, it may be desirable to continue to collect these types of measures on a periodic basis, such as annually or biannually, or as resources allow. Before-and-after surveys may focus on more market research, acceptance, and awareness issues, while periodic, post-opening-day performance measurement will likely focus on user satisfaction.

Example: Periodic Customer Satisfaction Surveys

As part of its performance evaluation program for the SR 91 Express Lanes in Orange County, California, the Orange County Transportation Authority conducts a periodic customer satisfaction survey. Approximately 400 to 500 customers are asked to respond to an established list of questions so that comparisons can be made and trends charted across surveys, which are now conducted biennially rather than annually. Among other issues, the survey focuses on customer satisfaction; expectations and perceptions of OCTA's management of the lanes; attitudes regarding the lanes' benefits, toll policies, and customer service; and awareness of existing communication programs and their effectiveness.

As shown in Table 5-5, measures of satisfaction are the most commonly applied in practice. General satisfaction with the facility, satisfaction with the perceived value the facility offers, or how well customers are satisfied with the facility are frequently applied measures. Similar measures directed at facility awareness are also prevalent. Generally though, awareness measures are collected prior to and just after the opening of a facility, as familiarity with the project grows after opening. From there, satisfaction with its performance becomes more relevant. Of the more specific satisfaction performance measures, traffic conditions (congestion levels), reliability, perceived time savings, and perceived safety have been found to be the most significant.

What is important to keep in mind when formulating measures of public perception is that they should address issues of public concern identified through a public outreach process. From region to region, project to project, the key issues that are worth tracking and responding to before, during, and after project implementation are often more unique than alike. In this manner, public perception measures should be tailored appropriately to each project application.

Facility Users

Facility Users represent the characteristics of those who make trips on a priced managed lane facility and the characteristics of the trips themselves.

Representative Facility User Goals

Understanding who the *users of a facility* are serves both operational and validation goals. One simple goal may be to increase patronage of the facility. Another may be to know the number of transponders issued to help understand how many to have on hand for future distribution. Often, however, characteristics of a facility's users are inputs to developing and measuring goals formulated under other evaluation subjects. For example from a validation perspective, knowing the socioeconomic profile of a facility's user base can help track the extent to which the goal of mitigating negative equity change is achieved (the special case of social equity is further discussed in Section 5.1.4). Operationally, users' departure times or trip times-of-day can inform decisions on setting toll policies, which can be tied to goals of congestion reduction or revenue generation.

What Are the Most Frequently Applied Facility User Measures?

Measures of facility users primarily focus on characteristics of the users themselves or the trips they take. Specific data on their accounts or toll transaction type are also found among those measures used in practice. The full list derived from current operating facilities is shown in Table 5-1. User characteristics include demographic and socioeconomic data, vehicle data, and whether any special registration exists (HOV or hybrid vehicle, for example). Trip characteristics include, among others, frequency, departure times, travelshed determinations, overall trip length and trip purpose.

Research indicates that a user's home zip code, as well as a variety of demographic and socioeconomic data (not detailed further in these guidelines) are the most commonly applied user characteristic measures, as shown in Table 5-6. Specific to users' trips, frequency and travelshed or full origin-destination determinations are most frequently used. Finally tracking the number of transponders is pervasive, but in reality, expected of any toll operator using ETC equipment, even if not explicitly reported in their performance evaluation materials.

The following two sections explain how these measures are used in both the ongoing operations of the priced facility and making the facility's case to the public and other interested parties.

TABLE 5-6: MOST FREQUENTLY APPLIED PERFORMANCE MEASURES – FACILITY USERS

Performance Measures	What Measures Are Used	Purpose		Importance	
		Operations	*Validation*	*Key*	*Secondary*
User home zip code	**4**	1	2	1	2
Frequency of use (trips)	**4**	1	4	1	3
Trip O-D/travelshed determination	**4**		3		4
No. of transponders issued	**3**		2	1	1
User demographics/socioeconomics	**3**		3		3

Operations: Facility User Measures as Indirect Inputs to Facility Operations

Generally, measures of a facility's users are used in a validation capacity and less so for operations. As with public perception measures, data collected about users and their trips may serve to inform operations and policy decisions, but generally apply to only back office day-to-day operations, rather than the facility itself. Managing customer accounts and registrations, issuing transponders, and formulating potential (long-term) adjustments to facility operation based on trips frequencies and times-of-day are several operational aspects that can be informed through user measures. Generally these measures are used with less frequency than those (such as volumes or speeds) monitored on a real time basis to make immediate adjustments to facility operation (as with dynamic tolls) or feed into later performance reviews for periodic adjustments (as with a fixed toll schedule). However, they can act as indirect inputs to system performance and help plan for future operational changes or expansion. For example, user vehicle classification or the number of HOV registrations may help predict when an adjustment from HOV2+ to HOV3+ may become necessary.

Validation: Characterizing Facility Users and Their Trips to Validate Variably Priced Managed Lanes

Many measures of system users are collected to validate the project. Measures of user characteristics, especially demographics and socioeconomics, help facility operators understand who their customer base is. This knowledge, in

Using Performance Data to Shape Transportation Policy

In addition to being used to optimize the operation of pricing projects and to validate the use of congestion pricing to the public at large, performance monitoring data can also be used to inform decision making on transportation policy issues related to the use of congestion pricing. One such issue that is being addressed with increased frequency across the U.S. is whether single occupant hybrid and low-emission vehicles should be afforded similar privileges to HOV vehicles, including open access to HOV lanes and use of HOT lanes at no cost.

Initially a number of states passed laws providing drivers of alternative fuel and low emission vehicles open access to HOV lanes regardless of the number of occupants in the vehicle in order to promote the use of these vehicles. However, since their introduction, hybrid vehicles have become widely available and more affordable, and are often sought after by drivers interested in lowering their fuel bills. In some congested areas including greater Washington, D.C. and Los Angeles, drivers have purchased hybrid vehicles for the express purpose of using HOV lanes to bypass congested areas while driving alone. This policy has important repercussions on highly utilized HOV lanes such as I-66 and I-95 in Northern Virginia, where low emission vehicles can account for up to 17 percent of the vehicles in HOV lanes during peak periods.[1] The viability of potential HOV-to-HOT conversions is also diminished in corridors where a large percentage of peak period vehicles in HOV lanes is actually composed of SOV hybrids.

Accurate performance monitoring data is essential in quantifying the effects that hybrid and low emission vehicles have on the performance of congested managed lane facilities in peak periods. Performance data can also be used to derive other important pieces of information, including comparisons of the emissions of multiple SOV hybrid vehicles to HOV or transit vehicles carrying the same number of people. Performance monitoring data will likely play and increasingly important role to transportation professionals and policy makers as they consider this and other related issues.

turn, can help communicate who is benefiting from the facility (Are they just those "wealthy" enough to pay or are lower income groups prominent users as well?) and how widespread those benefits reach. Likewise trip characteristics help inform where and when their users travel. This data is potentially valuable to examine the potential reduction in peak period usage or shift to alternative routes, common goals among congestion-priced facilities.

> **Example: Surveyed User Characteristics**
>
> WSDOT has conducted an online survey of *Good To Go!* account holders who use the SR 167 Hot Lanes to obtain a representative cross section of its users. Among the results, WSDOT has highlighted the distribution of users' age, income level, and vehicle make in its publically available performance evaluation publications. Although the numbers reported are not adjusted for actual proportions within the population at large, WSDOT states that the data helps to dispel the "Lexus Lane" concern that only the "rich" can afford to use the lanes.

Collection methods and frequencies vary for user measures. Some measures, such as demographics, transponders issued, or vehicle make are naturally tracked through the customer registration/management process. Again though, for facilities that do not require mandatory transponder usage or registration, this data cannot be obtained without manual survey work. Soliciting some user measures is possible only through surveys, such as total trip length (including non-priced segments) and trip purpose. Collection of these data is naturally done on an infrequent, as-needed basis. Comprehensive travelshed determinations may even require travel demand forecasting or modeling efforts.

System Operations

For the purposes of these guidelines, system operations refer to operational aspects of a priced facility that are not directly related to measures of traffic, as discussed in the Traffic Performance section. They are categorized in five ways:

- Finance
- Enforcement
- Safety
- Customer service
- System function

Representative System Operations Goals

A wide variety of goals can be set by and evaluated against *system operations*. A significant system operations goal is to collect a certain level of revenue. Another goal may be to not exceed a certain threshold for violation rates. Maintaining or improving levels of safety after the conversion of HOV lanes to HOT operation is often tracked. Finally, system operators may want to achieve established levels of customer service or targets of system equipment availability/accuracy.

What are the Most Frequently Applied System Operations Measures?

Because of system operations' broad scope, a wide variety of measures are used to track this evaluation area as detailed in Table 5-1. Finance measures include revenue (tolls, fees, etc.) and expenditures (O&M). Enforcement measures track data that includes traffic stops, violation rates, and citations issued. Measures of safety often look at accident rates and incident response times. A long and very detailed number of performance metrics can measure customer service, from volumes of inquiry and comments received (positive or negative), to customer service center response time and average inquiry resolution time. Application of these measures is highly dependent on facility sponsor preference, as discussed below. Finally, measures of system function focus on facility and specific equipment availability and accuracy, numbers of equipment incidents, and repair rates.

Research for these guidelines has shown, as indicated in Table 5-7, that system operations performance measures are widely collected in practice across all five categories. Those measures related to finance are the most commonly used among operating facilities, with measures of safety and customer service also factoring significantly in performance evaluation programs.

TABLE 5-7: MOST FREQUENTLY APPLIED PERFORMANCE MEASURES – SYSTEM OPERATIONS

Performance Measures	What Measures Are Used	Purpose		Importance	
		Operations	*Validation*	*Key*	*Secondary*
Revenue (toll/charge)	**6**	3	4	5	1
Number of violations/citations/fines	**6**	1	5		6
Average toll/highest toll	**5**	4	3	4	1
O&M expenditures	**5**	1	3	2	3
Total transactions	**4**	2	2	1	3
Collisions/accidents	**4**		4		4
Incident response time/duration	**4**		4		4
Inquiry activity (call, email)	**4**		4		4
System equipment availability	**4**		4		4
Revenue (fee)	**3**		2	1	2
Total traffic stops/ responses	**3**		2		3
System equipment incidents	**3**		3		3
Mean time to respond/repair (system incidents)	**3**		3		3

The following two sections explain how these measures are used in both ongoing operations of the priced facility and making in the facility's case to the public and other interested parties. It should be noted that many validation measures can also be used to make operational changes to the facility, such as when system equipment performance measures may indicate the need for a repair or replacement. However, these measures still serve to validate the integrity of facility system operations, and in turn, the facility itself.

Operations: System Operations Performance Measures as Direct and Indirect Inputs to Facility Operations

Among the five categories of system operations performance measures, financial performance data are often used in the operation of priced managed lanes. Performance measures of enforcement, safety, customer service, and system function may also be used operationally, but are discussed in the validation section.

Specific to finance, the average toll paid, highest toll paid, and total number of transactions can factor into the algorithms established for dynamic variably priced facilities. Likewise, they could be used in evaluating, on a periodic basis, the toll schedules of a fixed variably priced facility. Both the average toll paid and highest toll paid are indicators of whether an algorithm is responding appropriately to traffic levels, without excessive lags, overcompensation, or abrupt increases and decreases.

Toll revenue is also a key operational performance measure. Although more significant to toll facilities (see Section 5.3), priced managed lane revenue is a significant consideration for recovering operations and maintenance expenditures and potentially contributing to repaying capital cost expenditures on the facility itself, investing in parallel general purpose lane improvements, or other roadways (priced or unpriced) under the purview of the facility sponsor.

Collection of toll revenue data is managed through ETC equipment and does not represent a significant cost once a facility is operational. The data is captured on an ongoing, real time basis and can be considered a must-have among performance evaluation measures.

Example: Monitoring Safety

FDOT tracks safety conditions on the 95 Express using police crash reports. Two years of crash data will be needed before definitive safety information is available. Nonetheless, initial evaluation of incidents has not provided any indication of safety concerns. To supplement traditional police reports, FDOT installed video monitoring equipment along the 95 Express corridor to capture incidents that may not have been recorded in the past. Part of FDOT's reason for measuring safety is to comply with the federal requirements of the national Urban Partnerships Agreement program.

Validation: Using System Operations Performance Measures to Validate Variably Priced Managed Lanes

Revenue data (tolls, fees, fines), as discussed above, can also be used in a validation capacity to show that certain levels of income are being met to help make the case that implementation of a priced managed lane project was a wise investment.

Safety is frequently a primary concern of departments of transportation and other roadway facility operators. Although challenging to collect and use on a comparative basis, data based on accident or collision records has been commonly found in use among operating facilities as a means to validate its safety. (Operational changes may occur from safety data outcomes as well.) Collision data is typically collected by public safety agencies (police departments, for example) and often has data gaps and considerable lags in availability (often six months or more). It becomes the facility sponsor's responsibility to make sense of this data. Using it to compare safety conditions before and after project implementation or in comparison to parallel general purpose lanes is complicated by the need to understand the precise accident cause and location, data that is often unclear or absent from police records. For example, just because the location of an accident might be recorded as within the extent of a priced lane, the priced lane itself may not have been the origin location or cause. A situation such as this makes it difficult to determine if the configuration or presence of a priced lane was the root cause of the accident, and thus claim if it is more or less "safe."

Enforcement of occupancy and toll payment requirements is an important measure to present to a public that expects a high level of integrity for a service that requires payment or active participation in a carpool. Legitimate HOV users will want to be assured that in the case of conversion to HOT operation, their benefits are not diminished. Minimizing toll evasion (an issue for non-barrier separated

Example: Toll Revenue and Operations

Florida's Turnpike Enterprise closely monitors toll transactions and revenue on the 95 Express between Miami and (eventually) Fort Lauderdale. FTE summarizes all applied tolls, tolled and toll-exempt trips, and gross revenue into monthly performance measure reports. FDOT uses this data to chart monthly revenue trends and revenue receipts during different time periods—P.M. peak, weekend, or weekday, for example—from month to month. FDOT compiles similar information for toll rates and maximum tolls. Coupled with additional measured data, FDOT optimizes facility operations though an enhanced understanding of the relationships between toll rates, traffic volumes, and speeds.

lanes) is significant to the facility operator. In both cases measures of enforcement such as traffic stops and violation rates are relevant and help to validate the expectation for fair application of the facility's rules and requirements. (Again, enforcement outcome data may also lead to facility operational changes to reduce occupancy violations or toll evasion).

Example: Incident Response

Along the 91 Express Lanes, OCTA tracks the number and response time of safety service patrol trips made to assist motorists. Providing this service and minimizing response time is in keeping with OCTA's goal to provide enhanced customer service along the express lanes (this is also reflected in its higher levels of regular maintenance). In addition, minimizing this response time is important to user safety as the two-lane configuration (in both directions) lacks sufficient shoulder space for stopped vehicles.

Confirmation of delivering high quality customer service can be evaluated by many measures. Facility sponsors will want to consider tailoring a selection of these measures based upon the role the agency plays in providing customer service functions, public outreach outcomes, and other needs. If the operation of the facility is provided by a private entity to collect tolls and manage customer service, evaluation measures and reporting requirements can be specified in their contract. The most commonly applied customer service measure in practice is level of customer inquiry (by phone or email); generally low levels of inquiry are desirable because they are indicative of good customer satisfaction. A second common measure—incident response time by public safety agencies or safety service patrols—can be considered both a customer service and safety indicator.

Finally validating the proper function of the managed lanes' system equipment (and informing potential operational changes) can require certain performance evaluation measures. Frequently applied measures include system equipment availability (transponder readers and other toll collection hardware, cameras, and other vehicle detection and monitoring equipment), the number of system incidents (failures, errors, etc.), and the mean time to repair the result of the incident. Collection of these measures can be built into the software that manages the systems and directed to produce reports as necessary.

Environment

Performance measures to evaluate a variably priced managed lane facility's impact on the environment are not widely used in practice, as the overall effects of improved efficiency in heavily traveled highway corridors are not likely to generate meaningful improvements to such environmental conditions as air quality or noise. This is in sharp contrast to area or cordon pricing schemes, which have the potential to reduce regional emissions by an order of magnitude not imaginable for single highway improvement project—the Stockholm Congestion Tax trial reduced carbon dioxide and nitrogen oxide emissions within the city by 14 percent and within Stockholm County by 2.5 percent. If there is particular interest in monitoring the performance of priced managed lane projects on emissions, information on emission rates can be calculated using traffic volume and speed data as inputs to standard air quality forecasting tools, such as EPA's MOBILE6 Vehicle Emission Modeling Software.

Transit

Transit refers to aspects of transit service that operate on the priced managed lane facility or corridor. Transit service within the facility's travelshed may also be of interest, where it can offer an alternate route between origins and destination served by the managed lanes' corridor.

Representative Transit Goals

Goals related to *transit* service pertain to priced facilities that *have* transit operating along its corridor, or at least within the same region/travelshed. Transit goals include not degrading or reducing service. This goal may pertain to HOT lanes converted from prior HOV lanes that serve transit vehicles (express bus service, for example) and must negotiate increased traffic levels from newly paying SOV users. Improvements in transit service may also be an established goal if system enhancements, such as the addition of new capacity or park-n-ride facilities, are incorporated as part of a priced managed lane project.

What are the Most Frequently Applied Transit Measures?

Aspects of transit service include performance, ridership, finance (revenue), and quality of service (as measured attitudinally through customer surveys). Research indicates (as shown in Table 5-8) that transit performance is most often measured by travel times, on-time rates, or excessive wait times (delay), as well as ridership or boarding counts.

TABLE 5-8: MOST FREQUENTLY APPLIED PERFORMANCE MEASURES – TRANSIT

Performance Measures	What Measures Are Used	Purpose		Importance	
		Operations	*Validation*	*Key*	*Secondary*
Travel time/on-time/excess wait	**3**	1	2	1	2
Ridership/ boardings	**3**		3		3

Other measures used less frequently include farebox revenue and O&M expenditures, as well as quality, satisfaction, and reliability as perceived by customers.

The following two sections explain how these measures are used in both ongoing operations of the priced facility and making in the facility's case to the public and other interested parties:

- **Operations: Transit Performance Measures as Direct and Indirect Inputs to Facility Operations.** Transit performance measures are not generally collected as direct inputs into priced facility operation. However, one exception was presented as an example from actual application in the traffic evaluation area above. There, bus travel times were used to derive average speeds, which in turn were tied directly to the decision to raise tolls if thresholds were not met. In this case, the data was acquired from transponders outfitted to the buses.
- **Validation: Using Transit Performance Measures to Validate Variably Priced Managed Lanes.** If the priced managed lane facility sponsor or operator is also the agency responsible for transit service, acquiring transit performance data is not difficult. Otherwise, such data needs to be acquired (if it exists) from individual transit agencies. Obtaining the performance data sought, however, requires establishing a good working relationship with that agency and coordinating data collection efforts. Most times, transit data plays a validation role among currently operational facilities, to ensure non-impacted or improved transit service as measured most often by travel times, on-time arrivals, delay, and ridership.

Economics

Economics is another analysis area that is not generally assessed for a variably priced managed lane project. Impacts on local businesses and regional competitiveness are of extreme interest in a region implementing an area or cordon pricing project, but this is not normally the case with priced managed lanes. Nonetheless, improved access along highly traveled corridors such as the SR 91, which connects residential communities in Riverside County with employment centers in Orange County, California, would be expected to have a positive economic effect. However, it is extremely challenging to measure the precise effect of an individual transportation improvement on regional economic trends. This type of analysis would be more likely to rely on the results of economic models, which would allow a comparison to be made between model outputs and data collected on regional economic activity and real estate prices.

Land Use

Performance measures to evaluate a variably priced managed lane facility's impacts on land use are not commonly used in practice and are not generally recommended by these guidelines. Nonetheless a facility sponsor may want to consider these measures (such residential or commercial land use trends) if found to be a particular issue of concern in its region.

5.3 Performance Measurement for Toll Facilities with Variable Pricing

As with the other forms of pricing, performance measurement for variably priced toll facilities is used to document traffic operations and service levels, and inform decisions on adjustments to their operational policies or physical configuration, which may also include toll plazas. Performance monitoring data is also used to document changes in travel patterns and peak period congestion as a result of the implementation of variably-priced tolls thereby validating the use of congestion pricing. In addition, most new or existing toll facilities where variably pricing could be introduced are run by toll authorities that rely on toll proceeds as their primary revenue source. As such, performance measurement for variably priced toll facilities is also likely to have a more concentrated focus on toll revenues and financial performance compared with variably priced managed lane projects. This reflects the fact that most toll facilities are self financing facilities built with debt leveraged from future toll proceeds. As such, management is likely to track their financial performance closely and they are also likely to have bond covenants that must be honored.

These areas are of particular concern when variably priced tolling is introduced on legacy toll facilities that have previously used fixed tolls. The conversion of toll regimens from fixed to variable pricing can also be expected to involve a considerable amount of up-front surveying to understand how travel behavior would change as a result of time-of-day pricing, together with travel demand and revenue modeling work to ascertain what the effects of variably priced tolling would be on overall revenue generation and financial performance. Once an acceptable level of comfort is achieved on the likely outcomes of a conversion to variably pricing a decision can be made on how and when to proceed with the conversion. After the implementation of variably pricing, financial performance would be closely tracked and compared with earlier forecasts. An optimal result would show that the introduction of variable pricing had no downside effect on revenue generation but was successful in reducing peak period congestion through mode shifts from SOVs to HOVs and transit, shifts to non-peak travel times and alternative destinations, and eliminated trips. As a result performance monitoring for projects involving the use of variably priced facility-wide tolls may also need to include capacity assessments demonstrating the effects of shifts to HOV and transit on the capacities of those systems.

Given the relatively small number of toll facilities currently using time-of-day pricing (see Table 4-2) and the fact that only two of the 12 case studies conducted for NCHRP 08-75 involved the use of variably-priced tolls on entire facilities, the recommendations provided here are based on the findings of the research effort, together with industry standards and best practices.

5.3.1 Distinguishing Characteristics of Toll Facilities with Variably Pricing

As described below, in spite of the small number of toll facilities using variable pricing, as with the other forms of pricing, there are a number of distinguishing characteristics that will influence performance monitoring programs for these facilities.

Configuration and Physical Integration with Other Regional Infrastructure

Toll facilities using variably priced tolls can have remarkably different configurations ranging from tolled bridge and tunnel crossings to regional or long distance tolled highways. The configuration of the facilities involved and their physical integration with other regional infrastructure will influence the metrics and thresholds used to monitor their performance. For example, speeds and lane volume capacities would be markedly higher for interstate highway facilities such as the New Jersey Turnpike than those on a bridge or tunnel such as the Lincoln Tunnel allowing traffic to move from an Interstate highway directly into the street grid of Manhattan. In all cases the measures used to track the performance of variably priced toll facilities will need to be tailored to reflect the type of facility involved and its physical setting.

Use of Manual vs. Electronic Toll Collection

Toll facilities using variably priced tolls could feature several different collection methods: open road tolling, a toll barrier-less system whereby vehicles' transponders are read by overhead gantries at the speed of traffic; transponder-based collection at a toll plaza, with our without barriers, but requiring traffic to slow or stop; manual toll collection (cash), either by a toll booth operator or collection machine; or combinations thereof. Open road tolling obviates the need for toll plazas and the inherent delays and operational challenges they introduce. Hybrid systems using manual and electronic toll collection require toll plazas and introduce new operational issues involving the overall balance between the number of manual and electronic booths and segregating vehicles equipped with transponders from those whose drivers will pay cash. These distinctions have a major influence on performance monitoring, as monitoring for toll plazas is a complex endeavor often involving and queuing and safety analyses, potentially requiring aerial photography. These types of performance tools and measures would likely be used with variably priced toll facilities using hybrid collection systems, while they would not be needed for those using open road tolling.

Congestion Pricing on New Versus Existing Toll Facilities

It can be expected that the operator of most any toll facility would have an established set of metrics it uses to monitor the performance of the facility, enabling it to track revenue generation, user base, operational performance and customer satisfaction. If variably priced tolls are introduced on an existing facility, these established monitoring programs would provide a wealth of baseline information and a platform for the ongoing monitoring activities. The operative issue in this type of situation would be to determine whether or not any additional information would be needed in order to assess how the introduction of variably priced tolls had influenced the overall performance of the facility. If variable pricing is used on new toll facilities then an entire monitoring protocol would need to be established prior to the opening of the facility. If the project sponsor operates other toll facilities, this process could involve a review and adaptation of the performance monitoring systems it already utilizes, and if it does not, the process would involve establishing an entirely new set of measures and procedures.

Level of Public Interest

As with other forms of pricing, the overall level of public interest in the use of variable pricing on new or existing toll facilities would be a key factor in establishing performance monitoring programs for these facilities. One of the main issues in the level of public interest would be whether or not congestion pricing is new to the region. In addition, if congestion pricing is introduced on an existing toll facility it will likely involve a toll increase and would receive close scrutiny by elected officials, the media and advocacy groups. In these cases it will be helpful for the project sponsor to document the cost of congestion in the region and establish expectations and a means to track how the introduction of pricing will impact congestion levels in the corridor to be priced. As with other forms of pricing, when there is a high level of concern regarding the use of congestion pricing, project sponsors should develop more comprehensive monitoring programs in order to generate performance data demonstrating the effect of the project and its influence on areas of key concern.

5.3.2 Selection of Performance Measures for Toll Facilities with Variable Pricing

This section provides specific factors for consideration, summaries of past experience, and recommendations on the selection of performance measures for toll facilities with variable pricing. The section's organization follows the order of the eight areas of evaluation identified among the operational congestion pricing projects examined as part of the NCHRP 08-75 research that produced these Guidelines. As noted previously, these evaluation areas are tied directly to the goals of a project. Specific project goals can be formulated and measured by framing them within the context of the evaluation areas. These evaluation areas and the full set of identified performance measures were introduced in Table 5-1 in Section 5.1.5.

The number of operational toll facilities with variable pricing is limited in practice. Five such instances were identified (see Table 4-2) and two were selected for close examination as part of the research behind these Guidelines. The number of distinct performance measures captured within each evaluation area for the two facilities studied is shown in Table 5-9 along with the total number of measures identified overall among congestion pricing projects. Because of this limited subset, it is more difficult to conclusively extract performance measures most commonly used in practice to a set of general guidelines than in the case of variably priced managed lanes. These Guidelines' recommendations take this into account and also draw from existing knowledge of industry best practice. Notably, however, it can be generally concluded that fewer evaluation areas are significant among toll facility performance monitoring requirements and a fewer number of performance measures are utilized compared to variably priced managed lanes.

TABLE 5-9: TOTAL PERFORMANCE MEASURES BY EVALUATION AREA

	Total Measures Identified	Measures Used in Facilities Examined
Traffic Performance	20	6
Public Perception	15	1
Facility Users	14	5
System Operations	15	4
Environment	3	0
Transit	7	1
Economics	9	0
Land Use	2	0

The full spectrum of performance measures used in practice is shown in Table 5-9. In most cases, a performance measure was used by just one facility examined; in a few cases, it was used by both facilities. The table also identifies whether the measures are generally applied in an operations or validation capacity, and whether they play a key (primary) or secondary role in a typical performance evaluation program. Some performance measures that validate a project may also be used to make operational facility changes, and vice versa; operational measures may also help validate the project. Those marked as operations are the critical measures used to assess facility function against achievement of its primary goals (such as meeting revenue targets or traffic thresholds), while validation measures, which may also be used operationally, are applied on a lower priority basis (such as adjusting the configuration of toll plazas based on collision data analysis).

Because of the limited sample size of operational facilities, other performance measures not listed in Table 5-10 could be significant or necessary to collect based on the goals set for a particular facility. These measures may not have been captured by these Guidelines' research; however, the issues discussed for each evaluation area can be applicable to those performance measures not identified.

TABLE 5-10: PERFORMANCE MEASURES IN PRACTICE – TOLL FACILITIES WITH VARIABLE PRICING (*ALL FACILITIES EXAMINED*)

Evaluation Area	Performance Measures		What Measures Are Used	Purpose		Importance	
				Operations	*Validation*	*Key*	*Secondary*
Traffic Performance	*Volume*	Vehicle volume (hourly/daily/weekly/monthly)	**2**	1	1	1	1
	Speed & Travel Time	Travel times	**1**		1		1
	VMT/VKT	VMT/ VKT	**1**		1		1
	Congestion	Delay/ wait times	**1**		1		1
	Congestion	Queue length	**1**		1		1
	Occupancy	Avg. vehicle occupancy (auto)	**1**		1		1
Public Perception	*Satisfaction*	General/perceived value/how well?	**1**		1		1
Facility Users	*Transaction Method*	Transponder/video/by-mail/cash	**1**		1		1
	User Characteristics	Vehicle classification	**1**		1		1
	User Characteristics	Vehicle registrations (HOV, vanpool, hybrid)	**1**		1		1
	Trip Characteristics	Time of day/ departure time	**1**		1		1
	Trip Characteristics	Toll spending/price paid (self-reported)	**1**		1		1
System Operations	*Safety*	Collisions/ accidents	**2**		2		2
	Finance	Total transactions	**1**	1		1	
	Finance	Revenue (toll/ charge)	**1**	1		1	
	Finance	Average toll/ highest toll	**1**	1			1
Transit	*Occupancy*	Ridership/ boardings	**1**		1		1

Traffic Performance

Traffic performance describes the fundamental purpose of a roadway: its ability to provide mobility to people and goods. It is the most important of the eight areas of evaluation and measured through a variety of traffic engineering measures answering the how much/many?, how fast?, and by what mode? questions pertaining to the facility.

Representative Traffic Performance Goals

Goals for toll facilities with variable pricing most commonly involve *traffic performance* (as well as the revenue aspect of system operations). Achieving congestion reduction is one prominent example. This goal, in turn though, may be further characterized on a more "measureable" basis or within a context that better resonates with facility users or those interested in improved performance. To that end, the goal of achieving congestion reduction could more specifically be stated as reducing the volume or extent of peak period congestion. Accomplishing this goal may require shifts in travel times to a shoulder period or alternate route/mode. As with variably priced managed lanes, traffic congestion reduction goals often imply improved system efficiency or reliability. However, these Guidelines' research has shown that these "goals" are often subjective, hard-to-define, and dependent on location-specific contexts. For example, one agency or region may define improved reliability simply as maintaining average speeds above 50 miles per hour, while another may characterize it as the ability to achieve a certain journey time 95 or more percent of the time. Significant differences in facility configuration play a role in these distinctions—a 50-mile toll facility may warrant characterization by time travel reliability given its substantial length within a roadway network, whereas travel time reliability may apply to a lesser extent to a tolled crossing, as it likely represents only a small fraction of an overall roadway network's length.

What Are the Traffic Performance Measures?

Measures of traffic, as indicated in Table 5-1 include vehicle and person volumes, speeds and travel times, mode share and vehicle occupancies, vehicle miles traveled, and indicators of congestion, such as delay, queue lengths, and specially developed coefficients comparing specific metrics during congested and uncongested conditions. Other measures that incorporate traffic include bicycle and pedestrian measures and parking, although these are not generally applied to toll facilities with variable pricing. Those measures that are deemed only the most broadly and beneficially applicable are discussed here, although others may certainly offer equal or better value depending on the context in which they are applied.

Research for these guidelines has shown that key performance measures of traffic for toll facilities with variable pricing depends significantly on the facility's configuration—ranging from long distance toll roads with open road tolling to short tolled crossings, potentially with manual toll collection. As with variably priced managed lanes, traffic volumes are critical to understanding facility usage. Other key measures include travel times and vehicle miles traveled (which relate more to toll roads than tolled crossings) and queue lengths and delay for facilities with toll booths incorporating manual collection or that require vehicles to slow as they pass through a point of toll collection.

How Are Traffic Performance Measures Applied?

Facility configuration significantly influences the selection of traffic performance measures for toll facilities with variable pricing. Those that utilize toll booths with manual collection or those that require vehicles to slow as they pass through the point of toll collection (effectively any facility without open road tolling) will likely be concerned with queues and attendant delays at toll booths. These concerns will apply to legacy toll facilities that introduce variable pricing and retain this type of configuration for toll collection. Queuing and delay are also greater concerns for tolled crossings, which often represent a bottlenecks or choke points within broader roadway networks and where facilities' traffic volume are concentrated over relatively short roadway segments. Greenfield toll facilities or those previously untolled will likely incorporate an open road toll system with mandatory electronic toll collection, obviating consideration of queues and associated delay.

Safety analyses of toll plaza configurations—a performance measure under the system operations evaluation area—are facilitated through an examination of queue length and delay in conjunction with collision location and rates. Aerial photography may be employed to help conduct these analyses, although this method is relatively expensive and allows measurements to be made at only limited intervals. Day-to-day or even A.M. to P.M. peak comparisons would require multiple collections to be made by the aerial vehicle.

From an operations standpoint, vehicle volumes, as with variably priced managed lanes, are a must-have traffic performance measure. It fundamentally describes the usage of the facility and is a common input measure for making toll rate adjustments, dynamically, or periodically to a fixed toll rate schedule. Other measures of facility usage can figure into toll rate adjustments or help communicate the utility of the facility. For corridor-type toll facilities (i.e. those that are not tolled crossings), vehicle miles traveled also provides a good indication of system usage. Travel times can be used to benchmark expected travel conditions between tolling points and usefully compared to periods when variable pricing may not be employed or compared to alternate routes to the tolled corridor. Although not revealed in the research for these Guidelines, speeds or LOS may also be applied to measuring the proper performance of a facility or its ability to provide reliable travel conditions to its users. Finally, unlike with variably priced managed lanes, measures of vehicle occupancy, mode share, and person volume are not generally relevant to toll facilities, unless special accommodation is made for higher levels of vehicle occupancy as part of the tolling regime. Such facilities would effectively represent HOT lanes or ETL without parallel general purpose lane capacity.

Example: Traffic Volume Monitoring on a Privately Operated Toll Road

The Ministry of Transportation Ontario (MTO) closely monitors traffic volumes on the Toronto area's 407 ETR, which is privately operated by Highway 407 International, Inc. The concessionaire provides Traffic Characteristics Reports to MTO on a regular basis, which include forecasts of anticipated traffic volumes by vehicle type for the next three-month period, traffic volume forecasts for the next year, and actual traffic counts for the past three-month period. The primary purpose of these comprehensive data is to maintain the Province's Freeway Traffic Management System and verify that the concessionaire's performance meets the standards established in the Ground Lease Agreement. Toll rates remain at the discretion of the concession company, although certain traffic thresholds must be met in order to justify a change in rates. MTO maintains the right to assess severe penalties if toll rates are changed without the corresponding threshold having been met.

Public Perception

Toll facilities often garner public skepticism and scrutiny because of the requirement to pay for the use of road capacity, which is often perceived of as a "free" public good. Familiarity with and acceptance of toll facilities can vary considerably based on historical experience and prevalence in any one particular region. In addition, the application of variable pricing on toll facilities has been limited. Given these considerations, public perception is an important factor among performance evaluation programs. Knowledge of a variably priced toll facility's purpose, acceptance of it as a mobility option, and satisfaction with the service it provides are characterized qualitatively through public perception.

Representative Public Perception Goals

Gauging *public perception* is at the heart of goals that seek to validate a variably priced toll facility project. Representative goals may include achieving or sustaining a prescribed level of satisfaction with the facility's operation. Specific targets of perception, travel time reliability, safety, or equity can be established and tracked. In addition to its relation to public perception, the special case of equity is discussed in depth in Section 5.1.4.

In general, measuring public perception is an attitudinal exercise that requires an appropriate instrument such as survey, focus group, or interview. Clearly, public outreach becomes a prime factor in establishing these goals and measuring their achievement. A detailed discussion of integrating performance evaluation and public outreach, including means of collecting attitudinal information, is provided in Chapter 4 of these guidelines. Provided here are details of the most relevant performance measures for capturing and quantifying public perception.

What Are the Public Perception Measures?

Public perception measures (as itemized in Table 5-1) focus on awareness, acceptance, and satisfaction. Among all three of these measures, specificity can range from the very broad to the more explicit. For example, general awareness of a facility's existence as a travel option or the use of variable pricing can be queried as easily as its specific features, such as pricing policy or hours of availability. Awareness of planned toll adjustments or future expansion may also be of interest. Similarly, acceptance and satisfaction measures can be general or specific. These Guidelines' research have uncovered few public perception measures used in practice, but that may be more an artifact of the maturity of the facilities studied than an indication of lack of purpose. Nonetheless, it can be expected that most public perception measures would focus on satisfaction, especially once a facility has been operational for some time.

What is most difficult about gauging public perception, however, is that there are no “loop detectors” for measuring it. That is, to make measurement that are inherently qualitative or subjective, a different set of tools are required, those that capture attitudes, as detailed in Chapter 4. In addition, many measures are stakeholder group-specific and require them to be custom tailored to a specific issue of significance.

How Are Public Perception Measures Applied?

Measures of public perception are not generally used—at least in a direct sense—to manage the operations of a toll facility. Certainly, the feedback assembled by assessing public perception can influence operational decisions, but do not dictate the specific day-to-day procedures, policies, or business practices that apply to a facility’s operation, such as toll adjustments or maintenance schedules.

All public perception measures can be characterized as serving a validation capacity, as well as playing a secondary role to those measures that dictate a facility’s operation—at least among operating facilities that have provided the foundation to these Guidelines. It is possible, however, that an agency contemplating the implementation of a variably priced toll facility project may view certain public perception measures as key to their performance evaluation program if, for example, a particular issue, such as user equity, is expected to be highly visible. Additionally, results of public perception measures may dictate necessary changes to customer service functions or public communication policies.

Survey instruments, focus groups, or interviews are generally used to collect data for public perception measures. These tools are described in greater detail in Section 6.2, and their advantages and disadvantages along with estimated costs are provided in Table 6-2. Generally speaking, these measures are more demanding and costly to collect and synthesize because of the user-specific, manual collection process required of attitudinal information. Because of this, their collection is often done on either a “before-and-after” or periodic basis. Surveyed public perceptions can be collected prior to the opening of a toll facility or its conversion to variable pricing, in either once or several waves, and compared with similar results after opening. Once operational, it may be desirable to continue to collect these types of measures on a periodic basis, such as annually or biannually, or as resources allow. Before-and-after surveys may focus on more market research, acceptance, and awareness issues, while periodic, post-opening-day performance measurement will likely focus on user satisfaction.

What is important to keep in mind when formulating measures of public perception is that they should address issues of public concern identified through a public outreach process. From region to region, project to project, the key issues that are worth tracking and responding to before, during, and after project implementation are often more unique than alike. In this manner, public perception measures should be tailored appropriately to each project application.

Facility Users

Facility Users represent the characteristics of those who make trips on a toll facility with variable pricing and the characteristics of the trips themselves.

Representative Facility User Goals

Understanding who the *users of a facility* are serves both operational and validation goals. One simple goal may be to increase patronage of the facility. Another may be to know the number of transponders issued to help understand how many to have on hand for future distribution. Often, however, characteristics of a facility's users are inputs to developing and measuring goals formulated under other evaluation subjects. For example from a validation perspective, knowing the socioeconomic profile of a facility's user base can help market the facility to an expanded user base. This understanding, in turn, can help maximize (or maintain) levels of revenue. Revenue generation as a goal can also be served through operational measures such as knowing users' departure times or trip times-of-day, which can inform decisions on setting toll policies.

What Are the Facility User Measures?

Measures of facility users primarily focus on characteristics of the users themselves or the trips they take. Specific data on their accounts or toll transaction type are also found among those measures used in practice. The full list derived from current operating facilities is shown in Table 5-1. User characteristics include demographic and socioeconomic data, vehicle data, and home zip code or other residence identifying measures. Trip characteristics include, among others, frequency, departure times, travelshed determinations, overall trip length, and trip purpose.

How Are Facility User Measures Applied?

Generally, measures of a facility's users are used in a validation capacity and less so for operations. As with public perception measures, data collected about users and their trips may serve to inform operations and policy decisions, but generally apply to only back office day-to-day operations, rather than the facility itself. Managing customer accounts and registrations, issuing transponders, and formulating potential (long-term) adjustments to facility operation based on trips frequencies and times-of-day are several operational aspects that can be informed through user measures.

Importantly, though, these data may be critical inputs for examining the level of revenue a toll facility generates. Whether a public toll authority or private sector operator, a greenfield toll facility or existing facility that recently incorporated variable pricing, achieving defined targets for revenue are necessary for planned expenditures on operations, maintenance, and enhancements, as well as honoring bond covenants or maintaining debt coverage ratios for past and future capital outlays. Being able to predict revenue generation accurately relies on accurate and thorough facility user data. This requirement is especially significant when the introduction of variable pricing (and future adjustments to a toll schedule) make predicting revenue more complicated and dependent on the share of users who shift their journey to an off-peak (cheaper) time, or off the facility altogether by taking another route or mode, or not making their trip at all.

Validating a variably priced toll facility is also accomplished through measures of system users. Measures of user characteristics, especially demographics and socioeconomics, help facility operators understand who their customer base is. This knowledge can help communicate who is benefiting from the facility (e.g., Is the facility drawing customers who are only "wealthy" enough to pay or are lower-income groups prominent users as well?) and how widespread those benefits reach. Likewise trip characteristics help inform where and when their users travel. As with examining a revenue generation goal, this data is potentially valuable to examine the potential reduction in peak period usage, a common goal among congestion-priced facilities.

Collection methods and frequencies vary for user measures. Some measures, such as demographics, transponders issued, or vehicle make are naturally tracked through the customer registration/management process. For facilities that utilize manual toll booths and do not require mandatory transponder usage, this data cannot be obtained without manual survey work. Soliciting some user measures is possible only through surveys, such as total trip length (including non-priced segments) and trip purpose. Collection of these data is naturally done on an infrequent, as-needed basis.

Comprehensive travelshed determinations may even require travel demand forecasting or modeling efforts.

System Operations

For the purposes of these guidelines, system operations refer to operational aspects of a priced facility that are not directly related to measures of traffic, as discussed in the Traffic Performance section. They are categorized in five ways:

- Finance
- Enforcement
- Safety
- Customer service
- System function

Representative System Operations Goals

A wide variety of goals can be set by and evaluated against *system operations*. The primary system operations goal for variably priced toll facilities is to collect a certain level of revenue. Safety is also an important goal for most all roadway operators, toll or otherwise. Finally, system operators may want to achieve established levels of customer service or targets of system equipment availability/accuracy.

What are the System Operations Measures?

Because of system operations' broad scope, a wide variety of measures are used to track this evaluation area as detailed in Table 5-1. Finance measures include revenue (tolls, fees, etc.) and expenditures (O&M). Enforcement measures track data that includes traffic stops, violation rates, and citations issued. Measures of safety often look at accident rates and incident response times. A long and very detailed number of performance metrics can measure customer service, from volumes of inquiry and comments received (positive or negative), to customer service center response time and average inquiry resolution time. Application of these measures is highly dependent on facility sponsor preference, as discussed below. Finally, measures of system function focus on facility and specific equipment availability and accuracy, numbers of equipment incidents, and repair rates.

Research for these Guidelines has shown that finance and safety are the two most prominent types of system operations measures used for variably priced toll facilities. Customer service and system function are also significant, although not necessarily revealed by the research. Violation rates may not factor as highly unless specific occupancy requirements are part of the tolling regime (as with HOT lanes) or the toll facility has limited controlled access (i.e. those without toll booths and without a license plate detection system that automatically records and bills users, effectively negating the possibility for violations).

How Are System Operations Measures Applied?

Finance: Among the five categories of system operations performance measures, financial performance data are universally used in the operation of variably priced toll facilities. In analyzing revenue collection targets and trends, the average toll paid, highest toll paid, and total number of transactions can factor into decisions made on setting toll rates and schedules.

A balance will need to be struck between managing traffic performance and generating an expected level of revenue. Budgets for operating expenses and maintenance are set and paid for with toll revenue. Bond issues to support facility construction or capital expansion or enhancements backed by future toll proceeds must meet established covenants or debt recovery ratios. Both of these considerations make financial performance a priority. Off peak discounts and/or less expensive shoulder periods are typical price differentiators (along with varying rates based on vehicle class and segment of roadway, if some are more heavily traveled than others) that if too "successful" or "generous" could erode a higher baseline level of revenue collection without them. This concern may be especially apparent when moving to a variable price toll structure from a fixed one on an existing toll facility, as compared with instituting variable pricing on a greenfield toll facility, because of historical expectations for toll revenue collections.

Collection of toll revenue data is managed through ETC equipment and does not represent a significant cost once a facility is operational. The data is captured on an ongoing, real time basis and can be considered a must-have among performance evaluation measures.

Example: Revenue is Key

The Port Authority of New York and New Jersey's implementation of variable pricing on the six tolled crossings between New Jersey and New York highlights the significance of carefully analyzing its impact on toll revenue. Revenue is tracked closely and compared with the estimates generated by the agency's sophisticated and well-calibrated traffic and revenue forecasting tools. As part of its standard accounting and business procedures, the Port Authority tracks the overall number toll transactions for each of its crossings by vehicle class, time of day, and payment method. This detailed and historic time series data has enabled the Port Authority to study what effects the introduction of congestion pricing had on travel patterns for motorists using its crossings and heightened its focus on variations in the time of day of travel by vehicle type and toll facility.

Enforcement: Enforcement of toll payment requirements (and vehicle occupancy if applicable) is an important measure to present to a public that expects a high level of integrity for a service that requires payment for use (or participation in a carpool if HOV requirements are applied in conjunction with variable pricing). Measures of enforcement such as traffic stops and violation rates are relevant in this case and help to validate the expectation for fair application of the facility's rules and requirements. However, minimizing toll evasion is generally an issue only with barrier-free access to a toll road; and with the incorporation of a license plate toll option, any user without a transponder can be billed through the mail, effectively eliminating violations.

Safety: With respect to safety, its monitoring and reporting may factor more prominently in operators' performance evaluation programs for variably priced toll roads than with an untolled roads because of the greater public visibility a toll road typically generates, the increased traffic safety risks from toll booth configurations and queuing, and the need to scrutinize the level of service provided by a private owner and/or operator.

Customer Service: Confirmation of delivering high quality customer service can be evaluated by many measures. Facility sponsors will want to consider tailoring a selection of these measures based upon the role the agency plays in providing customer service functions, public outreach outcomes, and other needs. If the operation of the facility is provided by a private entity to collect tolls and manage customer service, evaluation measures and reporting requirements can be specified in their contract.

Based on the findings for variably priced managed lanes (which are also deemed applicable to variably priced toll facilities), the most commonly applied customer service measure in practice is level of customer inquiry (by phone or email); generally low levels of inquiry are desirable because they are indicative of good customer satisfaction. A second common measure—incident response time by public safety agencies or safety service patrols—can be considered both a customer service and safety indicator.

System Function: Finally validating the proper function of the managed lanes' system equipment (and informing potential operational changes) can require certain performance evaluation measures. These measures were also captured through the research of variably priced managed lanes. Frequently applied measures include system equipment availability (transponder readers and other toll collection hardware, cameras, and other vehicle detection and monitoring equipment), the number of system incidents (failures, errors, etc.), and the mean time to repair the result of the incident. Collection of these measures can be built into the software that manages the systems and directed to produce reports as necessary.

Environment

Performance measures to evaluate the impact on the environment from a toll facility with variable pricing are not widely used in practice. For existing toll facilities that shift from a flat rate toll structure to one with variable pricing, the overall effects of improved efficiency in heavily traveled highway corridors are not likely to generate meaningful improvements to such environmental conditions as air quality or noise. Environmental impacts from greenfield toll facilities will have been analyzed extensively during the planning and environmental review phase of the project. Measuring predicted impacts after facility opening may be of concern to some project sponsors depending on stakeholder expectations. If there is particular interest in monitoring the performance of variably priced toll facility projects on emissions, information on emission rates can be calculated using traffic volume and speed data as inputs to standard air quality forecasting tools, such as EPA's MOBILE6 Vehicle Emission Modeling Software.

Transit

Transit refers to aspects of transit service that operate on the variably priced toll facility or corridor. Transit service within the facility's travelshed may also be of interest, where it can offer an alternate route between origins and destination served by the toll road corridor.

Representative Transit Goals

Goals related to *transit* service pertain to priced facilities that *have* transit operating along its corridor, or at least within the same region/travelshed. Transit goals include improving service during peak periods by encouraging travel time shifts from congested periods to off-peak or shoulder periods, to alternate routes, or to transit itself. Improvements in transit service may also be an established goal if system enhancements, such as the addition of new park-n-ride facilities, are incorporated as part of a toll facility conversion to variable pricing.

What are the Transit Measures?

Aspects of transit service include performance, ridership, finance (revenue), and quality of service (as measured attitudinally through customer surveys). Although the research of variably priced toll facilities did not reveal extensive use of transit performance measures, those used in practice most commonly among variably priced managed lanes can be applied instead. For those facilities transit performance is most often measured by travel times, on-time rates, or excess wait times (delay), as well as ridership or boarding counts.

Other measures used less frequently include farebox revenue and O&M expenditures, as well as quality, satisfaction, and reliability as perceived by customers.

How Are Transit Measures Applied?

Prioritizing transit vehicles (typically express bus service) along highway corridors is often accomplished by dedicating at least one transit-only or HOV lane to its use such that it can reliably travel in free-flow or near free-flow conditions during peak travel periods. It can be assumed, however, that transit vehicles could also use a variably priced toll facility where no priority distinction is given to transit operations. In this case, a variable toll structure that reduces peak period congestion by encouraging less travel during that time could benefit transit operations. The same benefit would occur with variably priced tolled crossings (bridges and tunnels) if no dedicated lane is already provided for the transit vehicle. A favorable toll rate (or no toll if the facility operator is also the transit operator) could be assessed to not penalize the transit service. Measured transit data would play a validation role for the toll facility's performance monitoring plan, documenting reliable and/or improved transit service, as measured most often by travel times, on-time arrivals, delay, and ridership.

If the variably priced toll facility sponsor or operator is also the agency responsible for transit service, acquiring transit performance data is not difficult. Otherwise such data needs to be acquired (if it exists) from individual transit agencies. Obtaining the performance data sought, however, requires establishing a good working relationship with that agency and coordinating data collection efforts.

Economics

Economics is not generally assessed for a variably priced toll facility project. Impacts on local businesses and regional competitiveness are of extreme interest in a region implementing an area or cordon pricing project, but this is not normally the case with single toll facilities. Nonetheless, improved travel time reliability along highly traveled corridors, such as the 407 ETR in Toronto, would be expected to have a positive economic effect. However, it is extremely challenging to measure the precise effect of an individual transportation improvement on regional economic trends. This type of analysis would be more likely to rely on the results of economic models, which would allow a comparison to be made between model outputs and data collected on regional economic activity and real estate prices.

Land Use

Performance measures to evaluate a variably priced toll facility's impacts on land use are not commonly used in practice and are not generally recommended by these Guidelines. Nonetheless a facility sponsor may want to consider these measures (such residential or commercial land use trends) if found to be a particular issue of concern in its region.

5.4 Performance Measurement for Cordon and Area Pricing Projects

Given their extremely high visibility and sensitive nature, performance measurement for cordon and area pricing programs is especially important and integral to their ongoing success. (The distinction between cordon and area pricing is provided in Section 1.2.3 and in Section 5.4.2.) While the use of congestion pricing on individual facilities or lanes affects travel pattern in given corridors, cordon and area pricing programs have profound effects on travel patters across entire regions. In addition, they are also likely to have important effects—both real and perceived—on other important issues. These can include issues such as regional emissions and air quality, business impacts, and economic competitiveness—issues that are not likely to be high priority concerns with other forms of congestion pricing and are likely to require creative approaches in order to be monitored in a meaningful way.

Given the regional nature of their influence on travel patterns and congestion, performance monitoring programs for cordon and area pricing projects should involve the collection of comparable sets of data in different locations around the region, both within the pricing zone and outside it. While the benefits in terms of reductions in traffic volumes and congestion and increased travel speeds will be greater in the pricing zone than outside it, the benefits may actually be the greatest at pinch points leading into the pricing zone including bridges, tunnels and major arterial streets or highways. Monitoring programs for cordon and area pricing projects should focus on these types of locations and generate data showing how the benefits of pricing accrue to surrounding areas as well as the pricing zone itself. Project sponsors should also consider collecting baseline data in any neighborhoods or communities that may oppose the implementation of cordon or area pricing programs and then monitor appropriate metrics such as traffic and environmental conditions in those locations once the system is implemented. In many cases it is likely that conditions could improve, allowing project sponsors to use the performance monitoring data to garner support for the pricing program.

Another area of concern with the use of cordon or area pricing is the ability for existing transit infrastructure to accommodate the increased passenger loads that would be expected as motorists shift their trips to transit.[7] Given the heavy utilization of rail transit and the longer lead times needed to expand rail capacity, preparations for the area pricing programs in both London and Stockholm included the purchase of new bus fleets to augment transit capacity. This was a particularly strategic move as increased travel speeds, particularly within the pricing zones themselves made bus travel far more attractive than in the past once the pricing systems were activated. Performance monitoring programs for cordon or area pricing schemes should track utilization, crowding, and travel times on all relevant rail and bus lines likely to be impacted by the new programs.

Equity is also an inevitable concern with cordon and area pricing programs. Together the high cost of parking and excellent transit availability in locations where cordon or area pricing may be introduced limit the number of people in lower income groups who make regular trips to these areas by automobile. However, residents in areas with poorer transit access or other low to moderate income earners who happen to have free parking at their places of employment may be affected by the introduction of cordon or area pricing. If these types of concerns arise, it may be helpful to develop specific performance metrics to track how these communities are impacted by the pricing program. The special case of equity is discussed in greater depth in Section 5.1.4.

Lastly, by their very definition, cordon and area pricing programs will likely require the installation of new toll collection systems and technologies, including character recognition systems capable of reading license plates, as well as back office accounting systems to process payments and manage accounts and customer service centers. The performance monitoring programs for cordon and area pricing systems should include appropriate parameters to track the performance of these systems, the accuracy of the data collected, and the extent to which desired performance levels are achieved.

The findings and recommendations that follow on performance monitoring for cordon or area pricing projects are informed by the case studies prepared for the congestion charging programs operating in Singapore, London and Stockholm, which represent the three largest applications of cordon or area pricing in the world. They are also supplemented by the experiences of the Guidelines' authors in supporting the exploration of the introduction of congestion pricing in Manhattan, together with industry standards and best practices. In all cases, the use of cordon or area pricing should be expected to be a highly sensitive issue and of interest to elected officials, and community and stakeholder groups of all types. As such, performance monitoring efforts for these projects should involve extensive exploration of public opinions and concerns. The information gathered through this outreach process should be used to identify a tailored set of performance measures that track parameters of particular interest to different stakeholder groups, as well as to identify those analysis areas that are likely to be affected by the use of cordon or area pricing.

[7] The presence of comprehensive rail and bus transit networks is an essential requisite for any metropolitan region considering the use or cordon or area pricing.

5.4.1 Distinguishing Characteristics of Cordon and Area Pricing Programs

As with the other forms of pricing, there are a number of variables that distinguish cordon or area pricing schemes from one another and that are likely to influence their performance monitoring programs.

Toll Collection Technologies

There are two primary types of technologies that can be used to collect the entry fees associated with cordon or area pricing: transponder-based ETC systems and camera-based character recognition systems. In certain cases one or the other technology may be used exclusively, and in others, the system may utilize both. Operating costs for character recognition systems are likely to be higher than that of transponder based systems, but it is possible that pricing schemes could charge different rates for entering the pricing zone depending on which technology is used. Camera-based technologies are also more likely to raise privacy concerns. Performance monitoring programs for cordon or area pricing schemes may need to be developed to track and compare the performance of these different toll collection technologies in terms of accuracy, reliability, cost, and public perception.

Cordon Versus Area Pricing

There are two approaches for collecting entry fees with cordon and area pricing programs. The first is the cordon approach where motorists are charged a fee each time they enter the pricing zone, regardless of the number of trips made. This is the model that is used in Singapore. The other approach is to charge motorists a single fee to enter the pricing zone on multiple occasions during a designated period, such as 7:00 a.m. to 6:00 p.m. Monday through Friday as is the case in London. The back office accounting programs used to operate cordon and area charging schemes need to be capable of making these distinctions, and it is likely that performance monitoring programs will also need to be capable of tracking the net number of trips made by individual vehicles of different types (e.g., private vs. commercial) on a daily basis in order to gain a full understanding of the ways in which the charging schemes affect different types of motorists.

Fixed Versus Variable Price Rates

As these Guidelines are being written, two of the three major cordon or area pricing schemes—Stockholm and Singapore—vary their rates by time of day on a fixed schedule. It is possible that in the future new cordon or area pricing schemes could vary entry fees in real time based on actual travel conditions, with higher rates charged during periods of higher congestion. The rationale for using variably priced fees is to use higher toll rates as a further incentive to encourage motorists to make trips by alternative modes or during non-peak periods. Performance monitoring programs for cordon or area pricing programs using variable rates need to be capable of demonstrating the effects of changing toll rates on travel behavior. Regardless of the structure of the entry fee, performance monitoring programs for all cordon and area pricing programs should also be capable of tracking travel conditions by time of day—including those days and periods where no charge is levied—in order to provide a full understanding of how pricing influences travel patterns.

Intra-Area Charges

In some cases cordon and area pricing programs may involve levying a fee for vehicular trips made entirely within the pricing zone in addition to those that originate outside the zone. In situations where cordon or area pricing programs levy different fees for different types of trips (or trips made by residents who live in or next to the priced zone), performance monitoring programs need to be able to track the number of trips for each of the different fee structures and enable analysts to assess how these different fee policies influence overall travel behavior.

Geographic Specific Concerns

In certain cases the implementation of cordon or area pricing can result in comparatively severe impacts on residents in certain geographic areas. This is the case in Stockholm, for instance, for people living on the island of Lindingö, for which the only road access involves traveling through the pricing zone in the City of Stockholm. Given that there are no alternative routes for local residents and their visitors to use, trips to and from Lindingö are free provided vehicles enter or exit the pricing zone within 30 minutes of arriving or departing from the island. In cases where there are certain locations where local residents are provided with equity based discounts, performance monitoring programs should be able to provide separate data tracking the effects of the charging scheme on populations who qualify for these types of discounts in order to understand how they affect local travel patterns and the extent to which local residents find the discounted fees fair and acceptable.

Level of Public Interest

Perhaps to a greater degree than other forms of congestion pricing, the level of public interest in cordon or area pricing schemes can be expected to be extremely high. Performance monitoring programs for these schemes should provide comprehensive information on all the benefits of congestion pricing, and also be tailored to address specific areas of public concern. As a result of the regional nature of their impacts, as well as the potential for meaningful improvements in congestion levels and regional emissions and the heightened level of interest and concern, performance monitoring programs for cordon and congestion pricing schemes should be robust and comprehensive in order to demonstrate their multitude of potential effects on the region and to gain support for them.

5.4.2 Selection of Performance Measures for Cordon and Area Pricing Programs

This section provides specific factors for consideration, summaries of past experience, and recommendations on the selection of performance measures for cordon or area pricing schemes. The section's organization follows the order of the eight areas of evaluation identified among the operational congestion pricing projects examined as part of the NCHRP 08-75 research that produced these Guidelines. As noted previously, these evaluation areas are tied directly to the goals of a project. Specific project goals can be formulated and measured by framing them within the context of the evaluation areas. These evaluation areas and the full set of identified performance measures were introduced in Table 5-1 in Section 5.1.5.

The number of operational cordon or area pricing schemes is limited in practice. All are currently located outside the U.S., and the three most extensive ones (as measured by geographic extent and population served) were selected for close examination as part of the research behind these Guidelines. The number of distinct performance measures captured within each evaluation area is shown in Table 5-11 along with those measures used by the schemes studied. Because of this limited subset, it is more difficult to conclusively extract performance measures most commonly used in practice to a set of general guidelines than in the case of variably priced managed lanes. These Guidelines' recommendations take this into account and also draw from the authors' experience with the attempted implementation of cordon pricing in New York City and other industry knowledge.

TABLE 5-11: TOTAL PERFORMANCE MEASURES BY EVALUATION AREA

	Total Measures Identified	Measures Used by 2+ out of 3 Schemes	Measures Used by 1 out of 3 Schemes
Traffic Performance	20	7	9
Public Perception	15	1	3
Facility Users	14	3	1
System Operations	15	3	8
Environment	3	2	1
Transit	7	3	3
Economics	9	3	6
Land Use	2	0	2

The full spectrum of performance measures used in practice by at least two of the three area or cordon pricing schemes examined is shown in Table 5-12. As with the performance measures identified for variably priced managed lanes and variably priced toll facilities, the table also identifies whether the measures are generally applied in an operations or validation capacity, and whether they play a key (primary) or secondary role in a typical performance evaluation program.

TABLE 5-12: PERFORMANCE MEASURES IN PRACTICE – CORDON AND AREA PRICING (*2+ OUT OF 3 SCHEMES EXAMINED*)

Evaluation Area	Performance Measures		What Measures Are Used	Purpose		Importance	
				Operations	*Validation*	*Key*	*Secondary*
Traffic Performance	*Speed & Travel Time*	Travel times	3		3	1	1
	Speed & Travel Time	Speeds/ average speed	2	1	1	1	
	Volume	Vehicle volume (hourly/daily/weekly/monthly)	2		2	2	
	VMT/VKT	VMT/ VKT	2		2	1	1
	Congestion	Delay/ wait times	2		2	2	
	Mode Share	Mode share (SOV, HOV, transit)	2		2		1
	Bike/Ped	Bike/ped traffic counts	2		2		1
Public Perception	*Social Impacts*	Specific activities/populations	2		2		1
Facility Users	*Trip Characteristics*	O-D/ travelshed determination	3	1	2		2
	User Characteristics	Vehicle classification	2		2		1
	Trip Characteristics	Trip purpose	2		2		1
System Operations	*Finance*	Revenue (toll/ charge)	2		2		1
	Finance	O&M Cost	2		2		1
	Safety	Collisions/ accidents	2		2		1
Environment	*Air Quality*	NAAQS criteria pollutants/ VOCs	2		2	1	
	Air Quality	GHG/ CO2	2		2	1	
Transit	*Performance*	Travel time/on-time/excess wait	2		2		1
	Performance	Average speed	2		2		1
	Occupancy	Ridership/ boardings	2		2		1
Economics	*General*	Benefit-cost analysis	2		2		1
	Business Impacts	General performance/openings/closings	2		2		1
	Business Impacts	Retail traffic & sales	2		2		1

In the case of area and cordon pricing programs, however, the distinction between operations and validation is less significant than the other two forms of congestion pricing. Scheme sponsors may choose to use any particular performance measure in either an operations or validation capacity given the complexity of these programs' implementation and the high level of public scrutiny they assuredly will undergo. That is, any one measure may inform an operational change on an ad hoc or systematic basis, and similarly, any one measure may help to communicate to users and observers a scheme's successful (or unsuccessful) achievement of goals and predicted benefits. Nonetheless, several performance measures (specific to Singapore's Electronic Road Pricing program) are indicated to be used in an operations capacity because they feed directly into an established periodic review of scheme function; if certain thresholds or characteristics are observed, adjustments to toll rates or an expansion of the priced zone can be triggered. It can be assumed that the potential application of dynamically variable area or cordon charges would require the selection of operations-based performance measures as real time inputs to a pricing algorithm.

In addition to the measures in Table 5-12, many other performance measures are used by one of the three facilities, 33 measures in total, as indicated in Table 5-11. These measures are listed in Table 5-13. Again, give the wide variety of special considerations necessary for successful implementation and sustained operation of an area or cordon pricing program, these measures are also presented (without Purpose or Importance distinctions) because any one performance measure may be critical for project sponsors to utilize. Generally though, those measures captured only in at least two of the three examined schemes are detailed further in the sections that follow.

TABLE 5-13: PERFORMANCE MEASURES IN PRACTICE – CORDON AND AREA PRICING (*1 OUT OF 3 SCHEMES EXAMINED*)

Evaluation Area	Performance Measures	
Traffic Performance	*Speed & Travel Time*	LOS
	Speed & Travel Time	Travel time savings
	Speed & Travel Time	Cost of delay/ VOT
	Volume	Person volume (hourly/daily/weekly/monthly)
	Congestion	Congestion coefficient
	Occupancy	Avg. vehicle occupancy (auto)
	Parking	Park-n-ride activity (lot counts)
	Parking	Off-street parking activity (counts/occupancy)
	Parking	On-street parking activity (counts/occupancy)
Public Perception	*Awareness*	Of the facility/general/how much?
	Acceptance	General/fairness/equity
	Effectiveness	Congestion reduction
Facility Users	*Trip Characteristics*	Trip length
System Operations	*Finance*	Total transactions
	Finance	Average toll/ highest toll
	Finance	Revenue (fee)
	Enforcement	Violations/citations/fines
	Customer Service	Inquiry activity (call, email)
	Customer Service	Performance (quantitative measures)
	System Function	Facility availability
	System Function	Equipment availability
Environment	*Noise*	Noise levels
Transit	*Occupancy*	Average vehicle occupancy
	Finance	Farebox revenue
	Service	Quality/satisfaction/reliability
Economics	*General*	Gross regional product/ economic indices
	Business Impacts	Specific sectors/services/populations
	Business Impacts	Business costs and prices
	Business Impacts	Tourists/ visitors
	Property	Residential sales/rentals/values
	Property	Commercial sales/rentals/values
Land Use	*Residential*	Housing decisions
	Commercial	Business locations

Nonetheless, as with the other two forms of pricing, because of the limited sample size of existing programs, as well as the speicalized nature of these schemes, other performance measures not listed in Table 5-12 or Table 5-13 could be significant or necessary to collect based on the goals set for a particular area or cordon pricing scheme. These measures may not have been captured by these Guidelines' research; however, the issues discussed for each evaluation area can be applicable to those performance measures not identified.

Traffic Performance

Traffic performance describes the fundamental purpose of a roadway network: its ability to provide mobility to people and goods. An important distinction among cordon and area pricing programs compared to variably priced managed lanes or toll facilities is the greater emphasis placed on including transit, bicyclists, and pedestrians among the users of the roadway network and measuring "traffic" performance for these modes. In general, traffic performance is measured by a variety of traffic engineering measures answering the how much/many?, how fast?, and by what mode? questions pertaining to the roadway network.

Representative Traffic Performance Goals

Primary goals of area or cordon pricing programs involve *traffic performance*. Achieving congestion reduction in a city center or central business district (as well as its surrounding areas and routes into it) is one prominent example. This goal, in turn though, may be further characterized on a more "measureable" basis or within a context that better resonates with users or those interested in improved performance. To that end, the goal of achieving congestion reduction could more specifically be stated as reducing the volume or extent of peak period congestion, improving vehicular access (specific to commuters or goods and service providers), or improving travel time reliability into the priced zone. Accomplishing this goal may require a shift in travel time to less congested periods, a shift to an alternate mode (transit, bicycling, or walking, for example), or not making the trip at all. As with variably priced managed lanes and toll facilities, goals related to reliability can be subjective and dependent on location-specific contexts. Further specification by project sponsors may be required.

What Are the Traffic Performance Measures?

Measures of traffic, as indicated in Table 5-1 include vehicle and person volumes, speeds and travel times, mode share and vehicle occupancies, vehicle miles traveled, and indicators of congestion, such as delay, queue lengths, and specially developed coefficients comparing specific metrics during congested and uncongested conditions. Other measures that incorporate traffic include bicycle and pedestrian measures and parking, potentially significant considerations for area or cordon pricing schemes. Transit performance, closely tracked with these programs, is captured in its own evaluation area.

Nearly all the metrics captured in the research for these Guidelines have been applied to measure traffic performance, indicating a broad range that may offer project sponsor utility. Research has shown that key performance measures of traffic for area and cordon pricing depend significantly on scheme context. The extent of the scheme's physical coverage, existing roadway configuration, policy and method for charging a fee, and many other issues can all affect the importance attached to particular traffic performance measures. In one example, the priced zone may contain a mixture of low speed city streets, arterials, bridges, tunnels, and highways, unlike variably priced managed lanes or toll facilities, which are uniform road type.

How Are Traffic Performance Measures Applied?

Volumes: As with variably priced managed lanes and toll facilities, traffic volumes are critical to understanding system usage (the system in this case being both the priced zone itself and the surrounding region that may be directly or indirectly affected). Typically these volumes would be measured at the cordons (boundary) of the priced zone, effectively measuring the total volume of "system" users inside the zone. Volumes are also likely to be measured at any number of other critical locations both inside and outside the priced zone to assess the scheme's impact on particular roads or corridors of interest, especially those known to be highly congested and targeted for relief. These are likely to be the most heavily traveled routes that lead to the priced zone. Shifting traffic volumes and patterns are also likely to occur because of users seeking alternate routes to avoid the charge or parking near the boundary to take an available alternate mode, such as transit, into the zone. Volumes can be measured using system equipment installed at the zone's cordons, existing loop detector or camera infrastructure, or through manual counts where these options may not be available, such as streets near the zone boundary that may see a spike in traffic from those avoiding passing into the zone.

Example: Using Speeds to Adjust Pricing Policy

The pricing policy for Singapore's Electronic Road Pricing (ERP) is reviewed on a three-month cycle taking into account a wealth of collected data and computed traffic engineering metrics based on speeds. Speed-flow analyses are performed for all travel routes (expressways, major arterials, and minor arterials) to examine congestion levels relative to target LOS. This review duration is considered optimal to allow enough time for traffic patterns to readjust—passing through a transient period and accounting for altered driver behavior. A formal process is followed to make an adjustment to the ERP charge schedule. Approvals are required from the Minister of Transport, and the new rates are formalized through appropriate legal documents or law.

Speeds/Travel Times/Delay: Traffic speeds measured along specified corridors or averaged within specified zones help inform common traffic performance goals, as do travel times along defined routes or from identified origins and destinations. Speeds and travel times often are used to indicate reliability for journeys into the priced zone. A similar metric that represents speed and travel time in a reciprocal fashion is delay. The difference between actual speeds and travel times compared with a baseline accepted speed or travel time represents delay. Reduced delay can indicate improved traffic performance. Speeds along a single corridor or crossing the zone's cordons can be calculated using system equipment (ETC transponder equipment and/or cameras); otherwise a probe vehicle or other proxy equipped with GPS (such as taxis) would be required to capture average speeds across more complicated networks or within a defined zone.

Vehicle Miles Traveled: Given a need to aggregate traffic performance across an often extensive roadway network rather than just single lanes or corridor, vehicle miles traveled provides another means to measure traffic performance. VMT requires calculated estimates from other traffic data such as volumes or extrapolations from volunteer vehicles outfitted with GPS.

Other Modes: Encouraging the use of alternative modes to access the priced zone is a primary goal measured through traffic performance. In this respect, transit usage (as noted in the Transit evaluation area) as well as pedestrian and bicyclist counts measured at the zone's cordons can be applied.

Parking: Although captured for only one priced zone, on- and off-street public parking counts can provide a good secondary indication of improved traffic performance. Research has shown that a significant percentage of traffic volume in city centers is caused by people searching for parking. This means that not only does parking volume provide an indication of reduced traffic volume as a whole, but it can help provide an indication of further congestion reduction due to an increased ease in obtaining parking. Outside the priced zone, parking counts are of interest to measure the extent to which users are avoiding entry into the zone by simply parking outside it. This information can help identify areas for cordon adjustment or the need for policies to avoid oversubscribing parking (and potentially roadway capacity) near the zone's boundary.

Public Perception

Area and cordon pricing have been deployed in only a few select cities—none of which is in the U.S. as these Guidelines are being developed. Because of their untested application in the U.S. and the dramatic effects these schemes can be expected to have on how mobility and accessibility are both perceived and managed, perhaps with more significance than any other evaluation area, obtaining public buy-in to implement an area or cordon pricing scheme will require positive public perception. The public's knowledge of a program's purpose and acceptance of it as a new paradigm for managing access to the selected priced zone are critical to address prior to implementation. Their role before and after implementation, along with satisfaction with the service these schemes provide, are characterized qualitatively through public perception.

Representative Public Perception Goals

Gauging *public perception* is at the heart of goals that seek to validate an area or cordon pricing project—both before and after implementation. Representative goals may include achieving acceptance or sustaining a prescribed level of satisfaction with the facility's operation. Specific targets of the perception of the scheme's effect on congestion reduction, equity, or social impacts within the priced zone can be established and tracked. In addition to its relation to public perception, the special case of equity is discussed in depth in Section 5.1.4.

In general, measuring public perception is an attitudinal exercise that requires an appropriate instrument such as survey, focus group, or interview. Clearly, public outreach becomes a prime factor in establishing these goals and measuring their achievement. A detailed discussion of integrating performance evaluation and public outreach, including means of collecting attitudinal information, is provided in Chapter 4 of these guidelines. Provided here are details of the most relevant performance measures for capturing and quantifying public perception.

What Are the Public Perception Measures?

Public perception measures (as itemized in Table 5-1) focus on awareness, acceptance, and satisfaction. Among all three of these measures, specificity can range from the very broad to the more explicit. For example, awareness of a scheme's features (hours of operation, extent, exceptions to the charge, etc.), planned charge adjustments, or future cordon expansion can be queried. Similarly, acceptance and satisfaction measures can be general or specific.

One additional public perception measure found uniquely among area and cordon pricing programs relates to gauging a scheme's impacts on specific activities or populations. Activities could be industry, commercial, or touristic, for example, while particular populations could include the elderly, schoolchildren, or specific types of workers. It is somewhat surprising that this public perception measure was the only one found to be common among at least two of the three schemes examined for these Guidelines' research. However, this finding may be more of an indication of how public perception measures must be specifically tailored to each program's application more than a lack of applicability, leading to unique sets of measures for any one particular scheme. Additionally, sponsor's performance monitoring programs often focus on the results of post scheme implementation and report less on their *proposed* implementation, resulting in a smaller number of public perception measures employed than expected.

What is most difficult about gauging public perception, however, is that there are no "loop detectors" for measuring it. That is, to make measurement that are inherently qualitative or subjective, a different set of tools are required, those that capture attitudes, as detailed in Chapter 4. In addition, many measures are stakeholder group-specific and require them to be custom tailored to a specific issue of significance.

How Are Public Perception Measures Applied?

All public perception measures can be characterized as serving a validation capacity, but could very well lead to operational decisions as well, including significant modifications to a scheme's extent (see the associated Example text box). A sponsor contemplating the implementation of an area or cordon pricing scheme may view certain public perception measures as key to their performance evaluation program if, for example, a particular issue, such as user equity, is expected to be highly visible. Additionally, results of public perception measures may dictate necessary changes to customer service functions or public communication policies.

Survey instruments, focus groups, or interviews are generally used to collect data for public perception measures. These tools are described in greater detail in Section 6.2, and their advantages and disadvantages along with estimated costs are provided in Table 6-2. Generally speaking, these measures are more demanding and costly to collect and synthesize because of the user-specific, manual collection process required of attitudinal information. Because of this, their collection is often done on either a "before-and-after" or periodic basis. Surveyed public perceptions can be collected prior to the start of an area or cordon pricing program, either once or in several waves, and compared with similar results after implementation. Once operational, it may be desirable to continue to collect these types of measures on a periodic basis, such as annually or biannually, or as resources allow. Before-and-after surveys may focus on more market research, acceptance, and awareness issues, while periodic, post-opening-day performance measurement will likely focus on user satisfaction.

What is important to keep in mind when formulating measures of public perception is that they should address issues of public concern identified through a public outreach process. Given that no two cities' geographies, populations, transportation infrastructure, politics, and a host of other issues are the same, the key issues that are worth tracking and responding to before, during, and after project implementation are certainly more unique than alike. In this manner, public perception measures should be tailored appropriately to each project application.

Example: Public Perception Leads to Significant Operational Changes

A major proposed change to London's Congestion Charge in 2010 was the elimination of the Western Extension, which had effectively doubled the original Central London charging zone when added in 2007. The proposed retraction was initiated by Mayor Boris Johnson, elected in 2008, and a public [vote/survey was used to inform the decision]. Public perception of impacts to the local economy and the zone's residents were the impetus for the operational change—despite measureable reductions in traffic, increased use of alternative transportation modes, and improvements to the environment.

Facility Users

Facility Users represent the characteristics of those who make trips into, within, and out of the area or cordon pricing zone and the characteristics of the trips themselves. (For consistency with the other two forms of pricing, the term facility is retained, but in actuality a priced zone is not a facility per se.)

Representative Facility User Goals

Understanding who are the *users of a facility—users of the priced zone*—is critical to gaining acceptance of an area or cordon pricing program and ensuring its fair and successful deployment. One primary goal may be to identify and mitigate negative equity change for those who may be disadvantaged by the introduction of the priced zone—for example lower income commuters who drive into the priced zone for work and have few travel alternatives available (the special case of social equity is further discussed in Section 5.1.4). Goals may also be established for trip users' trip purpose such as a reduction in discretionary trips to ease others given higher priority such as transit or goods movement. Characteristics of a facility's users can be used as inputs to developing and measuring goals formulated under other evaluation subjects. For example, users' departure times, trip times-of-day, or origins/destinations can inform decisions on setting charging policies, which can be tied to goals of congestion reduction or revenue generation.

What Are the Facility User Measures?

Measures of facility users primarily focus on characteristics of the users themselves or the trips they take. Specific data on their accounts or charge transaction type are also found among those measures used in practice. The full list derived from current operating schemes is shown in Table 5-1. User characteristics include demographic and socioeconomic data, vehicle data, and home zip code or other residence identifying measures. Trip characteristics include, among others, frequency, departure times, travelshed determinations, overall trip length, and trip purpose.

How Are Facility User Measures Applied?

Measures of a facility's (priced zone's) users are made in a combined validation and operations capacity early on in the implementation and initial evaluation period of area or cordon pricing programs. As these schemes are expected to mature, facility user data is likely to become less significant, and may only be necessary to measure on either an infrequent basis or when a significant change in operation has occurred. As a cordon or area pricing program is considered and initially becomes operational, capturing the characteristics of its users (or non-users if the priced zone is avoided) such as socioeconomic and demographic characteristics is important in understanding if detrimental or inequitable impacts are occurring to certain groups. Operational or policy changes may be warranted to correct such findings. For example, physical adjustment to the priced zone's boundary or special accommodation (rebates, discounts or exemptions) to disadvantaged user groups may need to be introduced.

Performance Data in Stockholm Underpins a Successful Referendum

Stockholm became the second major urban area in Europe to implement congestion pricing with the permanent implementation of the Stockholm Congestion Tax on August 1, 2007. The decision to implement the system on a permanent basis was based on the outcome of local consultative referenda held in Stockholm and several surrounding municipalities on September 17, 2006. City residents approved the congestion tax by a margin of 51.3 percent. Local transportation planners in Stockholm credit this positive outcome on the extensive performance monitoring effort associated with a seven-month trial of the congestion tax from January 3 to July 31, 2006.

The prospect of a new and controversial tax, coupled with complicated legal and privacy issues, was cause for sharp political debate in the Swedish capital. Local polls showed that support for the tax was lowest right before the start of the trial period. However, support increased rapidly once the positive effects of the charging scheme became visible.[1]

In preparation for the trial, the Swedish government established a Congestion Charge Secretariat to plan, coordinate, and evaluate the outcome and communicate with the public. As part of its work the Secretariat established performance goals for the program together with a comprehensive evaluation program to assess the extent to which they would be achieved. The Secretariat's key findings from the trial included the following:

- Decrease in traffic volumes of 22 percent at the cordon during charging hours (half from commuters who shifted from driving to public transport, and half from consolidation, reduction, or new destinations for discretionary trips)
- Reduction in peak period delays of 33 percent on arterials leading into the city
- Public transport ridership increase of 6 percent
- Reduction of vehicle emissions in the inner city of 8 to 14 percent
- Marginal effect on trade and commerce

Overall, the Secretariat concluded that the goals for the trial were met, with an even greater-than-expected reduction in congestion, improved levels of CO_2 and particulates, and an improved city environment.

The Secretariat's comprehensive monitoring program was critical to validating the success of the trial and conveying the benefits of congestion pricing to voters in Stockholm. The decision to hold the trial and institute rigorous performance monitoring turned out to be a tactical success, without which transportation officials in Sweden do not believe it would have been possible to gain the needed approvals to make the congestion tax permanent. On a related note, officials involved with the failed campaigns to implement congestion pricing programs in Manchester and Edinburgh agree that the unsuccessful outcomes of referenda in those cities—82 percent voted against congestion pricing in Manchester—may have been different if similar trial and monitoring programs had been implemented prior to the vote.[1]

Of special significance to area or cordon pricing scheme sponsors is an understanding of the characteristics of users' trips. This information can validate whether the scheme is having the desired effect on managing trips into the priced zone—where the trips originate and conclude, how long they are, and for what purpose they are taken, like with user characteristics, can lead to operational or charging policy adjustments.

Collection methods and frequencies vary for user measures. Some measures, such as basic demographic data or vehicle classification (auto, taxi, small truck, large truck, public service vehicle, etc.) can be tracked through a customer registration/management process, if used by the scheme. The level of data available will depend on the technology used for the scheme. Many user measures can be obtained only through survey work, such as socioeconomic data and trip characteristics (e.g., trip length and purpose). Collection of these data is naturally done on an infrequent, as-needed basis. Comprehensive travelshed determinations may even require travel demand forecasting or modeling efforts.

System Operations

For the purposes of these guidelines, system operations refer to operational aspects of a priced zone that are not directly related to measures of traffic, as discussed in the Traffic Performance section. They are categorized in five ways:

- Finance
- Enforcement
- Safety
- Customer service
- System function

<u>Representative System Operations Goals</u>

A wide variety of goals can be set by and evaluated against *system operations*. A significant system operations goal is to collect a certain level of revenue, most likely to recoup the initial investment in establishing the scheme and to cover operating costs, but also potentially to improve or subsidize other travel options, such as transit. Safety is also an important goal for most all transportation infrastructure. Finally, priced zone sponsors may want to achieve established levels of customer service or targets of system equipment availability/accuracy.

<u>What are the System Operations Measures?</u>

Because of system operations' broad scope, a wide variety of measures are used to track this evaluation area as detailed in Table 5-1. Finance measures include revenue (charges, fees, etc.) and expenditures (O&M). Enforcement measures track data that includes violation data, fines, and penalties. Measures of safety often look at accident rates. A long and very detailed number of performance metrics can measure customer service, from volumes of inquiry and comments received (positive or negative), to customer service center response time and average inquiry resolution time. Application of these measures is highly dependent on facility sponsor preference, as discussed below. Finally, measures of system function focus on system and specific equipment availability and accuracy, numbers of equipment incidents, and repair rates.

Research for these Guidelines has shown that finance and safety are the two most prominent types of system operations measures used for area or cordon pricing schemes. Customer service and system function are also significant, although tracked by only one of the three schemes examined.

How Are System Operations Measures Applied?

Example: Revenue Usage in Stockholm

In 2008, revenue from Stockholm's congestion tax was approximately 850 million kroner, inclusive of the tax, administrative and late payment fees, and enforcement revenues. Operational costs amounted to about 393 million kroner, although this included several one-time charges. Estimated operational costs in 2010 and beyond were approximately 250 million kroner. Net revenues from the permanent charge (estimated to be 600 million kroner per year starting in 2010) have been reinvested in the Stockholm region's road network, unlike during the congestion tax's trial period when net revenues were invested in improving public transportation.

Finance: Among the five categories of system operations performance measures, financial performance data features the most prominently. In analyzing revenue collection targets and trends, total charge revenue and O&M costs were collected by two of three schemes examined, and are certainly collected for the third, but are not publicly available. The ability for priced zone programs to cover their operating costs as well as be able to repay their initial capital costs are a significant consideration for project sponsors because of the high level of resistance that can be expected when implementing these schemes. The use of significant public subsidies will only detract from their acceptance. However, based on existing experience, the level of charge necessary to have the desired (significant) effect on traffic reduction should yield revenue that will cover ongoing operating costs *and* result in a surplus. (London and Stockholm's pricing schemes yield net revenues that exceed operating costs by a factor of two to three.) Excess revenue can be reinvested to improve alternate modes of transportation and/or the existing roadway network within and around the priced zone. Such improvements are likely necessary both to absorb and attract users who switch modes (especially to transit) and to further bolster public acceptance for the scheme by transparently reinvesting the money collected rather than having it appear to be "just another tax." For pricing schemes with a variable charge rate structure, the average charge paid, highest charge paid, and total number of transactions are of interest to sponsors who look to manage the revenue collected.

Collection of toll revenue data is managed through ETC equipment and does not represent a significant cost once a facility is operational. The data is captured on an ongoing, real time basis and can be considered a must-have among performance evaluation measures.

Enforcement: Enforcement of charge payment requirements is an important measure to present to a public that expects a high level of integrity for a service that requires payment for use. Measures of enforcement such as violation rates and volume and revenue from penalties assessed are relevant in this case and help to validate the expectation for fair application of the facility's rules and requirements, as well as inform the sponsor who effective their enforcement practices are. Enforcement will likely take the form of camera-based system to photograph license plates of those without a valid transponder, or if an license plate reader system is used (as in London and Stockholm) to identify vehicles for which the charge is assessed, a bill is generated post-trip, with the option to charge a higher rate if not paid in advance.

Safety: Measuring safety is an important means to validate the benefits of area or cordon pricing. Reductions in vehicle collisions as well as accidents involving pedestrians or bicyclists can be tracked before and after scheme implementation. A reduction in traffic volume inside priced zone should naturally have a positive effect on safety conditions.

Customer Service: Confirmation of delivering high quality customer service can be evaluated by many measures—such as levels of customer inquiry (by phone or email) and quantitative customer service measures (e.g., inquiry answer time and resolution time). Scheme sponsors will want to consider tailoring a selection of these measures based upon role the agency plays in providing customer service functions, public outreach outcomes, and other needs. If the operation of the scheme is provided by a private entity to collect the charges and manage customer service, evaluation measures and reporting requirements can be specified in their contract.

System Function: Finally, validating the proper function of the priced zone's system equipment (and informing potential operational changes) can require certain performance evaluation measures. Drawing from other forms of congestion pricing along with the findings for area or cordon pricing, applied measures include system equipment availability (transponder or license plate readers, cameras, and other vehicle detection and monitoring equipment), the number of system incidents (failures, errors, etc.), and the mean time to repair the result of the incident. Collection of these measures can be built into the software that manages the systems and directed to produce reports as necessary.

Environment

Environment refers to aspects of the natural environment, such as air quality and noise that can be impacted by transportation infrastructure. The "urban" environment as may be evaluated based on quality of life is not explicitly included within this evaluation area. Measuring improvements in the urban environment or quality of life is imprecise and dependent upon specific factors of interest to scheme sponsors, stakeholders, and the public. It is characterized through measures captured across several evaluation areas, including the (natural) environment, traffic performance, public perception, and economics.

Representative Environment Goals

Area and cordon pricing schemes expected significant reductions in urban traffic levels often are accompanied by similarly aggressive environmental goals. Targeted reductions in National Ambient Air Quality Standards criteria pollutants (NO_x, CO, particulates, etc.), volatile organic compounds, greenhouse gases, and CO_2 are primary goals. Reductions in ambient noise levels are others.

What are the Environment Measures?

Measures of the identified pollutants listed under Goals above, as well as noise levels, are the environment measures included in evaluation programs for area and cordon pricing programs.

How Are Environment Measures Applied?

Calculating changes in air quality requires using traffic performance data, including traffic volumes and speeds as inputs to air quality forecasting tools, such as EPA's MOBILE6 Vehicle Emission Modeling Software. Air quality monitoring stations may already exist in the locations to be analyzed and should be incorporated into the scheme's performance evaluation program. Additional equipment can be deployed as needed. This work may require coordination with local, state, or federal environmental agencies. Reduction in noise requires deployment of targeted sound level measurement equipment in areas of concern; collected data can be compared to that before scheme implementation.

Transit

Transit refers to aspects of transit service that operate within the same region as the area or cordon pricing zone, especially those that provide access to the zone itself. Both bus and rail service is considered as alternate modes of travel to access the priced zone.

Representative Transit Goals

Goals related to *transit* service are of primary concern to priced zone scheme sponsors because having alternate modes available is a mandatory requirement for successful implementation. Increased ridership is a primary goal, indicative of a successful mode shift away from personal vehicles entering the priced zone. Related goals focus on improving specific aspects of service—frequency, timeliness, areas served, quality, and subjective indicators of customer satisfaction.

Example: Promoting Consideration for Transit

Singapore's Land Transport Authority (LTA) is responsible for the country's roads and public transportation systems, including heavy and light rail, buses, and taxis. One main goal of its Electronic Road Pricing (ERP) program is to encourage commuters to choose the most appropriate transportation mode. ERP optimizes the use of the city-state's constrained road capacity and strongly incentivizes public transportation, which has benefited from significant investments in parallel with 35 years of cordon pricing. Ambitiously, LTA has set a target of making 70 percent of all morning peak hour trips on public transport by 2020. Transit travel times from location benchmarks throughout Singapore have been established and are used to monitor the reliability of service.

What are the Transit Measures?

Aspects of transit service include performance, ridership, finance (revenue), and quality of service (as measured attitudinally through customer surveys). Research indicates that transit performance was measured in two of the three schemes by examining travel times, on-time rates, or excess wait times (delay); average speeds; and ridership or boarding counts. Average vehicle occupancy, farebox revenue, and quality, satisfaction, and reliability as perceived by customers were also employed by at least one pricing program. The more comprehensive number of metrics used for priced zones than for variably priced managed lane or toll facilities indicates the greater role transit plays in successfully operating these schemes and the importance of documenting the results.

How Are Transit Measures Applied?

If the sponsor of the area or cordon pricing scheme also operates the region's transit service, acquiring transit performance data is not difficult. Otherwise such data needs to be acquired (if it exists) from individual transit agencies. Obtaining the performance data sought, however, requires establishing a good working relationship with that agency and coordinating data collection efforts.

Economics

Economics refers to a broad range of economic indicators and trends within the region affected by an area or cordon pricing program. Equally they may include macro level quantifications of economic health as well as individual examinations of impacts to particular economic sectors, such as specific businesses or urban activities.

Representative Economics Goals

Unlike with variably priced managed lane or toll facilities, economics is likely to be an important consideration for area or cordon pricing projects because the expected significant reduction of vehicular traffic within the zone could have a measured impact, perceived or otherwise, on economic activity—both at a macro scale and individually on certain sectors. Goals may include having no net loss in economic activity or adverse effect on particular services, or more ambitiously, an increase in economic activity due to improved access, mobility, or a desirability to operate a business or conduct commerce with the zone because of an improved urban environment.

What are the Economics Measures?

Economic measures are shown in Table 5-12 and Table 5-13. Economic impacts at the macro level are measured by gross regional product or other economic indices that quantify activity in the priced zone's region at an aggregate scale.

Specific economic impacts focus on businesses and property. General business performance of commercial establishments, most easily captured through openings and closings, were found in two of the three schemes examined. Measures of retail patronage and sales were also quantified. Other measures employed in the case of one scheme include a qualitative service-by-service analysis of specific business sectors or worker populations, measures of business costs and prices, and impacts to tourists. Property impact measures include residential and commercial values, as well as sales and rental volumes.

Finally, unlike the findings from the other two forms of congestion pricing, research indicates that area and cordon pricing have leant themselves to performing benefit-cost analyses. This result may be indicative of the greater economic impact these schemes can have, as well as need to further justify instituting such a marked change to managing traffic within a region. It may also highlight the traditional lack of applying benefit-cost analyses to transportation improvement projects in the U.S.

How Are Economics Measures Applied?

Applying and analyzing economic impacts measures will require quantification of baseline economic activity level before scheme implementation, as well as control factors for other external impacts to the economy to definitively attribute economic impacts to the introduction of a priced zone. Obtaining measures of economic activity may rely on data collected by a city's economic development organizations, departments of revenue, and others. Specially designed survey will be needed to target particular economic sectors, businesses, or populations to focus on the effects of the pricing program. Economic modeling can also be performed as a substitute or complement to selected quantitative findings.

Land Use

Performance measures to evaluate a priced zone's impacts on land have been used in practice by one of the three schemes examined. Tracking patterns of residential and commercial development may be of interest to program sponsors, but the results of which would be a long-term outcome, as land use patterns would require significant periods of adjustment before measureable results could be achieved.

Chapter 6 Integrating Performance Evaluation and Measurement with Public Outreach

To date, interest in performance measures for facilities with congestion pricing has been relegated to technical discussion between planners and engineers tasked with developing these facilities. From a public education perspective, this is unfortunate because it is often decisions made on individual performance element thresholds that ultimately will drive positive (or negative) public opinion on a project. As a case in point: the top two reasons why a customer will consider using a congestion-priced facility—travel time savings and trip reliability—are performance based. For the public projects currently operating or being considered, key performance targets are often prescribed by the major funding proponent, FHWA. For example, a mandate of maintaining an average travel speed of 45 miles per hour (mph) at least 90 percent of the time on HOV lanes and priced HOT lanes is a common threshold performance standard established by FHWA that drives many supporting operating decisions.

In the case of the conversion of an HOV facility to HOT operation, it may be necessary to make some radical changes to the existing operations in order to meet the 45 mph speed mandate following the conversion. This may involve charging users who previous had no-toll access to the managed lanes, altering or closing some restricted lane access or exit locations, and/or requiring transponders or registration for users who used to be able to make a spontaneous choice to use the facility. These types of changes all have major implications that impact the public's positive perceptions of congestion-priced facilities as an acceptable travel option. In addition, congestion pricing involves the exchange of "money for service" which also introduces the associated expectations about how much money will be collected, who gets to keep it and how it will be spent. In the face of all these public acceptance challenges performance measures are vital in documenting the benefits of congestion pricing and then securing public knowledge and maintaining public support.

6.1 Advantages and Drawbacks of Including Performance Measures in the Public Outreach Process and How Existing Facility Characteristics Shape a Future Facility Vision

Integrating the concept of performance measures as the catalyst for decisions about congestion-priced facility operations can have three major benefits in the public affairs arena.

- **Performance monitoring presents existing conditions in a scientific manner.** Although painful and sometimes politically uncomfortable, sharing information on existing conditions openly and honestly with the public helps them to understand that change really is necessary. It is frustrating, expensive and counterproductive to try to convince people to support a solution if they do not believe there is a problem. For example, many HOV lanes experience periods of excessive demand resulting in the same congestion these lanes are supposed to offer an alternative to, and addressing this condition first means sharing information about why steps such as pricing need to be considered to regain lost benefits.
- **Performance monitoring establishes quantifiable benefits and trade-offs resulting from a congestion-priced facility.** Sharing anticipated performance of the congestion-priced facility builds public trust and confidence. Performance metrics should demonstrate how travelers, communities, business, and environmental and other special interest will be better off as a result of the priced facility.

Performance monitoring diffuses mistrust, disappointment and negative feelings about decisions that may be unpopular with specific markets, putting the focus on the project, not the personalities. A focus on existing and desired performance metrics as the blueprint for operational changes helps to maintain a decision making process that is separated from conflicting political and/or special interests. For example, in the case of converting an existing HOV lane to a congestion-priced facility, negative perceptions among HOV customers that may be excluded from future “no toll” travel will certainly arouse dissatisfaction. Maintaining free use or increasing occupancy requirements may have quantifiable benefits to the corridor and region. These thousands of travelers need to be persuaded that a change in facility operations will be to their benefit. One powerful method to achieve that outcome is to acknowledge the poor existing performance of “their” lane/s and to share a vision of what future travel can be like as evidenced by anticipated performance. While a win-win outcome may not be possible for all affected customers, an outcome that is both rational and objective, and founded on the region’s adopted goals and objectives provides a good framework for constituent support.

At the same time, highlighting performance standards as the catalyst for change also presents some risks:

- **Performance monitoring fosters closer scrutiny of individual performance standards and outcomes.** Sharing existing and anticipated performance takes nerve! It puts planners, modelers and mathematicians on notice that no longer is this data reserved for a select few or those “in the know.” Extra care needs to be taken to make certain that existing conditions information as well as anticipated performance is adequately collected from reliable sources, checked to verify accuracy and vetted for review prior to release. To secure and maintain the public’s confidence, project officials need to be well-versed in the details of how and when existing condition information was gathered, and how future condition performance measures are calculated.
- **Performance monitoring increases pressure to prepare alternative actions in case desired outcomes do not materialize.** When there is transparency and full disclosure about future facility expectations – as in the case of fully vetted performance measures – there is always the increased pressure to have back-up strategies in place if anticipated results do not materialize after the project has been implemented. While some level of back-up plan should always be prepared, there will likely be more public scrutiny of individual performance measures as a result of increased prominence during the outreach and education process.

While the process of converting a roadway facility to a more restrictive use may technically be the most straightforward and simple way to introduce pricing, it is a challenge from a public perspective. Newton’s Third Law of Motion “For every action there is a reaction” can hold true when introducing congestion pricing.

If the introduction of pricing has little impact or requires little change or “action” on the part of the current facility users, then there will likely be relatively little resistance to the change. However, as the change elements—or action—increases, then the pushback, or “reaction” will likely increase as well. In the United States, almost all variably priced managed-lane facilities began their “restricted access lives” as HOV lanes, or at a minimum offered HOV preferential access. With the exception of I-95 in Miami, existing HOV users were required to make relatively minor changes to stay in compliance as a result of the introduction of pricing. Table 4.1 documents the changes in HOV policies that occurred with the introduction of variable pricing on the seven HOT lane facilities for which case studies were prepared as part of this research effort.

TABLE 6-1: CHANGES IN HOV OPERATIONS AFTER HOT CONVERSION

Project	HOV Operations Before Conversion	Changes to HOV Operations after Conversion
I-25 Express Lanes Denver, CO	• Two-lane reversible facility • 2+ HOVs and registered • hybrids allowed access • Motorcycles allowed access • Under 10% violation rate • Six minute bus headways from of park-and-ride lots	• No capacity added – conversion required operational changes only • No occupancy requirement changes • HOVs and hybrids not required to carry transponder but must use a "declaration" lane at the toll gantry mid-way down the project • Free motorcycle access continued • SOVs pay toll for access • No trucks allowed (same as before conversion)
I-95 Express Lanes Miami, FL	• One lane directional facility • 2+ HOVs and hybrids allowed access • As high as 80% violation rate • One lane directional facility • • Limited transit service	• Added one new lane of capacity and converted existing HOV lane to comprise the two-lane directional priced facility (4 lanes total) • Only 3+ HOV with prior registration may use priced lanes at no charge • SOV hybrid users must have a FL State Decal and a an I-95 Express decal to use lane at no charge • SOVs, non registered 3+ HOVs, non registered Hybrids and HOV2 pay toll • No trucks allowed (same as before conversion)
I-10 "Katy Freeway" Managed Lanes Houston, TX	• Previous single-reversible HOV lane operated with 3+ restriction in peak-hours and 2+ outside the peak for most of the daytime hours (replaced with a new roadway facility as part of freeway reconstruction)	• Built two new managed lanes in each direction facility. • 2+ HOV and motorcycles travel for free 5 - 11 am and 2-8 pm. Required to pay at all other times • HOVs not required to carry a transponder but must enter the facility through "declaration" lane • SOV's, hybrids and small commercial vehicles allowed access for toll

TABLE 6-1: CHANGES IN HOV OPERATIONS AFTER HOT CONVERSION (CONTINUED)

Project	HOV Operations Before Conversion	Changes to HOV Operations after Conversion
Minnesota "MnPass Lanes" I-394 I-35W Minneapolis, MN	• 2+ HOV and motorcycles allowed access • I-394: Two-lane reversible and single lane directional facility • I-35W: limited single directional lanes • Significant transit service	• I-394: No capacity added – conversion required operational changes only • I-35W: Freeway modified and reconstructed with new capacity designated as priced lanes • 2+ HOV travel at no charge • HOVs not required to carry transponder • Free motorcycle access continued • Hybrids and SOV's allowed access for toll • No trucks allowed
SR-91 Express Lanes Orange County, CA	• Opened in 1995 as first privately funded tollroad built in US in 1940s. Project did not exist as an HOV lane as it opened as a priced lane under private ownership • Purchased by Orange County Transp. Authority in 2003 • Generally allowed 3+HOVs with transponders free use • No trucks	• Two-lane directional facility (4 lanes total) • Limited ingress and egress points only on each end • HOV3 motorists are typically allowed to use the facility free of charge, with the exception of the p.m. peak period from 4:00 to 6:00 p.m. eastbound, when they are required to carry a transponder and pay 50 percent of the established toll. • All other users pay toll via transponder • Limited transit service • No trucks allowed
I-15 Express Lanes San Diego, CA	• 2+ HOV, hybrids with HOV Access Clean Air decal and motorcycles allowed access • 8 mile 2-lane reversible facility • Limited access on each end • Limited transit service	• No capacity added initially – conversion required operational changes only • No occupancy requirement changes • All HOVs and hybrids with HOV Access Clean Air decals are not required to carry transponders • Free motorcycle access continued • SOVs pay toll for access • No trucks allowed • Project has since been expanded and lengthened to a facility that can operate as 3-1, 2-2 or 1-3 directional configuration

TABLE 6-1: CHANGES IN HOV OPERATIONS AFTER HOT CONVERSION (CONTINUED)

Project	HOV Operations Before Conversion	Changes to HOV Operations after Conversion
SR-167 HOT Lanes Seattle, WA	• 2+ HOVs and Motorcycles allowed access • 11 mile single-lane directional facility • Only two adjacent general purpose lanes in each direction • Unlimited access locations to HOV lane • Limited transit service	• No capacity added – conversion required operational changes only • No occupancy requirement changes • HOVs not required to carry transponders • Free motorcycle access continued • SOVs and hybrids pay toll for access • Access to HOT lane at designated locations only • No trucks allowed
I-15 Express Lanes Salt Lake City, UT	• 2+ HOV, hybrids with decals • and motorcycles allowed access • Single directional lanes in both directions • Unlimited access • Limited transit service	• Started with decal program to registered SOVs willing to pay $50/month for unlimited use, transitioning to toll for SOVs with transponders • No capacity added– conversion required operational changes only • No occupancy requirement changes • All HOVs and hybrids are not required to carry transponders • Free motorcycle access continued • SOVs pay toll for access • No trucks allowed • No transit service changes

As shown in Table 6-1, the vast majority of HOV to HOT conversions have required very little change on the part of the existing HOV customer. For the most part, access to new customers groups was added, but not at the expense of removing benefits to existing HOV's. Future projects, however, will likely require more significant operational changes in order to ensure operational benefits and achieve financial objectives. Fewer and fewer HOV lanes have excess capacity to "sell," so a conversion to a congestion-priced facility will require adding capacity and/or changing access requirements. Public education and outreach will become incrementally more important as the challenges facing HOV to priced lane conversion increase.

When considering the conversion of an existing free-of-charge facility to one where pricing is an element for access, establishing and sharing "baseline" conditions—which in layman's terms essentially means "just how bad is it now"—is elemental to beginning to secure support for changes being considered. Public buy-in on the legitimacy and accuracy of existing conditions is essential to the project's ability to garner support for change. Undertaking market research activities, such as those described in Section 4.2 of the Guidelines, in an unbiased manner will document where public opinion and reality intersect and where they diverge. Ongoing education and outreach activities should focus on those areas of deviation.

6.2 Market Research – Preparing for the Congestion Pricing Conversation

The way in which outreach and education are managed during the very early stages of considering the possible use of congestion pricing consideration may have more impact on the ultimate public acceptance outcome than at any other point in the overall planning and implementation process. From an outreach and education perspective, the initial outreach efforts focus on market research – the gathering and documenting of attitudes and opinions about existing traffic/freeway conditions and knowledge of congestion pricing. These very targeted initial outreach activities will highlight areas of agreement, disagreement and misunderstanding and provide the messaging template for future education and outreach actions. The information secured from market research should guide the technical team in envisioning a congestion-priced facility that meets project goals and objectives, satisfies the public's travel desires, and mitigates and/or minimizes documented objections to change.

In the case of converting HOV lanes to priced operations, pricing should be explored because the **performance** of the existing HOV facility is failing or not fully meeting expectations in one or more categories. Overcrowding, empty lane syndrome or high violation rates are among the most obvious reasons to the general public for considering a change in operations. Documenting the existing attitudes and opinions of a variety of different market groups on the performance of an HOV lane will help project sponsors identify those areas of most and least satisfaction, and guide the planning team as they consider potential operational changes.

Although always tempting, for the most part it is best to refrain from promoting a specific congestion pricing concept at this early information gathering stage. Rather, it is the time to determine prevailing attitudes, opinions and beliefs. Ultimately, it is those beliefs around which the education and promotion strategy for congestion pricing will need to be crafted. This is the "**listening**" stage of the project, and documenting inaccurate perceptions (toll booths on the freeway, unsafe operations, lots of violators) are as important as noting areas of agreement. The exception is "meeting" type forums, where conversations about the advantages and disadvantages of congestion pricing provide opportunities to clarify and elaborate on congestion pricing concepts.

As described below and shown in Table 4.2, there are many different research tools are available for eliciting attitudinal information; each with advantages and drawbacks. While the information provided here and in the accompanying table is not exhaustive, they provide summaries of approaches that have proven to be most useful in planning and evaluating priced facilities from a public perspective.

6.2.1 Focus Groups

A focus group discussion is a flexible research technique use to gather qualitative or exploratory information regarding individual perceptions of an idea or product. Small groups (usually 8 – 12 people) freely discuss a set of predetermined topics under the guidance of a trained moderator following an outline script. Focus groups are useful for sampling traveler opinions and attitudes regarding existing HOV lane performance, as well as testing new pricing concepts and exploring concerns and expectation in some depth.

Because focus groups are relatively small, they are not designed to provide precise statistical quantification of the issues under discussion, rather, they are designed to explore key issues in greater depth and highlight related attitudes and convictions. In-depth and/or significant insights are obtained at the expense of the more precise quantification available through large sample sizes of survey research. The insights obtained through focus group research discussion can, however, be applied to the development of formal surveys designed to permit more precise statistical quantification of key issues.

Focus groups can be used to pre-test congestion pricing marketing messages, probe awareness of existing priced facilities, sample driver opinions and attitudes about congestion pricing and explore public concerns and convictions in some depth. Most importantly, identifying and prioritizing performance measures, and quantifying levels of performance acceptability of a congestion-priced facility can be discussed in depth at a focus group. For these purposes, focus group participants should be composed of corridor drivers, employee organization representatives, carpoolers and transit users, community leaders or survey respondents.

While focus groups are relatively easy to manage, they yield subjective information and should not be used to support quantitative estimates or rank alternatives. They are most effective in exploring a participant’s direct experience and reactions.

6.2.2 Telephone Surveys

Telephone surveys are conducted by trained interviewers following a predetermined script with a statistically sampled population of residents or drivers.. Telephone surveys can be used to gather travel information and data, measure public opinions and attitudes, document awareness regarding existing priced facilities, record travel or mode shifts and track project acceptance over time. A well-designed and carefully executed telephone survey can document public reaction to congestion pricing with statistical precision and provide insights into the relative effectiveness of different campaign messages and media channels.

A minimum of 400 surveys is generally necessary to guarantee that measured responses are within 5 percent of statistical validity.. If the survey sample is to be subdivided significantly during analysis, a larger sample size will likely be necessary. Uncertainties regarding appropriate sample size should be resolved by consulting a statistician.

6.2.3 Mail-Back Driver Surveys

Mail-back driver surveys involve short questionnaires that are either distributed to drivers at sampling stations such as freeway on-ramps or mailed to registered owners of vehicles whose license plates were recorded using the project corridor. Mail-back surveys can be used to document attitudes, develop origin/destination data and document mode and route shifts. Mail back surveys can range from simple postcards designed to capture origin/destination data to more elaborate questionnaires documenting awareness, attitude, commute choices and demographic characteristics. Typically, the longer the questionnaire, the lower the response rate.

The advantage of mail-back questionnaires is that they can be distributed directly to the driving population in the corridor(s) affected by the proposed congestion-pricing project. While more difficult to track campaign awareness through mail-back surveys than through telephone surveys (unaided recall cannot be easily tested through mail-back survey, for instance) issues regarding perceptions, attitudes and mode choice can be pursued equally well by mail or phone.

6.2.4 On-Board Surveys

On-board surveys involve distributing questionnaires to transit riders as they board the vehicle and either collected when they leave or returned by mail. These surveys serve the same purpose for transit riders that mail-back surveys do for motorists traveling in the same corridor.

6.2.5 Internet-Based Surveys

Internet-based surveys are becoming an increasing popular method to document attitudes and opinions. Typically internet-based surveys, collected via a website or e-mail, allow for the creation of an unlimited number of questions. Many internet-based surveys customize the path respondents take to complete the survey by adding skip logic. This eliminates unnecessary confusion by skipping non-applicable questions and reduces "drop-outs" and overall frustration. Filter and cross tabulating data is relatively quick, and easy, as is developing custom charts for presentation. Results can be viewed “live” as they are recorded, responses can be browsed individually and there is usually the opportunity to include opened-ended comments.

The most obvious downside of using this type of survey is the difficulty determining/controlling selection probabilities, which ultimately hinders quantitative analysis of data. Samples can be skewed toward a younger demographic compared to telephone interviews, and if not password protected, these types of surveys are easy to manipulate by completing multiple times to skew results. Internet-based surveys are not considered statistically reliable.

6.2.6 Executive Interviews

Face-to-face interviews with representative opinion leaders and decisions makers are often conducted to gauge congestion-pricing perceptions and institutional issue concerns held by key groups. Executive interviews, which usually last less than an hour, can help to heighten the visibility and viability of congestion-pricing as an effective traffic management technique and/or revenue generation technique. Interview questions are designed to assess attitudes regarding a variety of pricing scenarios, and can help to identify where there is the greatest consensus and where there are the greatest differences. Interviews are also useful for establishing liaisons with business, environmental and political leaders and help to identify opportunities of regional partnership in building community awareness and support for congestion-pricing. Finally, executive interviews help to document the communication challenges foreseen by the interviewees and solicit participant assistance facilitating broader communication of the study process and ultimate outcomes.

Like focus groups, executive interview provide in-depth insights, but have no statistical validity.

Table 6-2 compares the relative costs and advantages and disadvantages of the different market research tools described above. It also identified specific ways in which they can be used to obtain helpful information on public perception of issues germane to congestion pricing.

TABLE 6-2: ADVANTAGES AND DISADVANTAGES OF MARKET RESEARCH TOOLS

Research Tool	Advantages	Disadvantages	Performance Monitoring Use
Focus Groups $3,500-$7,000 per focus group	• Flexible • Easy to assemble • In-depth exploration of key issues • Direct presentation of marketing concepts • Freedom of interaction between facilitator and group • One-way mirror/videotape viewable	• Not statistically precise • Group may defer to loudest voice	• Good forum for give-and-take conversation about performance elements • Secure input by market segment on desirable levels of performance
Telephone Surveys $15-30/ completed survey	• Structured • Relatively high response rates (40% - 60%) • Encourage frankness • Easy to screen for desired subpopulations • Immediate responses	• Unlisted / cell phone numbers may add to sampling bias • Unable to use visual aids • Necessarily short • Unable to interact freely with subject	• Can test awareness/ opinion about a variety of performance measures • Can cross reference performance measure(s) input and importance to individual demographic
Mail-Back Driver Survey $10 - $20/completed survey	• Automobile user population clearly defined • Relatively low cost • Can be statistically valid	• Distribution may disrupt traffic • Relatively low response rate (20%-40%) can introduce non-respondent bias • Privacy issues if license plate are used to generate sample • Limited number of questions • Response time drawn out	• Can match driver attitudes and opinions with facility performance at specific sites

TABLE 6-2 ADVANTAGES AND DISADVANTAGES OF MARKET RESEARCH TOOLS (CONTINUED)

Research Tool	Advantages	Disadvantages	Performance Monitoring Use
On-Board Transit Survey $8 - $15/ completed survey	• Transit users population clearly defined • Relatively low cost • Can be statistically valid	• Population limited to transit users and biased toward frequent users • Limited number of questions	• Ability to match respondent to transit route/corresponding facility performance
Internet-based Survey $4 -$10/ completed survey	• Can be developed and fielded quickly • Can provide targeted information from a specific audience with appropriate fielding parameters (i.e.: fielded only at a specific worksite)	• Data can be skewed due to repeat participants • Not statistically valid • Limited to people with access to internet	• Can quickly provide "birds-eye view" feedback on performance attitudes and opinions
Executive Interviews $400 - $800/ interview	• Flexible • Permits in-depth exploration of key issues with decision and opinion makers • Allows freedom of interaction between interviewer and participant • Supports exploration of institutional issues • Establishes early project liaison/relationship between interview participant and project	• Not statistically valid • Not representative of public at large	• Documents in-depth exploration of decision-maker perceptions of existing performance and expectations of performance with pricing • Identifies institutional challenges • Documents knowledge and perceptions gaps and misinformation

6.3 Constituency Building through Public Education and Outreach

Sponsors of congestion pricing projects should use the information on public opinion gathered from their market research activities to refine their pricing concept and ultimately identify pricing policies that will appeal to the widest possible cross section of the public. Once a pricing concept has been selected, the focus of project outreach efforts changes to constituency building. Constituency building is designed to secure broad-based support for the congestion-priced facility, recognizing that different issues or aspects of the pricing project will be of interest to different groups. In order to be most effective, constituency building activities must be tailored to different audiences or interest groups and focus on their areas of interest.

Constituency groups with an interest in the use of congestion pricing may include the following:

- Elected Officials;
- Transit Agencies and Advocates;
- Environmental Advocates;
- Employers;
- Public Agency Staff;
- The Media;
- Neighborhood Groups;
- Special Event Groups;
- Trucking Interest;
- Services Organizations;
- Taxi and Rental Car Industry; and
- Retailers

In order to arrive at a positive outcome, the constituency building activities for congestion pricing projects should include the following steps:

- **Segment audiences** by common interest and priority to the success of the facility
- Indicate the **outcome** (action you want them to make, knowledge you need them to have) from the communication effort
- Highlight the **information** that will be of most interest to that audience
- Identify the most effective **location** to provide information – work, home, public facility, etc.
- Determine the most effective **communication tool** (print, broadcast or web/social media advertising; direct mail, media relations, hotlines, displays, corridor tours, neighborhood or employment-site meetings, etc.) for those individuals and locations
- Identify the important **milestones** in the communication process

Validating the Cost of Subsidizing a HOT Lane's Operation

One major challenge that the Washington State Department of Transportation (WSDOT) has faced with the SR 167 Hot Lanes demonstration is conveying to the public and elected officials that the Department's intent in converting the HOV lanes to HOT operation was not to generate revenue but rather to manage the operation of its existing infrastructure to improve traffic service and the overall efficiency of the SR 167 corridor. In spite of this, the legislation enabling the SR 167 demonstration requires WSDOT to report on the "ability to finance improvements and transportation services through tolls [collected on the SR 167 HOT lanes]."

It is known, however, that the SR 167 HOT lanes operate at a deficit, with operating costs exceeding average monthly toll proceeds by a factor of nearly three. This has caused some to question the rationale behind the conversion. However, WSDOT's modest investment of $60,000 per month, or $720,000 per year, has resulted in a 21.5 percent increase in average peak period speeds on the congested SR 167 general purpose lanes and an 11 percent increase in average volumes in the corridor. The reality is that the cost of subsidizing the operation of the SR 167 HOT lanes is pennies on the dollar compared to the cost of implementing physical enhancements to SR 167 that could achieve the same level of congestion reduction as the HOV-to-HOT conversion. WSDOT's challenge has been helping its stakeholders understand the overall value for money that the project brings. (This challenge may be eased, as WSDOT anticipates that toll revenue will continue to approach operational costs and eventually the system will break even.)

Education and outreach efforts offer multiple opportunities to build understanding and support for performance measures as unbiased indicators of a priced facility's success. Comparing and contrasting individual performance measures of the existing (and likely poorly functioning) facility to the anticipated performance of the newly-priced facility during this phase helps to diffuse distrust of change as well as build accurate expectations for future operations.

Individual performance data elements will have varying interests given the audience. When considering the congestion pricing project, the outreach specialist will have to secure and translate individual performance data to help it become "real" to specific audiences. Sharing information on existing conditions as well as anticipated or actual outcome data will build interest and trust—and ultimately cultivate new congestion pricing champions. For example, the trucking industry will be very interested in how the introduction of congestion-priced lanes would influence traffic volumes at different times of the day. They will likely support the project if it increased windows of uncongested periods of time during which they can schedule deliveries. This may have a significant impact on their financial bottom line, and as such create a constituency of interest and support for potential priced facilities.

Table 6-3 indicates the likely level of interest in different performance measures identified in Chapter 3 across the 13 market constituencies listed at the beginning of this section of the guidelines. Before engaging in outreach or education activities with these groups, sponsors of congestion pricing projects should review which particular performance indicators will be of strong interest to the group and then tailor information to focus on those areas to achieve the greatest potential of gaining their support.

TABLE 6-3: PERFORMANCE MEASURE INTEREST BY MARKET

● Strong Interest
⦿ Some Interest
○ Limited Interest

	Elected Officials	Environmental Interests	Transit Agencies	Media	Public Agency Staff	Employers	Neighborhood Groups	Special Event Groups	Enforcement Agencies	Trucking Interests	Services Movement Orgs	Taxi/Rental Car Organizations	Retail Interests
SYSTEM IMPACTS													
Volume & Throughput													
Average Daily Traffic Corridor	●	●	●	●	●	⦿	○	○	○	●	●	●	○
Average Daily Traffic Priced Lane(s)	●	●	⦿	●	●	⦿	○	○	○	●	●	●	○
Traffic Volume Weekly GP Lanes	⦿	⦿	●	⦿	●	⦿	○	○	○	●	●	●	○
Traffic Volume Weekly Priced Lane(s)	⦿	⦿	⦿	⦿	●	⦿	○	○	○	●	●	●	○
Average Daily People Volume GP Lanes	●	●	●	●	●	⦿	●	○	○	⦿	⦿	⦿	⦿
Average Daily People Volume Priced Lane(s)	●	●	●	●	●	⦿	●	○	○	⦿	⦿	⦿	⦿
Speeds & Travel Time													
Peak Hour Travel Time in GP Lanes	●	⦿	●	●	●	●	⦿	●	○	●	●	●	⦿
Peak Hour Travel Time in Priced Lane(s)	●	⦿	●	●	●	●	⦿	●	○	●	●	●	⦿
Delay in GP Lanes	●	⦿	●	○	●	●	⦿	●	●	●	⦿	●	●
Time savings in Priced Lane(s)	●	⦿	●	○	●	●	⦿	●	○	●	⦿	●	●
Cost of Delay	●	⦿	●	○	●	●	○	○	○	○	○	○	○
Occupancy													
Mode share/split	●	●	●	⦿	●	⦿	⦿	●	○	○	○	⦿	○
Average Vehicle Occupancy	●	●	●	○	●	⦿	○	⦿	○	○	○	⦿	○
Parking													
Park-N-Ride Activity (lot counts)	⦿	●	⦿	⦿	●	○	●	⦿	○	○	○	○	○

TABLE 6-3: PERFORMANCE MEASURE INTEREST BY MARKET (CONTINUED)

● Strong Interest
⦿ Some Interest
○ Limited Interest

	Elected Officials	Environmental Interests	Transit Agencies	Media	Public Agency Staff	Employers	Neighborhood Groups	Special Event Groups	Enforcement Agencies	Trucking Interests	Services Movement Orgs	Taxi/Rental Car Organizations	Retail Interests
User Characteristics													
UTILIZATION													
HOV Usage	●	●	●	●	●	⦿	●	●	●	○	○	○	○
SOV Usage	●	●	●	●	●	⦿	●	●	●	○	○	○	○
Hybrid Usage	●	●	⦿	●	●	⦿	●	○	●	○	○	○	○
Demographics/Socioeconomics	●	●	●	●	●	●	●	●	○	○	○	○	⦿
Trip Characteristics													
Frequency of Use	●	⦿	⦿	●	●	⦿	⦿	○	○	○	○	○	○
Departure Times	⦿	○	●	⦿	●	⦿	●	○	○	○	○	○	○
Trip Length	⦿	●	●	⦿	●	⦿	○	○	○	○	○	○	○
Reason for Use/Trip Purpose	⦿	⦿	⦿	⦿	●	⦿	○	●	○	○	○	○	●
OPERATIONS													
Finance													
Revenue	●	●	●	●	●	●	●	○	○	○	○	○	○
Average Toll	●	●	●	●	●	●	●	●	⦿	●	●	●	●
Enforcement													
Violations	●	⦿	⦿	●	●	○	⦿	○	●	○	⦿	⦿	○
Penalty notices issued/paid/unpaid	⦿	○	○	●	●	○	○	○	●	○	○	○	○
Representations & appeals	⦿	○	○	●	⦿	○	○	○	●	○	○	○	○
Safety													
Collisions	●	⦿	●	●	●	⦿	⦿	⦿	●	●	⦿	●	○
Incident Response Time	⦿	⦿	●	●	●	⦿	○	⦿	●	●	●	●	⦿
Speed Differential	○	○	●	⦿	⦿	○	○	○	●	⦿	⦿	●	○
On-the Job Injuries	○	○	●	⦿	⦿	○	○	○	●	○	○	○	○
Customer Service													
Call center performance	⦿	○	○	⦿	○	○	○	○	○	○	○	○	○
Call/Email activity	○	○	○	○	○	○	○	○	○	○	○	○	○

TABLE 6-3: PERFORMANCE MEASURE INTEREST BY MARKET (CONTINUED)

● Strong Interest
◉ Some Interest
○ Limited Interest

	Elected Officials	Environmental Interests	Transit Agencies	Media	Public Agency Staff	Employers	Neighborhood Groups	Special Event Groups	Enforcement Agencies	Trucking Interests	Services Movement Orgs	Taxi/Rental Car Organizations	Retail Interests
ENVIRONMENT													
Air Quality													
CO emissions	●	●	◉	●	●	◉	●	○	○	○	○	○	○
VOC/TOG Emissions	●	●	◉	●	●	◉	●	○	○	○	○	○	○
Nox/NO2 emissions	●	●	◉	●	●	◉	●	○	○	○	○	○	○
Noise													
Noise Levels	●	●	◉	●	●	◉	●	○	○	○	◉	○	○
Fuel Consumption	●	●	◉	●	●	●	◉	○	○	●	●	○	○
TRANSIT													
Performance													
General Operational Impacts	●	●	●	●	●	◉	○	○	○	○	○	○	○
Travel times/On-Times/Excess Wait	●	●	●	●	●	◉	◉	◉	○	○	○	○	○
Average Speed	◉	●	●	◉	●	◉	◉	◉	○	○	○	○	○
Occupancy													
Ridership	●	●	●	●	●	◉	○	○	○	○	○	○	○
Average Vehicle Occupancy	◉	◉	●	◉	●	○	○	○	○	○	○	○	○
Finance													
Farebox Revenue	●	◉	●	●	●	◉	○	○	○	○	○	○	○
Safety													
On-the-Job Injuries	◉	○	◉	◉	●	○	○	○	○	○	○	○	○
PUBLIC PERCEPTION													
Acceptance													
Awareness	●	●	●	●	●	●	●	●	●	◉	◉	◉	◉
General	●	●	●	●	●	●	●	●	○	◉	◉	◉	◉
Fairness/Equity	●	●	●	●	●	●	●	○	○	◉	◉	○	○
SOV use for a fee OK?	●	●	◉	●	●	◉	●	●	○	●	●	●	●
Tolling HOVs OK?	●	●	●	●	●	◉	●	●	○	●	●	●	●
Free hybrid access OK?	●	●	●	●	●	◉	●	●	○	●	●	●	●
Time-of-day Pricing OK?	●	●	◉	●	●	◉	●	●	○	●	●	●	●

TABLE 6-3: PERFORMANCE MEASURE INTEREST BY MARKET (CONTINUED)

● Strong Interest
◉ Some Interest
○ Limited Interest

	Elected Officials	Environmental Interests	Transit Agencies	Media	Public Agency Staff	Employers	Neighborhood Groups	Special Event Groups	Enforcement Agencies	Trucking Interests	Services Movement Orgs	Taxi/Rental Car Organizations	Retail Interests
24 hour operation?	●	◉	●	●	●	○	●	●	○	●	●	●	●
Tolls to support transit	●	●	●	●	●	◉	●	◉	○	○	○	◉	○
Affordability	●	●	◉	●	●	●	●	●	○	●	●	◉	◉
Satisfaction													
Perceived Time Savings	●	◉	●	●	●	●	●	●	○	○	○	●	◉
Perceived Safety	●	◉	●	●	●	◉	◉	●	○	○	○	●	◉
Signage	◉	◉	●	◉	●	○	○	◉	●	○	○	◉	○
Enforcement	●	○	●	◉	●	◉	◉	○	●	○	○	◉	◉
Effectiveness													
Congestion Reduction	●	●	●	●	●	●	◉	●	●	◉	●	●	●
Improve Urban Environment	●	●	◉	●	●	●	●	●	○	○	○	○	◉
Media Coverage													
# of article/reports pos. & neg.	●	◉	◉	○	●	○	◉	○	○	○	○	○	◉
Economics & Land Use													
On Goods and Services Movement	●	◉	○	●	●	●	●	○	○	●	●	○	●
Housing Decisions	●	●	◉	●	●	●	●	○	○	○	○	○	●

Once the decision has been made regarding what information needs to be shared with which audiences, the final step in the public outreach and education plan involves identifying which communication methods would be the most effective and appropriate to deliver the information. Table 6-4 provides a comprehensive listing of the full array of materials and approaches that can be used to deliver information on congestion pricing projects, together with summaries of their respective advantages and disadvantages. They range from print media from brochures to advertisements, issue papers and lengthy technical reports, as well as broadcast and social networking media. Each of these media can be expected to reach different types of constituencies. For example, younger people may be more likely to use social networking media, while home owners would be more likely to see flyers included with utility bills. Care should be taken to match the different outreach and education techniques with the audiences that are being target. However, no matter what technique(s) are selected to be part of the congestion-priced facility's education and outreach plan, data about the performance of the existing facility as well as details about the benefits of the new priced facility should always be consistently and concisely presented.

TABLE 6-4: EDUCATION AND OUTREACH TECHNIQUES

Education Techniques		
Technique	**Advantages**	**Disadvantages**
Printed Public Information Materials • Fact Sheets • Newsletters • Brochures • Issue Papers	• Can reach large target audience • Allows for technical and legal reviews • Encourages written responses if comment form enclosed • Facilitates documentation of outreach process	• Only as good as the mailing list/distribution network • Limited capability to communicate complicated concepts • No guarantee materials will be read • May need to translate into a variety of languages
Information Repositories Libraries, city halls, distribution centers, schools, and other public facilities are good locations for housing project-related information	• Relevant information is accessible to the public without incurring the costs or complications of tracking multiple copies sent to different people • Can set up visible distribution centers for project information	• Information repositories are often not well used by the public
Technical Reports Technical documents reporting research or policy findings	• Provides for thorough explanation of project decisions	• Can be more detailed than desired by many participants • May not be written in clear, accessible language
Print Advertisements Paid advertisements in newspapers and magazines	• Potentially reaches broad public	• Expensive, especially in urban areas • Allows for relatively limited amount of information • May need a variety of formats to ensure language requirement of audience are met

TABLE 6-4: EDUCATION AND OUTREACH TECHNIQUES (CONTINUED)

Education Techniques(continued)		
Technique	**Advantages**	**Disadvantages**
Broadcast Advertisements Paid or in-kind on the radio or televisions	• Reaches broad public	• Expensive, especially in urban areas • Allows for relatively limited amount of information • May need a variety of placements to ensure language requirement of audience are met
Information Inserts A “fact sheet” inserted into another periodical	• Provides community-wide distribution of information • Presented in the context of local paper, insert is more likely to be read and taken seriously • Provides opportunity to include public comment form	• Expensive, especially in urban areas • May need a variety of formats to ensure language requirement of audience are met
Internet and Social Media Outreach • Facebook • MySpace • Twitter • E-Blast	• Inexpensive to implement • Allows for two-way communication	• Needs to be constantly monitored and updated to remain fresh • Access to those with varying degrees of internet savvy
Website	• Optimal location to post detailed information • Allows for ability to ask questions	• Needs to be constantly monitored and updated to remain fresh • Access to those with varying degrees of internet savvy
Bill Stuffer Information flyer included with monthly utility bill	• Widespread distribution within service area • Economical use of existing mailings	• Limited information can be conveyed • Message may get confused as from the mailing entity
Information Hotline A phone number for public access to prerecorded project information or to reach project team members who can answer questions/obtain input	• People don’t get “the run around” when they call • Controls information flow • Conveys image of “accessibility” • Easy to provide updates on project activities	• Designated contact must be committed to and prepared for prompt and accurate responses
Media Relations • News release • Feature Stories • Editorial briefings • New Conferences	• Very inexpensive method for broad audience reach	• No guarantee of reporting accuracy • Inability to assure that stories will run in a timely manner
Pod Casts and Webinars	• Good forum for providing detailed information • Webinars can include one-to-one communication	• Relatively limited reach give length of presentations and access to internet

TABLE 6-4: EDUCATION AND OUTREACH TECHNIQUES (CONTINUED)

Outreach Techniques		
Technique	*Advantages*	*Disadvantages*
Information Centers and Field Offices Office established with prescribed hours to distribute information and respond to inquiries	• Provides an opportunity for more responsive ongoing communications • Gives the project a visible presence in the community	• Relatively expensive, especially for one project only • Access is limited to those in vicinity of the center unless facility is mobile
Expert Panels Public meeting designed in "Meet the Press" format. Media panel interviews experts from different perspectives.	• Encourages education of the media • Presents opportunity for balanced discussion of key issues • Provides opportunity to dispel scientific misinformation	• Requires substantial preparation and organization • May enhance public concerns by increasing visibility of issues
Briefings Use regular meetings of social and civic clubs and organizations to provide an opportunity to inform and educate. Normally these groups need speakers. Examples of target audiences: Rotary Club, Lions Clubs, Elks Clubs, Kiwanis, League of Women Voters. Also a good technique for elected officials.	• Control of information/ presentation • Opportunity to reach a wide variety of individuals who may not have been attracted to another format • Opportunity to expand mailing list • Similar presentations can be used for different groups • Builds community good will	• Project stakeholders may not be in target audiences • Topic may be too technical to capture interest of audience
Central Information Contact Providing access to technical expertise to individuals and organizations	• Builds credibility and helps address public concerns about equity • Can be effective conflict resolution technique where facts are debated	• Limited opportunities exist for providing technical assistance • Technical experts may counter project information
Tours Provide tours for key stakeholders, elected officials, advisory group members and the media	• Opportunity to develop rapport with key stakeholders • Reduces outrage by making choices more familiar	• Number of participants is limited by logistics • Potentially attractive to protestors
Open Houses Allows the public to learn at their own pace. The open house location should be set up with several stations, each addressing a separate issue. Resource people guide participants through the exhibits.	• Foster small group or one-on-one communications • Ability to draw on other team members to answer difficult questions • Builds credibility • Conducive to media coverage	• Difficult to document public input • Agitators may stage themselves at each display • Usually more staff intensive than a meeting

TABLE 6-4: EDUCATION AND OUTREACH TECHNIQUES (CONTINUED)

Outreach Techniques(continued)		
Technique	*Advantages*	*Disadvantages*
Community Fairs Central event with multiple activities to provide project information and raise awareness	• Focuses public attention on one element • Conducive to media coverage • Allows for different levels of information sharing	• Public must be motivated to attend • Usually expensive to do it well
In-Home "Coffee Meetings" Small meetings within neighborhood usually at a person's home	• Relaxed setting is conducive to effective dialogue • Maximizes two-way communication	• Can be costly and labor intensive
Meetings with Existing Groups Small meetings within neighborhood usually at a person's home	• Opportunity to get on the agenda • Provides opportunity for in-depth information exchange in non-threatening forum	• May be too selective and can leave out important groups
Survey Facilitated Workshops Any sized meeting when participants use interactive computer technology to register opinions	• Immediate graphic results prompt focused discussion • Areas of agreement/ disagreement easily portrayed • Minority views are honored • Responses are private • Levels the playing field	• Software limits design • Potential for placing too much emphasis on numbers • Technology failure
Advisory Committee A group of representative stakeholders assembled to provide public input to the planning process	• Provides for detailed analyses for project issues • Participants gain understanding of other perspectives, leading toward compromise	• General public may not embrace • committee's recommendations • Members may not achieve consensus • Sponsor must accept need for give-and-take • Time and labor intensive
Task Forces A group of experts or representative stakeholders formed to develop a specific product or policy recommendation	• Findings of a task force of independent or diverse interests will have greater credibility • Provides constructive opportunity for compromise	• Task force may not come to consensus results may be too general to be meaningful • Time and labor intensive
Panels A group assembled to debate or provide input on specific issues	• Provides opportunity to dispel misinformation • Can build credibility if all sides are represented • May create wanted media attention	• May create unwanted media attention

TABLE 6-4: EDUCATION AND OUTREACH TECHNIQUES (CONTINUED)

Outreach Techniques(continued)		
Technique	*Advantages*	*Disadvantages*
Community Fairs Central event with multiple activities to provide project information and raise awareness	• Focuses public attention on one element • Conducive to media coverage • Allows for different levels of information sharing	• Public must be motivated to attend • Usually expensive to do it well
Workshops An informal public meeting that may include a presentations and exhibits but ends with interactive working groups	• Excellent for discussions on criteria or analysis of alternatives • Fosters small group or one-to-one communication • Ability to draw on other team members to answer difficult questions • Builds credibility • Maximizes feedback obtained from participants • Fosters public ownership in solving the problem	• Hostile participants may resist what they perceive to be the “divide and conquer” strategy of breaking into small groups • Knowledgeable small-group facilitators are necessary

Chapter 7 Synthesis

7.1 Providing a Framework to Approach Performance Measurement for Congestion Pricing Projects

These Guidelines provide a framework for measuring and evaluating the performance of congestion pricing projects. The findings presented in the Guidelines are informed by case studies focusing on actual performance measurement practices in use on 12 congestion pricing programs currently in operation in the United States and abroad.

A number of overarching findings have emerged from the research captured within these Guidelines:

- Performance measurement for pricing projects should reflect the goals that underpin them. While the most common goals behind pricing projects are congestion reduction and revenue generation, the rationale for implementing congestion is different from project to project. Local issues and concerns regarding the use of congestion pricing also vary, and the performance measures used to evaluate pricing projects should illuminate the different issues in play.
- With a vast number of possibilities in terms of physical configuration, toll rates and collection technologies, operational policies, and transit components, no two pricing projects are alike. Similarly the performance measures used to track pricing projects vary from project to project and individual metrics are often tied to specific features of a facility.
- The research informing these Guidelines has demonstrated that there is no single prescribed set of performance measures that should be incorporated into performance monitoring programs. Rather, project sponsors should tailor performance programs to align with project goals, community concerns, agency needs, project configuration and operational policies, and the resources available for monitoring purposes.

To facilitate the identification of trends and best practices, the Guidelines have grouped existing congestion pricing applications into three forms:

- *Variably priced managed lanes* that involves charging variably-priced tolls along designated highway lanes, such as HOT lanes or express toll lanes, in order to provide improved travel conditions to eligible users.
- *Toll facilities with variable pricing* that incorporate “full facility” pricing, where all lanes of a facility are tolled at variably-priced rates in response to time of day and travel demand.
- *Cordon and area pricing* strategies that are designed to mitigate traffic congestion in urban environments by charging vehicles as they enter a designated zone or travel across a set boundary, potentially with higher prices during peak periods.

The research has found that the goals underpinning congestion pricing projects tend to have somewhat different focuses depending on the form of pricing involved. With variably priced managed lanes, goals are often focused on improved traffic performance in the priced corridor. This objective can be expressed in terms of person and vehicular throughput, travel speeds, and other highway operations metrics. Performance monitoring usually involves tracking the same parameters on the managed lanes and the general purpose lanes, and demonstrating that conditions do not deteriorate with the introduction of additional vehicles on the managed lanes. Changes in the general purpose lanes may also be measureable but are not generally obvious to motorists using them. With projects that add major capacity to a highway corridor, revenue generation may also be included as a fundamental goal, like any other toll road, with the understanding that revenue generation and improved traffic performance are not mutually exclusive.

With variably priced toll facilities, goals normally involve meeting critical revenue thresholds, and at the same time, reducing congestion without compromising revenue requirements. Given that most toll facilities are financed with bonds leveraging toll revenue and involve conservative reserve and coverage ratio policies, it is essential that the introduction of variably priced tolls does not reduce revenue generated. However, the rationale for using variably priced tolls is to manage congestion during peak periods, so performance monitoring programs for priced toll facilities must document traffic performance in the corridor as well as revenue generation.

With cordon and area pricing, goals normally involve enhancing regional sustainability and quality of life, which can be expressed through such metrics as congestion reduction, vehicle emission levels, and economic competitiveness. Given that cordon and area pricing affects travel behavior across an entire metropolitan region rather than individual corridors, the physical scope of performance measurement programs for this pricing form is more expansive than with other pricing forms focused on specific corridors. Revenue generation is also a common goal with cordon and area pricing applications, and a key parameter in this area is net revenue or financial performance expressed as gross revenue minus operating costs.

While no two pricing projects are the same, similar issues and concerns do arise with all three forms of pricing. One concern is achieving political consensus on who is tolled, who is not, and what maximum toll rates should be. Another common concern is how the proceeds from congestion pricing will be used. Both of these issues impact equity concerns, which are often mitigated by using a portion of the revenue generated by these projects to support transit improvements and enhance travel options in areas where pricing is used. Performance monitoring programs for congestion pricing projects must also address these important issues by documenting baseline conditions prior to the implementation of pricing and demonstrating how they have changed once the pricing project is active.

While no formal or prescribed process is identified in the Guidelines, the research indicates that it is helpful to assemble a multidisciplinary team comprised of relevant staff from the agency sponsoring the congestion pricing project and other concerned stakeholder groups to guide the development of performance monitoring programs for pricing projects. The research also finds that the level of detail for congestion pricing project performance monitoring programs should generally be commensurate with the level of public interest and concern with the use of pricing.

These Guidelines identify an array of different performance measures that have been used to monitor the performance of congestion pricing projects across eight broad analysis areas. The Guidelines review these measures, identifying those that are used most commonly and generally perceived to provide higher value and useful information on different aspects of the performance of congestion pricing projects. In addition, the Guidelines discuss which types of stakeholder groups would be likely be interested in the different performance indicators, as well as the comparative cost and ease with which the information may be obtained.

With these different components, the Guidelines provide potential sponsors of congestion pricing projects with a contextual framework for approaching performance monitoring programs for pricing projects. They offer a menu of performance measures arrayed across a broad set of analysis areas, which can be used to create tailored performance monitoring programs designed to meet agency needs, reflect the interests of local stakeholders, and align with resources available for performance evaluation.

Finally, the context and background against which information is gathered through performance monitoring programs for congestion pricing projects must be assessed for its effects and possible influence on the findings of these programs. Even the results of the most thoughtful performance monitoring programs may be influenced by externalities ranging from ongoing construction activities, fluctuations in the price of fuel, and regional or national economic trends.

7.2 Outreach and Communication Day-of-Opening and Beyond

These Guidelines have emphasized the importance of effective outreach and communication to the ultimate success of congestion pricing projects. Project sponsors must recognize that all eyes will be on congestion pricing programs during their first days of operation. The public and their elected officials will have little patience with pricing programs that appear to not deliver on the promises described in marketing and outreach efforts leading up to facility opening. Project sponsors must be able to provide daily data documenting the performance of new facilities as soon as they open.

Travelers, the media and community officials will draw many conclusions—accurate and inaccurate—about the performance of pricing programs during those first important days. Depending on the pricing form used, the public's observations will likely include such issues as:

- Did the introduction of pricing save me time (volume, speed, accidents/incidents)?
- Were the priced facilities easy to access? Were access locations clear to users?
- Were the priced facilities easy to exit? Were exit locations clear to users?
- What was traffic like in the adjacent general purpose lanes (volume, speed, accidents/incidents)?
- Was there visible enforcement?
- How much money was collected?
- How many carpools used the priced lanes?
- How many SOVs used the priced lanes?
- What was the effect of pricing on transit service?
- Did I see any evidence of increased transit service?

Project sponsors and operators must have mechanisms in place enabling them to provide information on all of the issues identified above – and likely others – on the day of opening. This information must also be analyzed to identify and facilitate any potential "day-after-

A Glimpse of the Future in San Diego: Integrating Real-time Performance Monitoring Across Modes

As these Guidelines are being finalized, the San Diego Association of Governments (SANDAG) is formulating its plans to utilize a $9 million Integrated Corridor Management (ICM) grant from USDOT to develop a platform to integrate real-time performance monitoring data from systems in the San Diego region to track the performance of the highway system, transit vehicles, and arterial streets. The system, which will include data collected from the dynamic tolling ETC system used to operate the I-15 Express Lanes, ramp metering locations, loop detectors, video cameras, traffic lights, transit vehicles and parking stalls in park-and-ride lots, among others, will be used to detect incidents and deploy a coordinated response under different conditions including normal operations, special events, periods of heavy congestion, traffic incidents on highways or arterial streets, transit incidents, and natural disasters.

The ICM approach was designed to leverage the strengths of San Diego's different transportation management systems, as well as its travel demand model, which is being used to test different management plans and formulate business procedures for implementing them. San Diego's ICM approach provides a glimpse of the future when performance management will not be practiced on a facility-specific basis, but rather across multiple components of the regional transportation system. For example, if a traffic incident were to occur on the I-15 in the a.m. peak near to Downtown San Diego the ICM system could be used to suspend tolling on the managed lanes and direct motorists in the general purpose lanes to divert to the managed lanes or local arterial streets, or take transit. The system would also have the capability to direct drivers to the nearest park-and-ride station and provide real-time information on the number of available parking spaces and the arrival time and number of seats available on the next bus traveling into Downtown. In the future, performance monitoring data on managed lanes will be just one of many data strands that will enable all components of a region's transportation network to be managed in an integrated fashion in response to changing conditions.

opening" changes that may need to be made to ensure safe and optimal operation. These changes could include modifying operational policies, the wording on electronic signings, or the number of and location of enforcement personnel.

Project sponsors should disseminate performance data <u>immediately</u> via a range of communication channels including websites, e-blasts, press conferences, and formal press releases. Immediate dissemination is vital because the media and public will be drawing their own conclusions on the performance of the pricing program based on their own observation and what they hear from users. Accurate performance data will either support or discount those observations and will put the media on notice that accuracy ***does*** matter when drawing conclusions on the use of pricing. It will also alert the media that the project sponsor can be depended upon to provide timely and interesting information. More importantly, providing honest and accurate information about what went right, what went wrong, and how problems are being addressed will also assure the public that pricing has the ability to deliver travel time savings and trip reliability in a safe and effective manner.

APPENDIX

Congestion Pricing Case Studies

Appendix: Case Studies

Tables

Figure

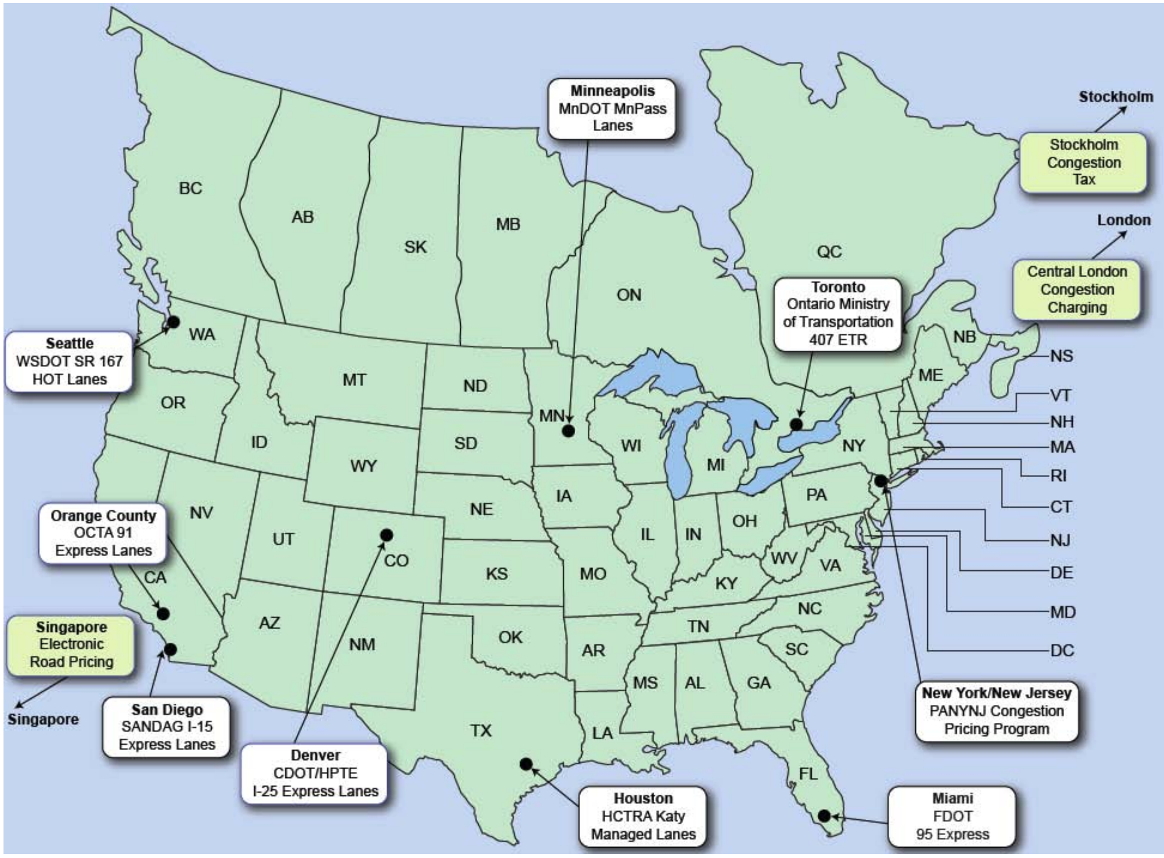
Introduction

This appendix to the Guidelines for Evaluation and Performance Measurement of Congestion Pricing Projects contains the 12 congestion pricing project case studies conducted as the main component of the original research undertaken for NCHRP 08-75. These case studies represent three major congestion pricing categories, as shown in Table 1. Their locations are indicated in Figure 1.

TABLE 1: CASE STUDY CONGESTION PRICING PROJECTS BY TYPE

Variably Priced Managed Lanes	Colorado Department of Transportation I-25 Express Lanes
	Florida Department of Transportation 95 Express
	Harris County Toll Road Authority Katy Managed Lanes
	Minnesota Department of Transportation MnPASS Lanes
	Orange County Transportation Authority 91 Express Lanes
	San Diego Association of Governments I-15 Express Lanes
	Washington Department of Transportation SR 167 HOT Lanes
Toll Facilities with Variable Pricing	Ontario Ministry of Transportation Highway 407 Express Toll Route
	The Port Authority of New York and New Jersey Congestion Pricing Program
Cordon and Area Pricing	Central London Congestion Charging
	Singapore Electronic Road Pricing
	Stockholm Congestion Tax

FIGURE 1: CASE STUDY CONGESTION PRICING PROJECTS BY LOCATION



The process for having assembled these case studies is described below.

First, the Research Team completed national and international inventories of congestion pricing projects, identifying a total of 12 projects and grouped them into three major categories:

- Variably priced managed lanes
- Toll facilities with variable pricing
- Cordon and area pricing

The research for the case studies was then completed in two phases. Initially the Research Team conducted internet-based research to identify germane reports and other documentation available on performance measurement activities associated with these active congestion pricing projects. The Research Team identified reports and other publically available materials describing the methodologies used and the results of these performance evaluation programs. In many cases, the research was supplemented with telephone conversations with staff from the transportation agencies sponsoring the projects to obtain additional information and clarifications.

Following this initial effort, the Research Team conducted telephone and in-person interviews with staff from each of the sponsoring agencies of the 12 pricing projects focusing on a comprehensive list of questions designed to explore gaps in knowledge ensuing from the initial investigations. These discussions generally lasted one to one-and-a-half hours and focused on the unique goals and context of the different pricing projects, together with a review of the specific performance metrics used to assess them and the ways in which the sponsoring agencies use those difference pieces of information in the ongoing management of their facilities and the information they provide about them to the public and interested stakeholders. These discussions also explored the challenges sponsoring agencies had in developing monitoring procedures for their pricing projects, the types of information that would have been helpful to them in overcoming those challenges, and lessons derived from their experiences that would be helpful to other peers implementing pricing projects.

Following the case study research, the Research Team then organized its findings in written case studies providing salient information on the contexts in which the pricing projects had been implemented and the programs used to monitor and document their performance. Varying in length from four to seven pages, the case studies are intended to provide readers with parallel information about each of the congestion pricing project case studies, enabling them to identify parallels and distinguish unique aspects. The case studies are organized in the following sections:

- An overview of the agency sponsoring the congestion pricing project
- A review of the agency's congestion pricing program
- A discussion of the different metrics that are used to monitor the performance of the agency's congestion pricing projects
- Identification of other data collection efforts associated with the implementation of the agency's congestion pricing projects
- A review of why performance evaluation takes place and how the agency uses the performance monitoring data it collects
- A review of lessons learned and discussion of additional data or information that would be helpful to the sponsor or other agencies considering the use of congestion pricing

In addition the case studies are accompanied by a detailed Facility Performance Monitoring Summary Matrix providing a comprehensive record of all current, known metrics used to monitor performance on the facility, organized by evaluation category. In addition, the matrices provide the following information for each individual metric:

- Frequency of collection
- Purpose
- A simple indication of overall importance
- Characterizations of the metric that relate back to agency or facility goals
- Sources of information
- Other related notes

The matrices are presented in a parallel format and contain a comprehensive listing of each and every performance metric identified among the 12 case studies, together with an indication of whether the different measures are actually tracked for each specific project. This approach was used to facilitate easy comparisons of the monitoring procedures used for the 12 case studies and to facilitate a further distillation of best practices by type of priced facility. The matrices organize the performance metrics in the following broad categories:

- Traffic Performance
- Public Perception
- Facility Users
- System Operations
- Environment
- Transit
- Economics
- Land Use

THIS PAGE LEFT BLANK INTENTIONALLY.

Variably Priced Managed Lanes

1. Colorado Department of Transportation I-25 Express Lanes

On March 2, 2009, Governor Ritter signed into law S.B. 09-108, Funding Enhancement for Surface Transportation and Economic Recovery, or FASTER. The legislation created the High Performance Transportation Enterprise (HPTE), replacing the Colorado Tolling Enterprise (CTE), which was established in 2002 to implement tolling and pricing projects in Colorado. Like its predecessor, HPTE is a government-owned business, vested with the authority to issue revenue bonds to accelerate construction of toll improvements on any corridor or roadway in the state of Colorado. The new statute eliminated the previous prohibition on tolling existing capacity, provided that all affected communities are in agreement. The new law also changed the composition of the Enterprise Board of Directors to include three members of the Colorado Transportation Commission and four external members, making it more independent of CDOT. There is also a new emphasis on congestion management, as potential projects are assessed for congestion reduction rather than strictly on financial considerations.

The HPTE operates the I-25 Express Lanes, a HOT lane facility described in further detail below. In addition, it is considering the possible use of tolling and public-private partnerships to deliver improvements on other highway corridors in the state including:

- US 36;
- I-70 East;
- C-470;
- I-70 West; and
- I-25 North.

1.1 Overview of HPTE's Congestion Pricing Program

The I-25 Express Lanes is a 7-mile, two-lane, reversible flow HOT lane facility operating between Downtown Denver and US 36. The facility was created by converting the existing HOV lanes to provide two HOT lanes southbound into Downtown Denver during the A.M. period and two lanes northbound during the P.M. period. HOV2+ vehicles and registered energy efficient/hybrid vehicles may use the facility at no cost, while single occupant passenger vehicles pay fixed variable toll rates based on time-of-day to use the facility. The preferred hierarchy of users is transit vehicles, HOVs, toll payers, and hybrids. The number of hybrids allowed on the facility is capped and the privilege will expire with SAFETEA-LU. There is a consistent two-to-one split between non-paying and tolled vehicles on the facility. The facility provides declaration lanes for HOV vehicles, which are not required to carry transponders.

Prior to the HOT conversion, the I-25 facility was constructed as a bus-only HOV lane by the Regional Transportation District, the local transit authority, with 50 percent of the funding provided by the Federal Transit Administration. Transit ridership in the I-25 corridor was the most robust in the Denver region, providing six-minute bus headways during peak periods from park-and-ride staging areas, making it easier for most commuters to use transit rather than forming carpools. The intent of the conversion was to take advantage of under-utilized capacity on the managed lanes without impacting the express bus service. Given the importance of providing high-quality transit service in the corridor, express bus travel times are a key performance metric in the corridor and can trigger a toll adjustment if a degradation is detected. In addition, peak hour tolls on the I-25 Express Lanes cannot be less than the express bus fare on the corridor.

Pricing on the I-25 Express Lanes is variable on a fixed time-of-day schedule. The lanes are closed for maintenance activities from 3:00 to 5:00 A.M. and from 10:00 A.M. to noon each weekday. Tolls range from a low of $0.50 during off-peak period and a high of $3.50 during the morning peak period and feature a variety of shoulder rates. Revenues from the facility are used to repay a $3.0 million loan from the Colorado Transportation Commission for capital expenditures on toll collection technology and signage needed for the HOV-to-HOT conversion on the I-25 corridor. They also pay for contracted and internal maintenance, toll collection and back office operations, enforcement, toll violation processing, and administration. Any remaining proceeds are put into a reserve fund for major capital improvements—per the I-25 capital plan, which includes a proportional share paid by the I-25 Express Lanes. Revenues are approximately $2.5 million annually, with expenses of roughly $1 million. In addition to the loan cited above, CDOT also received a $3.2 million grant from the FHWA Value Pricing Pilot Program, which was used to cover other implementation and outreach costs.

1.2 What is Monitored?

The full spectrum of HPTE's performance monitoring activities is provided in the accompanying Facility Performance Monitoring Summary Matrix for the I-25 Express Lanes. The matrix is a comprehensive record of all current, known metrics used to monitor performance on the facility, organized by evaluation category. The matrix also provides the following information for each individual metric: frequency of collection; purpose; a simple indication of overall importance; particular characterizations of the metric that relate back to agency/facility goals or applications; sources of information; and other notes. The matrix is intended to be a visual overview of HPTE's complete monitoring effort, easily comparable to other HOT lane facilities with similar matrix summaries. A more qualitative discussion of how these metrics are applied in practice and which ones are the most significant is provided below. Not all metrics noted in the matrix are discussed here.

Prior to the conversion of the I-25 HOV lanes, a formal performance monitoring plan was established for the facility. FHWA had required that the HOV lanes perform at LOS C, but CDOT and its partners found that this was a difficult criterion to measure. Because the managed lanes were essentially a long ramp with a single point of access and egress, they instead used travel times on the facility as the major criteria. A study was performed to track travel times for buses by installing non-revenue transponders to monitor travel times and speeds. This continues to be the primary means for measuring transit travel times in the corridor and to verify that the 45 mph average speed threshold is not degraded. The average on-time rate for buses operating on the I-25 Express Lanes for the past four years as been achieved 97 percent of the time. The travel time savings for motorists using the I-25 Express Lanes during peak periods is approximately ten minutes.

In addition to bus travel times, HPTE collects a variety of secondary performance metrics. These include traffic volumes reported by time of day in 15-minute intervals, enforcement statistics, incident data and response times, and a variety of maintenance measures. Maintenance activities, including plowing and sweeping, are contracted out to a private vendor and are performed at a higher level of service compared to the general purpose lanes.

The metrics included in the performance monitoring plan were identified by a stakeholder group tasked with addressing a variety of policy issues associated with the conversion of the I-25 HOV lanes to HOT operation. This group was comprised of CDOT, CTE, FHWA, FTA, the City and County of Denver, the

Regional Transportation District (RTD – Denver's transit authority), and the Denver Regional Council of Governments (DRCOG – greater Denver's Metropolitan Planning Organization).

CDOT and CTE coordinated separately with the local and regional police departments to develop incident management plans with protocols for emergency response, detours, and related monitoring information.

1.3 Other Essential Data Gathering Activities

Prior to the opening of the I-25 Express Lanes, CTE conducted a series of focus groups and surveys to gauge expectations for the facility. CTE also conducted a number of outreach activities to inform the public about the rational for the conversion and how the new HOT lanes would function. These included a video, which was available on CTE's website and on DVD, a moving billboard installed on the back of a flatbed truck, which was deployed in the I-25 corridor, and comprehensive press coverage. HPTE staff report that response to these activities was positive. The DRCOG recorded an initial increase in the number of carpool registrations prior to the opening of the I-25 Express Lanes, and there was also an increase in the number of *EXpressToll* transponders issued by the E-470 Public Highway Authority, which also provides back office services for the I-25 Express Lanes.

HPTE staff report that equity has not been found to be a concern in the conversion of the I-25 HOV lanes to HOT operation. Interestingly, when HPTE marked the milestone of the 500,000th paying customer using the I-25 Express Lanes, the motorist turned out to be a lower-income, single mother who commutes to downtown Denver and appreciates having the option of using the I-25 Express Lanes. This coincidence reinforces the fact that people of all income levels take advantage of the I-25 Express Lanes and generally hold favorable opinions of the facility.

1.4 Why Performance Evaluation Takes Place and How Performance Monitoring Data is Used

The primary purpose for performance monitoring on the I-25 Express Lanes is to manage traffic on the facility and ensure that the bus speed threshold is maintained. Traffic performance on the facility has been very constant and no adjustments to toll levels have been necessary to maintain bus travel times, even with the addition of license plate tolling in early 2009. While there has been one adjustment to peak period tolls on the Express Lanes since their opening, this was due to an increase in bus fares rather than conditions on the lanes themselves.

Most data collection and management on the facility is automated. Monthly and annual performance reports are produced. However, HPTE staff report that after four years of service, the routine operational nature of the Express Lanes suggests that quarterly reports would be sufficient. HPTE uses cameras deployed on the facility to detect incidents. These include an initial set of cameras installed prior to the conversion and others that were added because of it.

HPTE has used information from its outreach efforts to make some minor adjustments to the I-25 Express Lanes. These include some initial changes to signing due to customer feedback early on, as well more recent requests from customers to accommodate special events, especially football on the weekend. HPTE staff report that they receive approximately one to two customer service calls per week.

1.5 What Additional Performance Metrics or Data Would be Helpful to HPTE or Other Agencies Considering Congestion Pricing?

HPTE staff believe that there is no cookie-cutter approach to developing performance monitoring programs for priced highway facilities. Each facility is different and pricing is implemented to address differing operational objectives. With the I-25 Express Lanes, the impetus behind the HOT conversion was not congestion, but rather HOV underutilization. At the time there was some legislative pressure to simply allow general purpose use of the HOV lanes, so conversion to HOT was seen as a compromise. HPTE staff believe that it is necessary to identify performance management goals upfront and then develop monitoring metrics around them. They also believe that selling a pricing project as a pilot that can be changed and is flexible is helpful, but that proponents of pricing should not be overly cautious or nothing will get done.

In terms of what might have been done differently, HPTE staff noted that they would like to have performed before-and-after traffic counts on the general purpose lanes to explicitly identify any congestion reduction due to the HOT conversion. This was not done because the operative issue behind the conversion was to meet the legislature's mandate of optimizing the utilization of the HOV lanes, rather than reducing congestion on the I-25 general purpose lanes. Interestingly, this dynamic was also reflected in the negotiations with stakeholder agencies, which focused on meeting the mandate of addressing the underutilization issue, rather than "testing the waters" of implementing congestion pricing on the I-25 Express Lanes.

TABLE 1-1: COLORADO DEPARTMENT OF TRANSPORTATION I-25 EXPRESS LANES SUMMARY MATRIX

	Performance Category	Performance Metrics	What Measures Are Used	When				Purpose		Importance		Goal/ Application/ Characterization	Source	Notes
				Ongoing	*Before & After*	*Once*	*Irregular*	*Operations*	*Validation*	*Key*	*Secondary*			
Traffic	*Speed & Travel Time*	LOS	X	X				X		X			Interviews	Calculated from bus travel times
		Speeds/ average speed												
		Speed differential (GP vs. HOT lanes)												
		Travel times	X	X				X		X			Interviews; CTE Annual Reports 2006-2009	Measured for buses; proxy for LOS
		Travel time savings	X	X					X		X		Interviews	
		Cost of delay/VOT												
	Volume	Vehicle volume (hourly/daily/weekly/monthly)	X	X					X		X		Interviews; CTE Annual Reports 2006-2009	
		Person volume (hourly/daily/weekly/monthly)												
		Tolled trips/ untolled trips												
	VMT/VKT	VMT/VKT												
	Congestion	Delay/wait times												
		Congestion coefficient												
		Queue length												
	Mode Share	Mode share (SOV, HOV, transit)	X	X					X		X		Interviews; CTE Annual Reports 2006-2009	
	Occupancy	Avg. vehicle occupancy (auto)												
	Bike/Ped	Bike/ped traffic counts												
	Parking	Park-n-ride activity (lot counts)												
		Off-street parking activity (counts/occupancy)												
		On-street parking activity (counts/occupancy)												
		Cost of parking/parking revenue												
		# of resident permits/permit cost												
		Violations/revenue												
Public Perception	*Awareness*	Of the facility/general/how much?												
		Specific features												
		Toll adjustments												
		Future plans												
	Acceptance	General/fairness/equity												
		Specific questions	X			X			X		X		HOV/Express Lanes User Survey 2008	
	Satisfaction	General/perceived value/how well?	X			X			X		X		HOV/Express Lanes User Survey 2008	
		Traffic conditions/ reliability	X			X			X		X		HOV/Express Lanes User Survey 2008	
		Perceived time savings	X			X			X		X		HOV/Express Lanes User Survey 2008	
		Perceived safety	X			X			X		X		HOV/Express Lanes User Survey 2008	
		Signage												
		Agency performance/customer service												
		Enforcement												
	Effectiveness	Congestion reduction												
	Social Impacts	Specific activities/populations												
	Media Coverage	No. of articles/reports (positive or negative)												
	Marketing	Volume/success												
Users	*Transaction Method*	Transponder/video/by-mail/cash	X	X					X		X		CTE Annual Reports 2006-2009	
	Accounts	Total, open/closed												
		No. of transponders issued												
	User Characteristics	Vehicle classification												
		Vehicle make												
		Vehicle registrations (HOV, vanpool, hybrid)												
		Home zip code	X			X			X		X		HOV/Express Lanes User Survey 2008	
		Demographics/socioeconomics	X			X			X		X		HOV/Express Lanes User Survey 2008	
	Trip Characteristics	Frequency of use	X			X			X		X		HOV/Express Lanes User Survey 2008	
		Time of day/departure time												
		O-D/ travelshed determination	X			X			X		X		HOV/Express Lanes User Survey 2008	
		Toll spending/price paid (self-reported)												
		Trip length												
		Trip purpose	X			X			X		X		HOV/Express Lanes User Survey 2008	

TABLE 1-1: COLORADO DEPARTMENT OF TRANSPORTATION I-25 EXPRESS LANES SUMMARY MATRIX (CONTINUED)

	Performance Category	Performance Metrics	What Measures Are Used	When				Purpose		Importance		Goal/ Application/ Characterization	Source	Notes
				Ongoing	*Before & After*	*Once*	*Irregular*	*Operations*	*Validation*	*Key*	*Secondary*			
System Operations	*Finance*	Total transactions												
		Revenue (toll/charge)	X	X					X		X		CTE Annual Reports 2006-2009	
		Average toll/ highest toll												
		Revenue (fee)	X	X					X		X		CTE Annual Reports 2006-2009	
		O&M Cost	X	X					X		X		Interviews; CTE Annual Reports 2006-2009	
	Enforcement	Total traffic stops/ responses	X	X					X		X		Interviews; CTE Annual Reports 2006-2009	
		Violations/citations/fines	X	X					X		X		Interviews; CTE Annual Reports 2006-2009	
	Safety	Collisions/ accidents	X	X					X		X		CTE Annual Reports 2006-2009	
		Incident response time/ duration												
		Speed differential												
	Customer Service	Inquiry activity (call, email)												
		Performance (quantitative measures)												
	System Function	Incidents	X	X					X		X		CTE Annual Reports 2006-2009	
		Facility availability												
		Equipment availability												
		Mean time to respond/ repair												
Environment	*Air Quality*	NAAQS criteria pollutants/VOCs												
		GHG/CO2												
	Noise	Noise levels												
	Fuel Consumption	Fuel consumption												
Transit	*Performance*	Travel time/on-time/excess wait	X	X				X		X			Interviews; CTE Annual Reports 2006-2009	
		Average speed												
	Occupancy	Ridership/ boardings												
		Average vehicle occupancy												
	Finance	Farebox revenue												
		O&M Cost												
	Service	Quality/satisfaction/reliability												
Economics	*General*	Gross regional product/economic indices												
		Benefit-cost analysis												
	Business Impacts	Awareness/importance												
		General performance/openings/closings												
		Specific sectors/services/populations												
		On commercial trucking												
		Business costs and prices												
		Retail traffic & sales												
		Tourists/visitors												
	Property	Residential sales/rentals/values												
		Commercial sales/rentals/values												
Land Use	*Residential*	Housing decisions												
	Commercial	Business locations												

2. Florida Department of Transportation 95 Express

The Florida Department of Transportation (FDOT) operates a total of 1,471 centerline miles of Interstate highway out of a statewide network of 121,526 miles of roads. There are a total of 44 standalone toll facilities in Florida, the largest number of any state. Toll revenues represented approximately 12 percent of FDOT total revenues in 2007, or nearly $1.1 billion out of $9.2 billion.[8] FDOT is in the process of converting and expanding 21 miles of HOV lanes on I-95 between I-395 in Miami and I-595 in Fort Lauderdale—known as 95 Express—with the support of a $62.9 million UPA grant from USDOT. It is also implementing a $1.8 billion expansion of I-595 on a public-private partnership basis. The expansion will feature a new three-lane reversible flow, 10.5-mile, variably priced HOT lane that with the converted I-95 facility will create the beginning of a network of priced lanes in the Miami-Fort Lauderdale region.

The impetus for the 95 Express conversion was driven by congestion on the existing I-95 HOV lanes, which no longer offered reliable trips during peak travel periods. Working with multiple partners—including the metropolitan planning organizations of Miami-Dade & Broward Counties, Miami-Dade & Broward County Transit, Florida's Turnpike Enterprise (FTE), Miami-Dade Expressway Authority and South Florida Commuter Services—FDOT took advantage of USDOT's UPA program to gain funding for the conversion and implement transit enhancements in the corridor.

The goals established for the I-95 Express Lanes are as follows:

1. Maximize throughput
2. Maintain free flow speed on the Express Lanes and travel time savings
3. Increase trip reliability
4. Incentivizing transit and carpooling
5. Reduce congestion through diverting traffic to non-peak period
6. Meet increasing travel demand in the future
7. Facilitate trip-reducing carpool formation

A conscious decision was made by FDOT to maximize the throughput and operational efficiency of the 95 Express rather than optimize revenues. However, it is not guaranteed that the express lanes will be congestion-free during peak hours, even with the payment of a toll. Nonetheless, motorists are provided a high level of reliability to expect free flow conditions.

2.1 Overview of the FDOT's Congestion Pricing Program

The 95 Express involves the conversion of the existing HOV lane to HOT operation and addition of a second HOT lane in each direction within the existing I-95 right-of-way made possible by narrowing the existing travel lanes slightly. The project is being developed in two sections. The first is a 7-mile segment at the southern end of the corridor from SR 112 in downtown Miami to the Golden Glades Interchange in Miami Gardens. Phase 1 of the 95 Express has been completed with the northbound lanes in this section opening to operation on December 5, 2008 (Phase 1A), and the corresponding southbound lanes (Phase 1B) opening on January 15, 2010, together with both north and southbound lanes between SR 112 and I-395 near Miami. Phase 2, expected to be completed in 2011, extends the facility 14 miles north to Fort Lauderdale from the I-395 Interchange to a point north of I-595 in Fort Lauderdale. The completed 21-mile facility will have eight access and egress points.

[8] AASHTO Center for Excellence in Project Finance

In addition to providing a second HOT lane in each direction, FDOT has also increased the occupancy requirement for free use of the 95 Express from two to three people per vehicle making work-related trips. These vehicles must also be registered with the South Florida Commuter Services—a regional commuter assistance program established by FDOT—in order to use the lanes at no cost. As part of the registration process, carpoolers must document the fact that they are composed of at least three commuters traveling to and from work in one vehicle. Each participant is provided with a 95 Express decal that allows them to use the facility without incurring toll charges. The 95 Express decals are valid for six months, after which registrations must be renewed.

Hybrid vehicles are also allowed to use the 95 Express at no cost. To do so, hybrid owners must first have a valid State of Florida HOV decal in order to register for 95 Express. Qualified registrants receive a 95 Express decal which is valid for a year. Hybrid vehicle must have both decals in order to use the 95 Express without paying tolls. Motorcycles, transit vehicles and registered vanpool vehicles may also use the 95 Express at no cost.

Toll rates for all other vehicles on the 95 Express are dynamically priced and updated every 15 minutes based on the traffic conditions of the express lanes only. Detection equipment provides continuous information on the number of vehicles in the express lanes, their speeds, and distance of separation. An algorithm compares the real-time information to historical data and generates toll rates reflecting traffic densities on the express lanes. Toll rates are designed to maintain travel speeds of at least 45 miles per hour on the 95 Express while maximizing throughput. Typical toll rates for Phase 1 fluctuate between $0.25 and $4.00, and may rise to a cap of $7.10 under extreme conditions. Toll rates are displayed on the variable message signs upstream of all entrance points to the 95 Express, providing drivers with time to decide whether to use the lanes.

2.2 What is Monitored?

The full spectrum of FDOT's performance monitoring activities is provided in the accompanying Facility Performance Monitoring Summary Matrix for the 95 Express. The matrix is a comprehensive record of all current, known metrics used to monitor performance on the facility, organized by evaluation category. Provided in the matrix for each metric used are frequency of collection; purpose; a simple indication of importance; particular characterizations of the metric that relate back to agency/facility goals or applications; sources of information; and other notes. The matrix is intended to be a visual overview of FDOT's complete monitoring effort, easily comparable to other HOT lane facilities with similar matrix summaries. A more qualitative discussion of how these metrics are applied in practice and which ones are the most significant is provided below. Not all metrics noted in the matrix are discussed here.

FDOT collects a comprehensive set of monitoring parameters for the 95 Express. It had a formal monitoring in place prior to the opening of the 95 Express. The plan has been updated numerous times, with most of the changes consisting of repackaging the data to enable better management. The monitoring plan requirements drove the selection of the systems and equipment used to collect data. Battelle, which is responsible for monitoring the performance of all UPA and CRD projects, was involved in the formative stages of the monitoring plan. All monitoring requirements were vetted through workshops with the different stakeholders involved. One recurring challenge was tracking the performance of a facility that was being opened in phases, which meant that monitoring would begin when the facility was only partly opened and impacted by ongoing construction. FDOT's monitoring activities have been so intensive that they have hired a dedicated staff person to coordinate requests and have developed a master matrix to keep track of the different pieces of information that are measured. FDOT also makes performance data available to the public on a weekly basis through the 95 Express website.

Speed information on the 95 Express is collected by 31 vehicle detection sensor sites located throughout the corridor, processed by the ETC software. Speed data for each site can be averaged across a specified number of detectors or made at a single location. Speed data is tracked in both the express lanes and general purpose lanes, with comparisons made for the A.M. and P.M. peak periods as well as weekday, weekend and monthly averages. FDOT has also made before-and-after speed comparisons on both the express and general purpose lanes. FDOT calculates reliability on the express lanes by documenting the amount of time they operate at speeds above a minimum threshold of 45 miles per hour.

Data on vehicle volumes is collected at toll gantry locations with and synthesized by the ETC software. FDOT's philosophy is to use as much instrumentation as possible to collect speed and volume data because it can be better managed. For example, data can continue to be collected even when a particular detector is disconnected. In addition, data can be cherry-picked using information by the most reliable detectors to produce standard reports. Traffic volume data is compiled for the same time analysis periods as speed data described above.

FDOT also calculates person throughput on the I-95 corridor using average vehicle occupancy (AVO) rates and volumes by type of vehicle for both the express and general purpose lanes. Express bus ridership is added manually. Before-and-after comparisons were made of person throughput during the peak period, in accordance with the UPA framework.

FDOT tracks safety conditions on state roadways using police crash reports. Two years of crash data will be needed for the 95 Express before definitive safety information is available. However, initial evaluation of incidents has not provided any indication of safety concerns. FDOT also has installed video monitoring equipment on the 95 Express that operates around the clock. This may enable it to capture incidents that may not have been recorded in the past. In addition, FDOT monitors incident clearance times.

Revenue and toll data is tracked by FTE. FTE summarizes all the applied tolls, tolled and toll-exempt trips, and gross revenue into monthly performance measure reports and delivers them to FDOT. FDOT tracks monthly revenue trends and revenue receipts during different time periods—P.M. peak, weekend, or weekday, for example—from month to month. FDOT compiles similar information for toll rates. In addition, it tracks maximum tolls. FDOT's systems also allow it to identify the express lane travel speeds that occurred at any period of time, which enhances the ability to understand the relationships between toll rates, traffic volumes and speeds on the 95 Express.

In addition to revenue data, FDOT tracks both toll exempt registrations and actual toll exempt trips by vehicle class. While toll exempt trips only represent 1 percent of the total trips on the express lanes, they do have important implications on project goals such as a mode shift away from SOVs in favor of transit and ride sharing.

FDOT also tracks the overall availability of the 95 Express, meaning the amount of time that the lanes are open and available to motorists, making a distinction between planned closures due to construction and unanticipated closures due to traffic incidents. In addition to the number of traffic incidents, FDOT also documents the average duration of lane blockages as a result of them. FDOT also monitors enforcement data compiled by the Florida Highway Patrol, which tracks HOV occupancy warnings and citations, toll violation citations, and other infringements include speeding, seat belt use, and driving while intoxicated. Information on toll violations is generated automatically by the Sunpass ETC system. However other enforcement activities rely on visual enforcement by the Florida Highway Patrol.

FDOT monitors the performance of the different ETC and detection equipment installed on the 95 Express. These include closed circuit television cameras, dynamic message signs, and microwave vehicle detection system sensors used to measure spot speeds, volumes, and lane occupancy. Malfunction of any piece of equipment are noted, together with downtimes. FDOT uses this information to calculate the percentage of time that the different systems are operable and available.

FDOT monitors the performance of express bus services operated on the 95 Express by Miami Dade Transit (MDT). An evaluation of the impacts of the 95 Express, Phase 1A on transit services was conducted by Center for Urban Transportation Research (CUTR) at the University of South Florida. The evaluation was based on the comparison of transit operations from January to March 2008 (Pre-Deployment) with January to March 2009 (Post-Deployment) using data provided by MDT. In addition, two onboard surveys were conducted by FDOT in May 2008, May 2009, and June 2010 to gauge the impact of the project on user perceptions. The transit evaluation report also draws upon information from FDOT's I-95 Lane Monitoring Reports in order to assess the impact on transit mode share. FDOT and its partners will continue to monitor transit performance as additional components of the 95 Express become operational.

Lastly, FDOT tracks public perception of the 95 Express. In May 2009, a survey was distributed to commuters in the South Florida Region to gauge feedback on the I-95 Express Lanes (northbound). The survey was sent to 160,000 SunPass account holders in Broward and Miami-Dade Counties, 30,000 South Florida Commuter Services database participants, 28,000 Miami-Dade County government employees via their newsletter, and 126 employers along the I-95 corridor. 9,156 individuals participated, of whom 8,986 traveled on I-95 in Broward or Miami-Dade County in the prior six months. Participants were queried on their overall use of the I-95 Express, the purpose of their trips on the facility, their familiarity with the express lanes, the reliability of trips on the 95 Express, and whether they would favor the development of express lanes on other roadways in southeast Florida.

2.3 Other Essential Data Gathering Activities

Prior to the opening of the 95 Express, FDOT conducted a variety of public outreach activities. FDOT held two public hearings, numerous presentations to local municipalities and elected officials, and two public meeting within the areas affected by the project. In addition, FDOT organized a webinar on the 95 Express and launched a project website providing detailed information on all aspects of the facility. In addition, FDOT held public hearings during the rulemaking phase prior to project implementation.

There was extensive discussion about the expected performance with all the groups mentioned above. FDOT informed stakeholders that HOT lanes would provide users with travel options and that the facility was expected to improve overall travel times on I-95. Most queries focused on congestion reduction.

2.4 Why Performance Evaluation Takes Place and How Performance Monitoring Data is Used

FDOT utilizes the monitoring data it collects on the I-95 Express for a variety of different purposes. These are described in further detail below.

Maintaining Traffic Service and Speed Levels on the HOT Lanes. As described earlier, FDOT uses dynamic tolling on the 95 Express, whereby toll levels are adjusted every 15 minutes in order to maintain traffic service and speed levels on the express lanes using real-time information on travel conditions in the corridor. The application used to calculate toll rates collects real-time traffic data from the express lanes (including speeds and volumes), compares it to historical data, and analyzes this information to dynamically generate tolls based on traffic density within the express lanes. FDOT has made some minor adjustments to the pricing algorithm after reviewing monitoring data. However, the only outcome that the algorithm is expected to achieve is the Federal requirement to maintain a minimum speed of 45 miles per hour (LOS C) 90 percent of the time. Other than this requirement, the process of setting tolls is flexible and can be adjusted based on FDOT's judgment as well as feedback from the public.

Fulfilling Federal UPA Performance Monitoring Requirements. One of the primary reasons behind USDOT's decision to provide over $850 million in dedicated funding for congestion pricing projects through the UPA and CRD programs is to gain a better understanding of the effects of congestion pricing in its different forms on congestion levels and travel behavior. As a result, UPA and CRD grants require recipients to meet rigorous and standardized performance monitoring requirements. The information obtained through this process is part of a national effort is to assess the impacts of the UPA/CRD projects in a comprehensive and systematic manner across all sites. The intent of the national evaluation is to generate information and produce technology transfer materials to support deployment of the strategies in other metropolitan areas. The national evaluation requires recipient DOTs to track the following performance monitoring categories:

- Highway Performance
- Transit performance
- Public Acceptance
- Safety Performance
- Enforcement Performance
- Revenue and ETC System Performance
- Greenhouse Gas Emissions

The national UPA and CRD evaluation is being conducted by a team lead by Battelle. The Battelle team has worked closely with FDOT and its fellow sponsors of the 95 Express to ensure that the monitoring program for the facility is consistent with needs and overall structure of the national evaluation.

Improving Operational Performance. The performance monitoring and user satisfaction data FDOT collects enables it to assess the operational performance and safety of the 95 Express and identify potential adjustments to them, which since opening has only resulted in several "tweaks."

Validating the Case for Congestion pricing. In addition to meeting Battelle's requirements, the monitoring plan also reflects issues of concern to local stakeholders identified through the project public outreach efforts. There has been an unanticipated level of interest in the effects of the 95 Express in Miami, so much so that FDOT has had to hire an additional staff person to coordinate responses and provide information on the project. This level of interest within the local community and the fact that FDOT is responsive to it provides FDOT with an excellent opportunity to document the benefits of the project and the ways in which it influences and ameliorates local concerns. It also allows FDOT to build credibility with local stakeholders both in on its own abilities to implement congestion pricing as well as the ability of pricing to help reduce traffic congestion and meet other needs. FDOT has articulated a vision of implementing a network of managed lanes in southeast Florida and the credibility it has established through the 95 Express will be an essential tool in advancing that vision.

2.5 What Additional Performance Metrics or Data Would be Helpful to FDOT or Other Agencies Considering Congestion Pricing?

FDOT staff remarked that they would liked to have had more “before” data from prior to the facility’s opening, but maximized the volume of “after” data through extensive collection efforts and instrument deployment to provide the flexibility to analyze their operations and performance metrics. The 95 Express is well equipped with detection equipment throughout the corridor providing it with extremely rich raw data. FDOT’s systems enable it to collect data on vehicle volumes and speeds at multiple locations along the facility, rather than at tolling points alone. Working in concert with FTE, one of the nation’s largest and technically advanced toll operators, FDOT has developed sophisticated software to manage and synthesize the information received from its field equipment in order to set toll rates. Reviewing the data that it receives from the different detection points along the 95 Express, FDOT has witnessed variability in the data reported and has ascertained that the information obtained from certain detectors is more accurate than others. Through a process of continued monitoring and analysis, FDOT has learned how to select the best data collected from its detection equipment and then how to process it in order to identify accurate and comprehensive performance monitoring data. FDOT’s ability to do so reflected the fact that the 95 Express needed to be equipped with detection equipment at multiple locations along its entire length. It also reflects FTE’s hands on experience with ETC systems and the fact that the I-95 corridor was highly congested both before and after the conversion. Together these different factors have incentivized FDOT to explore new ground in monitoring and operating the 95 Express. FDOT’s experience is far different from that of other agencies operating less complex priced facilities, many of which have only one point of access and egress. As other longer and more complex priced facilities are built, their operators would benefit from FDOT’s experience with the 95 Express.

Another issue of note mentioned by FDOT staff is the unanticipated level of interest in general information on the 95 Express and its performance. This can be attributed to issues ranging from FDOT’s outreach efforts, which have raised awareness and interest in the 95 Express, to concerns over congestion levels in Miami, or skepticism regarding the introduction of pricing on I-95. Whatever the genesis of the interest in the 95 Express, FDOT’s comprehensive monitoring data allows the facility’s performance to speak for itself. Given the strong interest in the facility’s performance data, FDOT staff recommend that a process be put in place for centralized data dissemination so that requests are handled in a coordinated and consistent manner. Processing raw data prior to its release should also be considered in this process.

One last issue of note is the recognition that with the implementation of the 95 Express, FDOT was successful in increasing the occupancy requirements for free use of the managed lane from HOV-2 to HOV-3, while at the same time limiting eligible HOV-3 trips to work-related carpools who must re-register every six months. SOV low emission vehicles are still allowed on the lanes free of charge, but they too must go through an annual registration process. It would be interesting to explore the circumstances that enabled FDOT to introduce these restrictions, particularly in light of the fact that other cities implementing HOT conversions of congested HOV lanes—most notably Los Angeles—have avoided the liability of increasing occupancy requirements because such a change was thought to have the potential to generate extreme opposition. FDOT’s experience in this area could be extremely helpful and informative to other urban areas with congested HOV facilities.

TABLE 2-1: FLORIDA DEPARTMENT OF TRANSPORTATION 95 EXPRESS SUMMARY MATRIX

	Performance Category	Performance Metrics	What Measures Are Used	When				Purpose		Importance		Goal/ Application/ Characterization	Source	Notes
				Ongoing	*Before & After*	*Once*	*Irregular*	*Operations*	*Validation*	*Key*	*Secondary*			
Traffic	*Speed & Travel Time*	LOS	X	X				X		X		UPA req'ment; reliability	Interviews	
		Speeds/ average speed	X	X				X	X	X		Reliability	Interview documentation; UPA Eval. Midyear Report	Also measured in GP lanes; 45 mph 90% of the time
		Speed differential (GP vs. HOT lanes)												
		Travel times	X	X					X		X		UPA Eval. Midyear Report	
		Travel time savings												
		Cost of delay/VOT												
	Volume	Vehicle volume (hourly/daily/weekly/monthly)	X	X				X		X			Interview documentation; UPA Eval. Midyear Report	Also measured in GP lanes
		Person volume (hourly/daily/weekly/monthly)	X		X				X		X		UPA Eval. Midyear Report; UPA Phase 1A Transit Eval. Report	Also measured in GP lanes
		Tolled trips/ untolled trips	X	X					X		X		Interview documentation	
	VMT/VKT	VMT/VKT												
	Congestion	Delay/wait times												
		Congestion coefficient												
		Queue length												
	Mode Share	Mode share (SOV, HOV, transit)	X		X			X	X	X			UPA Eval. Midyear Report; UPA Phase 1A Transit Eval. Report	
	Occupancy	Avg. vehicle occupancy (auto)	X		X				X		X		UPA Eval. Midyear Report	Also measured in GP lanes
	Bike/Ped	Bike/ped traffic counts												
	Parking	Park-n-ride activity (lot counts)	X		X				X		X		UPA Phase 1A Transit Eval. Report	
		Off-street parking activity (counts/occupancy)												
		On-street parking activity (counts/occupancy)												
		Cost of parking/parking revenue												
		# of resident permits/permit cost												
		Violations/revenue												
Public Perception	*Awareness*	Of the facility/general/how much?												
		Specific features												
		Toll adjustments												
		Future plans												
	Acceptance	General/fairness/equity												
		Specific questions												
	Satisfaction	General/perceived value/how well?												
		Traffic conditions/ reliability	X			X			X		X	Public perception	Interviews	Customer survey - may be repeated
		Perceived time savings												
		Perceived safety												
		Signage												
		Agency performance/customer service												
		Enforcement												
	Effectiveness	Congestion reduction												
	Social Impacts	Specific activities/populations												
	Media Coverage	No. of articles/reports (positive or negative)												
	Marketing	Volume/success												
Users	*Transaction Method*	Transponder/video/by-mail/cash												
	Accounts	Total, open/closed												
		No. of transponders issued												
	User Characteristics	Vehicle classification												
		Vehicle make												
		Vehicle registrations (HOV, vanpool, hybrid)	X	X				X		X			Interview documentation; UPA Eval. Midyear Report	
		Home zip code												
		Demographics/socioeconomics												
	Trip Characteristics	Frequency of use												
		Time of day/departure time												
		O-D/ travelshed determination												
		Toll spending/price paid (self-reported)												
		Trip length												
		Trip purpose												

TABLE 2-1: FLORIDA DEPARTMENT OF TRANSPORTATION 95 EXPRESS SUMMARY MATRIX (CONTINUED)

					Before &									
				Ongoing	*After*	*Once*	*Irregular*	*Operations*	*Validation*	*Key*	*Secondary*			
System Operations	*Finance*	Total transactions	X	X				X			X		Interview documentation	
		Revenue (toll/charge)	X	X				X	X	X			Interview documentation; UPA Eval. Midyear Report	
		Average toll/ highest toll	X	X				X	X	X			Interview documentation; UPA Eval. Midyear Report	
		Revenue (fee)												
		O&M Cost												
	Enforcement	Total traffic stops/ responses												
		Violations/citations/fines	X	X				X	X		X		Interview documentation; UPA Eval. Midyear Report	
	Safety	Collisions/ accidents	X	X					X		X		Interview documentation	
		Incident response time/ duration	X	X					X		X		Interview documentation; UPA Eval. Midyear Report	
		Speed differential												
	Customer Service	Inquiry activity (call, email)	X	X					X		X	Public perception	Interviews	
		Performance (quantitative measures)												
	System Function	Incidents	X	X					X		X		Interview documentation	
		Facility availability	X	X					X		X		Interview documentation; UPA Eval. Midyear Report	
		Equipment availability	X	X					X		X		Interview documentation; UPA Eval. Midyear Report	
		Mean time to respond/ repair												
Environment	*Air Quality*	NAAQS criteria pollutants/VOCs												
		GHG/CO2												
	Noise	Noise levels												
	Fuel Consumption	Fuel consumption												
Transit	*Performance*	Travel time/on-time/excess wait	X		X				X		X	UPA req'ment; reliability	UPA Phase 1A Transit Eval. Report	
		Average speed												
	Occupancy	Ridership/ boardings	X		X				X		X	UPA req'ment; reliability	UPA Phase 1A Transit Eval. Report	
		Average vehicle occupancy	X		X								UPA Eval. Midyear Report	
	Finance	Farebox revenue	X		X				X		X		UPA Phase 1A Transit Eval. Report	
		O&M Cost	X		X				X		X		UPA Phase 1A Transit Eval. Report	
	Service	Quality/satisfaction/reliability	X		X				X		X	UPA req'ment; reliability	UPA Phase 1A Transit Eval. Report	
Economics	*General*	Gross regional product/economic indices												
		Benefit-cost analysis												
	Business Impacts	Awareness/importance												
		General performance/openings/closings												
		Specific sectors/services/populations												
		On commercial trucking												
		Business costs and prices												
		Retail traffic & sales												
		Tourists/visitors												
	Property	Residential sales/rentals/values												
		Commercial sales/rentals/values												
Land Use	*Residential*	Housing decisions												
	Commercial	Business locations												

3. Harris County Toll Road Authority Katy Managed Lanes

The Harris County Toll Road Authority (HCTRA) is a toll authority serving the Greater Houston region. It was established in 1983 with the voter approval of $900 million in bonds to build local toll roads. HCTRA's annual toll revenues exceeded $440 million in 2009, providing 90 percent of the authority's income. Jurisdictionally, HCTRA is a function of Harris County. The County, in turn, is governed by four geographically-based commissioners representing the county precincts and a County Judge who presides over the County Court. These are the decision-makers to whom HCTRA answers.

HCTRA's toll system covers over 100 route-miles of roadway in the Houston / Harris County area. Its facilities include the 74-mile circumferential Sam Houston Tollway and the 20-mile Hardy Toll Road, both of which feature fixed tolls which are collected both manually and electronically. HCTRA also operates the Westpark Tollway, which is the first fully electronic toll road in the United States. HCTRA attempted to address the extensive peak direction congestion on this two-by-two lane facility by implementing congestion pricing on the facility in September 2007. However, the new toll structure quickly encountered a swell of opposition, forcing the County Court to rescind its approval within a matter of days.

HCTRA has established the following goals for its toll facilities:

- Not superseding toll rate covenants;
- Maintaining an investment grade rating for HCTRA of at least "A;"
- Maintaining toll levels that are commensurate with toll rate policies associated with private toll road operators; and
- Allowing for continued maintenance and orderly improvement of the HCTRA system.

HCTRA has also been a partner in the redevelopment of the I-10 Katy Freeway—Houston's major east-west roadway—together with the Texas Department of Transportation (TxDOT), and the Metropolitan Transportation Authority of Harris County (METRO). This project involved the five-year reconstruction of a 12-mile section of the Katy Freeway from west of SH 6 to the I-10/I-610 interchange, building five general purpose lanes and two variably priced HOT lanes in each direction. HCTRA provided over $237 million toward the financing of the $2.8 billion project and has the right to operate the facility's HOT lanes until it has recouped its investment. Prior to the reconstruction, the original Katy Freeway, which dated to the 1960s, provided three general purpose lanes in each direction and a one-lane, reversible flow bus/HOT lane that was available to transit and HOV3 vehicles at no cost and to registered HOV2 vehicles for a fee of $2.00 during peak periods.

3.1 Overview of HCTRA's Congestion Pricing Program

The Katy Managed Lanes are a 12-mile HOT lane facility providing two travel lanes in each direction in the median of I-10. It opened to tolled operations in April 2009, following a six-month soft launch for HOVs only in October 2008. There are seven access and egress points to the lanes; five from the I-10 general purpose lanes and two from dedicated park-and-ride transit hubs. The managed lanes are separated from the general purpose lanes by flexible "candlestick" barriers and have three tolling points. Tolls are collected each time a vehicle passes below one of them. For motorists traveling the entire length of the corridor, tolls are collected three times. During the peak period—7:00 to 9:00 A.M. eastbound and 5:00 to 7:00 P.M. westbound—toll rates are $4.00 for traveling the entire length of the corridor. This rate is reduced to $2.00 during shoulder periods—6:00 to 7:00 and 9:00 to 10:00 A.M. eastbound and 4:00 to 5:00 and 7:00 to 8:00 P.M. westbound—and a rate of $1.00 is charged for trips made at any other time.

Passenger cars with two or more passengers and motorcycles are exempted from tolls from 5:00 to 11:00 A.M. and from 2:00 to 8:00 P.M., at which time they must pass below tolling points in a dedicated "declaration lane" for vehicle occupancy enforcement periods. At all other times, HOV motorists must pay the discounted $1.00 toll for trips on the managed lanes. Commercial vehicles may use the Katy Managed Lanes at any time and incur a fixed toll of $7.00 at each of the facility's three toll collection points.

3.2 What is Monitored?

The full spectrum of HCTRA's performance monitoring activities is provided in the accompanying Facility Performance Monitoring Summary Matrix for the Katy Managed Lanes. The matrix is a comprehensive record of all current, known metrics used to monitor performance on the facility, organized by evaluation category. Provided in the matrix for each metric used are: frequency of collection; purpose; a simple indication of importance; particular characterizations of the metric that relate back to agency/facility goals or applications; sources of information; and other notes. The matrix is intended to be a visual overview of HCTRA's complete monitoring effort, easily comparable to other HOT lane facilities with similar matrix summaries. A more qualitative discussion of how these metrics are applied in practice and which ones are the most significant is provided below. Not all metrics noted in the matrix are discussed here.

With its sophisticated tolling systems, HCTRA collects comprehensive data on toll transactions. This includes the number of transactions, toll rates charged, time of transaction, direction of travel, and vehicle type. Other than this, HCTRA does not have a formal program for monitoring other aspects of the performance of the Katy Managed Lanes. HCTRA receives feedback on the facility from the county commissioners and through the Katy Managed Lane website and reports that there have been few complaints since the facility opened.

HCTRA reports that its pricing policy was established shortly before the opening of the Katy Managed Lanes. HCTRA adopted a simple toll structure with three rates of $1.00, $2.00, and $4.00 for off-peak, shoulder, and peak periods, respectively. Currently, volumes on the managed lanes are nearing the peak capacity level of 2,200 vehicles per hour per lane at certain times. As a result, HCTRA is analyzing volume data to develop a new schedule of rates that will sustain expected traffic levels for at least 6 months without adjustment. The new rate structure will be modeled after the SR-91 Express Lanes in Orange County, California, which have fixed variable pricing with different rates assigned to different days of the week and hours and direction of travel. HCTRA has not completed any formal analyses to determine how much toll rate would need to increase to cause drivers to stop using the managed lanes. As a result, it will study volumes closely after the rates are changed to ascertain what the effect has been.

Prior to the opening of the Katy Managed Lanes, HCTRA expected that the facility would lose money. However, monthly revenue has been approximately $550,000, while annual maintenance costs amount to only $350,000. Revenue from the Katy Managed Lanes is "coded" and traceable and is not initially pooled with toll proceeds from other HCTRA facilities. This enables HCTRA and its partners to track the extent to which it has been able to recoup its $237.5 million contribution toward the reconstruction of the Katy Freeway.

3.3 Other Essential Data Gathering Activities

Prior to the opening of the Katy Managed Lanes, HCTRA conducted customer satisfaction surveys across its toll system and also held public meetings along the I-10 corridor. These outreach efforts revealed that there was some pushback to the concept of congestion pricing and confusion on why prices could change during a person's drive. Initially, in an effort to maximize revenues from the lanes, HCTRA intended to exempt registered HOV3 motorists from tolls and charge all other vehicles for using the facility. However, this issue proved particularly contentious during the public meetings, and as a result, HCTRA changed its operational strategy to exempt HOV2 vehicles from paying tolls during the highest hours of demand and not require that they register to use the facility. The change in the proposed toll structure also coincided with a change in HCTRA's management.

Prior to the opening of the Katy Managed Lanes, HCTRA staff also visited several other operating HOT lanes in person to learn more about them and the different ways in which they operate. HCTRA staff found these visits extremely helpful and informative, and also left them with an understanding that each of the HOT lane facilities operating in the United States is unique. The HCTRA managed lane team was able to incorporate bits and pieces of strategies and lessons learned from several of the facilities they visited into the operation of the Katy facility. In particular, the SR-91 was influential and led to HCTRA's decision to used fixed variable pricing rather than dynamic pricing. HCTRA staff have been pleased with the outcome of that decision and stated that their experience from the site visits have encouraged them to opt for simplicity whenever possible.

3.4 Why Performance Evaluation Takes Place and How Performance Monitoring Data is Used

HCTRA performance monitoring activities are modest compared those of other agencies operating priced toll facilities. The primary purpose of HCTRA monitoring and evaluation work is to ensure that the Katy Managed Lanes do not exceed their designated capacity of 2,200 vehicles per hour per lane. While there is often a desire to maintain the status quo while things are working, utilization of the Katy Managed Lanes has been higher than expected in its first year of operation, and during the six-month soft launch, as many as 1,400 HOV motorists used the lanes during the peak hour. HCTRA recognizes that its toll policies will need to change to keep up with growing traffic and is developing a new fixed variably priced toll structure.

3.5 What Additional Performance Metrics or Data Would be Helpful to HCTRA or Other Agencies Considering Congestion Pricing?

HCTRA staff are not certain whether performance monitoring guidelines would have been helpful to them had they been available prior to the opening of the Katy Managed Lanes. From their site visits and investigations of other operating HOT lanes, they found that no one facility or location is the same. Some of the most important distinctions in their opinion were the different types of operating agencies and back office procedures, as well as the presence or lack of other toll facilities in the region. They believe that the process of determining how a priced facility will operate is facility-specific and needs to be driven by local conditions.

Prior to opening the Katy Managed Lanes, HCTRA did not know whether usage would be high or low. While they had not originally intended to open the facility in a phased sequence—first to HOVs only and then later to paying vehicles—the ultimate decision to do so was extremely helpful on a number of fronts. Most importantly, it provided HCTRA with an excellent understanding of HOV utilization in the corridor, which as stated earlier at 1,400 vehicles during the peak hour was higher than expected, and whether or not there were any operational issues that could be enhanced. The soft launch period also gave the public time to become accustomed to the lanes and for HCTRA to conduct outreach activities. With local elections following the soft opening by one month in November 2008, a county judge who was up for election came out in support of the lanes and later assisted HCTRA in the development of television commercial for them. While they cite the soft launch as "dumb luck" necessitated by delays in implementing toll collection equipment in the corridor, HCTRA staff believe a phased opening might be beneficial to other operators launching new congestion pricing facilities.

One area that HCTRA wishes it has been able to improve was streamlining the management of the variable message signs deployed in the I-10 corridor. HCTRA believes it has devoted an inordinate amount of time to managing its software and functioning of its variable message signs.

TABLE 3-1: HARRIS COUNTY TOLL ROAD AUTHORITY KATY MANAGED LANES SUMMARY MATRIX

				Ongoing	Before & After	Once	Irregular	Operations	Validation	Key	Secondary			
Traffic	*Speed & Travel Time*	LOS												
		Speeds/ average speed												
		Speed differential (GP vs. HOT lanes)												
		Travel times												
		Travel time savings												
		Cost of delay/VOT												
	Volume	Vehicle volume (hourly/daily/weekly/monthly)	X	X				X		X			Interviews	Being used by Wilbur Smith to develop new toll rate structure
		Person volume (hourly/daily/weekly/monthly)												
		Tolled trips/ untolled trips												
	VMT/VKT	VMT/VKT												
	Congestion	Delay/wait times												
		Congestion coefficient												
		Queue length												
	Mode Share	Mode share (SOV, HOV, transit)	X	X					X		X		Interviews	
	Occupancy	Avg. vehicle occupancy (auto)												
	Bike/Ped	Bike/ped traffic counts												
	Parking	Park-n-ride activity (lot counts)												
		Off-street parking activity (counts/occupancy)												
		On-street parking activity (counts/occupancy)												
		Cost of parking/parking revenue												
		# of resident permits/permit cost												
		Violations/revenue												
Public Perception	*Awareness*	Of the facility/general/how much?												
		Specific features												
		Toll adjustments												
		Future plans												
	Acceptance	General/fairness/equity	X			X			X	X			Interviews	Conducted prior to facility opening; current feedback via website
		Specific questions												
	Satisfaction	General/perceived value/how well?												
		Traffic conditions/ reliability												
		Perceived time savings												
		Perceived safety												
		Signage												
		Agency performance/customer service												
		Enforcement												
	Effectiveness	Congestion reduction												
	Social Impacts	Specific activities/populations												
	Media Coverage	No. of articles/reports (positive or negative)												
	Marketing	Volume/success												
Users	*Transaction Method*	Transponder/video/by-mail/cash												
	Accounts	Total, open/closed												
		No. of transponders issued												
	User Characteristics	Vehicle classification												
		Vehicle make												
		Vehicle registrations (HOV, vanpool, hybrid)												
		Home zip code												
		Demographics/socioeconomics												
	Trip Characteristics	Frequency of use												
		Time of day/departure time												
		O-D/ travelshed determination												
		Toll spending/price paid (self-reported)												
		Trip length												
		Trip purpose												

TABLE 3-1: HARRIS COUNTY TOLL ROAD AUTHORITY KATY MANAGED LANES SUMMARY MATRIX (CONTINUED)

	Performance Category	Performance Metrics	What Measures Are Used	When				Purpose		Importance		Goal/ Application/ Characterization	Source	Notes
				Ongoing	*Before & After*	*Once*	*Irregular*	*Operations*	*Validation*	*Key*	*Secondary*			
System Operations	*Finance*	Total transactions	X	X				X		X			Interviews	
		Revenue (toll/charge)	X	X				X		X			Interviews	
		Average toll/ highest toll	X	X				X		X			Interviews	
		Revenue (fee)												
		O&M Cost	X	X				X		X			Interviews	
	Enforcement	Total traffic stops/ responses												
		Violations/citations/fines	X	X					X		X		Interviews	
	Safety	Collisions/ accidents	X	X					X		X		Interviews	
		Incident response time/ duration												
		Speed differential												
	Customer Service	Inquiry activity (call, email)												
		Performance (quantitative measures)												
	System Function	Incidents												
		Facility availability												
		Equipment availability												
		Mean time to respond/ repair												
Environment	*Air Quality*	NAAQS criteria pollutants/VOCs												
		GHG/CO2												
	Noise	Noise levels												
	Fuel Consumption	Fuel consumption												
Transit	*Performance*	Travel time/on-time/excess wait												
		Average speed												
	Occupancy	Ridership/ boardings												
		Average vehicle occupancy												
	Finance	Farebox revenue												
		O&M Cost												
	Service	Quality/satisfaction/reliability												
Economics	*General*	Gross regional product/economic indices												
		Benefit-cost analysis												
	Business Impacts	Awareness/importance												
		General performance/openings/closings												
		Specific sectors/services/populations												
		On commercial trucking												
		Business costs and prices												
		Retail traffic & sales												
		Tourists/visitors												
	Property	Residential sales/rentals/values												
		Commercial sales/rentals/values												
Land Use	*Residential*	Housing decisions												
	Commercial	Business locations												

4. Minnesota Department of Transportation MnPASS Lanes

The Minnesota Department of Transportation (MnDOT) is responsible for 137,700 miles of roads, 13,000 of which are state highways. County highways and municipal roads make up another 40,000 miles. There are four toll facilities in the state of Minnesota. They include two non-Interstate toll bridges which are not operated by MnDOT, as well as two Interstate HOT lane facilities described in further detail below. Toll revenues represent far less than 1 percent of MnDOT's total revenues of $2.65 billion in 2007.[9] However, MnDOT is currently assessing the possibility of implementing new highway improvements as tolled facilities through its innovative financing program, as well as through expansion of MnPASS lanes.

Following several years of study and off-and-on support for congestion pricing, the Minnesota State Legislature passed enabling legislation (160.93, Sec. 7) in 2003 authorizing MnDOT to implement user fees on HOV lanes. The enabling legislation required MnDOT to document the performance of any HOT lane facilities implemented in the state and established four main goals for congestion pricing:

- Maintain travel speeds and level of service for HOVs and carpools;
- Improve the efficiency of the converted HOV facility;
- Provide new travel options; and
- Demonstrate the use of dynamic pricing.

4.1 Overview of the MnDOT's Congestion Pricing Program

MnDOT has developed two operating HOT lane facilities in Minneapolis. The first is the 11-mile, I-394 HOT lanes facility on the primary travel corridor between downtown Minneapolis and the city's western suburbs. The facility provides two reversible-flow, barrier-separated HOV lanes on a three-mile section between I-94 in downtown Minneapolis and Trunk Highway 100 (TH 100), together with one non-barrier-separated lane in each direction between TH 100 and I-494. Originally developed as an HOV system, the I-394 managed lanes were converted to HOT service, opening on May 16, 2005. Single occupancy vehicles (SOVs) using the MnPASS lanes pay a toll depending upon congestion levels and the distance traveled, with a different rate paid based on whether motorists travel on the reversible section, the diamond lane section, or both. The facility provides inbound (east) service from 6:00 A.M. to 10:00 A.M. and outbound (west) service from 2:00 P.M. to 7:00 P.M. MnPASS provides 11 access points, five eastbound and six westbound.

With the support of a $133 million Urban Partnership Agreement (UPA) grant awarded by USDOT, MnDOT opened a second HOT lane facility in September 2009 on I-35W between Downtown Minneapolis and the city's southern suburbs. The 12-mile HOT lane is being opened in two major phases and will be fully operational in fall 2010. The I-35W corridor improvements include the following elements:

- Priced dynamic shoulder lanes on I-35W from 46th Street to downtown Minneapolis
- Addition of a HOT lane in the Crosstown reconstruction project from 66th Street to 46th Street
- Conversion of the HOV lane to HOT lane on I-35W from 66th Street to Burnsville Parkway, similar to the I-394 MnPASS Lanes
- Construction of additional park-and-ride lots along the I-35W corridor north and south of Minneapolis
- Construction of additional dedicated bus lanes in downtown Minneapolis

[9] AASHTO Center for Excellence in Project Finance

- Partnerships with major employers along the I-35W corridor to promote telecommuting programs
- Use of additional Intelligent Transportation Systems technology

Both HOT lane facilities use dynamic pricing, with the average peak period fee varying between $1.00 and $4.00 depending on the level of congestion in the MnPASS Express Lanes. Minimum toll rates are $0.25 per segment, but can rise to a cap of $8.00 during periods of peak congestion. Dynamic pricing ensures that traffic in the managed lanes flows at least 50–55 mph.

4.2 What is Monitored?

The full spectrum of MnDOT's performance monitoring activities is provided in the accompanying Facility Performance Monitoring Summary Matrix for the I-394 and I-35W MnPASS. The matrix is a comprehensive record of all current, known metrics used to monitor performance on the facility, organized by evaluation category. Provided in the matrix for each metric used are: frequency of collection; purpose; a simple indication of importance; particular characterizations of the metric that relate back to agency/facility goals or applications; sources of information; and other notes. The matrix is intended to be a visual overview of MnDOT's complete monitoring effort, easily comparable to other HOT lane facilities with similar matrix summaries. A more qualitative discussion of how these metrics are applied in practice and which ones are the most significant is provided below. Not all metrics noted in the matrix are discussed here.

MnDOT's monitoring program for its two MnPASS facilities are identified in reporting requirements expected of Cofiroute, the MnPASS HOT Lanes operator. With the recent addition of I-35W MnPASS, MnDOT has also established performance monitoring requirements associated with the state's UPA grant. In response to the legislative requirement of maintaining traffic service levels on converted HOV lanes using a benchmark of minimum speeds of 50-55 miles per hour at least 95 percent of the time, speed is the most important monitoring metric on HOT lane facilities in Minnesota. HOT lane speeds are monitored 24 hours a day by MnDOT's system operator using a series of loop detectors.

Speed data is available to MnDOT electronically at any time and is also summarized in quarterly reports prepared by the system operator. These reports also provide comprehensive information on a number of other parameters. These include:

- Traffic volumes, including
  - Trips by hour
  - Trips by day of week
  - Eastbound and westbound trip comparison;
- Toll revenue statistics;
- Information on new ETC accounts and transactions;
- A summary of call activity and other performance indicators for the MnPASS Customer Service Center; and
- Information regarding the performance of the computer systems and servers used to operate the MnPASS system.

The measures reported by the system operator were identified by MnDOT's technical consultant at the time the systems operations procurement was prepared and were then negotiated directly with Cofiroute, which was awarded the system operator contract.

In addition to these metrics, MnDOT tracks a number of other performance parameters. These include crash and enforcement information maintained by the state police. MnDOT also monitors transit ridership and carpooling activity, and compares trends in these areas on its priced corridors to other non-priced "control" corridors in the Twin Cities region. Utilization data involves field or video counts of vehicles using the corridor, together with assumptions on average occupancy rates for different vehicle types. Although there is no specific measure of reliability in Minnesota, given that acceptable speeds are always maintained and the HOT lanes are always operational, they are perceived by all stakeholders as being reliable.

MnDOT has also conducted comprehensive user satisfaction surveys for MnPASS account holders covering a wide range of issues. The surveys were conducted in three waves starting prior to opening in fall 2004, six months after opening in fall 2005, and one year after opening in spring 2006. The effort involved interviews with a panel of 1,200 individuals who were pre-recruited and participated in telephone and in-person discussions. Over 340 of these individuals participated in all three phases of the survey. The survey effort covered such issues as:

- Satisfaction with the HOT lane concept by income group
- Satisfaction with all electronic tolling
- Satisfaction with traffic speed in the lanes
- Satisfaction with dynamic pricing
- Satisfaction with the safety of merging

MnDOT's survey work indicated that there is widespread support for congestion pricing on the I-394 corridor among people of all incomes and that favorable opinions of the HOT lane concept and the I-394 facility specifically grew following the implementation of MnPASS.

4.3 Other Essential Data Gathering Activities

Prior to deciding to implement congestion pricing on I-394, MnDOT completed numerous feasibility pricing studies both in the Twin Cities region and the I-394 corridor specifically. Through those studies, it developed different travel demand forecasts and assumptions on how travel behavior would be influenced by variably priced tolls. In addition it had a good understanding of public perceptions of congestion pricing in the Twin Cities.

In addition, while it was in the process of converting the I-394 MnPASS lanes, MnDOT established an Implementation Committee comprised of legislators, other public officials, and stakeholders to provide feedback and advice on a wide range of technical and policy issues, including:

- Hours of operation
- Transponder technology
- Safety and enforcement
- Toll rates
- Dynamic message signs
- Public outreach
- Expected revenues
- Type of vehicles allowed
- Access points/traffic operations

In addition, MnDOT held open houses to elicit feedback on the same issues from the public at large. Attendance was not high but the media was present. MnDOT also met at least twice with all city councils in both corridors prior to their implementation so that council members could learn about pricing, provide feedback, and become champions.

4.4 Why Performance Evaluation Takes Place and How Performance Monitoring Data is Used

MnDOT utilizes the monitoring data it collects on its HOT lane facilities for a variety of purposes. These are described in further detail below.

Maintaining Speed, Efficiency, and Operational Standards on HOT and General Purpose Lanes. Arguably, the most important function that MnDOT's performance data facilitates is ensuring that the HOT lanes meet their travel speed requirements, while at the same time maximizing the overall performance and efficiency of the two priced corridors. During their first year of operation, a number of important changes were made on the I-394 MnPASS lanes based on the performance data collected by MnDOT. In particular, the algorithm used to set the dynamically priced tolls was modified to be less sensitive to changes in traffic volumes and speeds on the HOT lanes. When it first opened, dynamic toll rates increased rapidly, and these large increases priced many motorists off the HOT lanes, leaving them underutilized. After a series of adjustments to the algorithm, it remained unchanged for four years when a decision was made to adjust it to enhance toll revenues. This was accomplished by lowering toll rates during shoulder periods, a change which resulted in a healthy increase in MnPASS utilization, increasing net toll revenues and allowing more efficient use of both the managed and general purpose lanes.

Fulfilling Legislatively Mandated Reporting Requirements. Under the UPA program, state legislation enabling the implementation of the I-35W HOT lanes requires that MnDOT submit annual reports on their performance to the State Legislature. These reports must document whether travel speeds on the HOT lanes have met the requirement of operating at speeds above 50-55 mph at least 95 percent of the time. MnDOT is also required by the legislature to include information on toll revenues collected, safety conditions, and the operational efficiency of the two highway corridors. The metrics for which MnDOT collects monitoring data have been specifically selected to enable the Department to fulfill its reporting requirements.

Improving Operational Performance. The performance monitoring and user satisfaction data MnDOT collects enables it to assess the operational performance and safety of the HOT lanes and identify potential adjustments to them. This has included a major operational adjustment on the I-394 MnPASS lanes soon after they opened. Rather than operating the westbound HOV lane as a HOT lane in the A.M. peak period as initially intended, MnDOT reversed this policy and made it available as a general purpose lane in response to initial confusion and severe congestion in the westbound travel direction.

Documenting Changes in Travel Behavior. Performance monitoring data documents changes in travel behavior by different user groups, including SOV motorists who pay to use the HOT lanes, carpoolers and transit riders who use the HOT lanes, and HOV violators. MnDOT has also compared conditions in the MnPASS corridors to other "control" corridors in the Twin Cities region in order to determine how transit ridership and carpooling have been influenced by the HOV-to-HOT conversions.

Validating the Case for Congestion Pricing. Lastly, the collective data derived from the performance monitoring program enables MnDOT to validate all aspects of the performance of the MnPASS lanes to stakeholders to whom it answers. The positive response to the I-394 HOT lanes has been an important factor behind MnDOT's decision to pursue a HOT conversion on I-35W and consider pricing on other facilities in the state.

4.5 What Additional Performance Metrics or Data Would be Helpful to MnDOT or Other Agencies Considering Congestion Pricing?

The primary metric that MnDOT uses to monitor the performance of its two HOT lane facilities is travel speed. While all pricing projects are different, MnDOT staff believe that it would be helpful to identify other types of metrics that are used to monitor the performance of priced facilities, such as travel reliability and travel time savings. Having a better knowledge of the relative measures of success helps pricing proponents do a more effective job communicating the purpose and benefits of pricing projects.

If MnDOT had time and resources they would increase their outreach activities. One measure that is not formalized is public perception and user satisfaction. MnDOT has surveyed transponder users on the I-394 MnPASS facility in 2006, but that effort did not include HOV or transit users. Transponder users only represent 25 percent of all trips on the MnPASS lanes, leaving MnDOT with an incomplete understanding of user satisfaction. The department would like to conduct more extensive surveys capturing this information, but they do not have the money to do so, and at the same time, they do not sense that there is dissatisfaction in the corridor.

MnDOT staff also point out the difficulty they face in assembling meaningful before-and-after data on the I-35 corridor due to the MnPASS improvements being opened on a rolling basis and to travel conditions on the corridor being impacted by the construction of the Crosstown reconstruction and the replacement of the Mississippi River crossing near downtown Minneapolis. These factors will result in a substantial time gap between comparable before-and-after conditions.

THIS PAGE LEFT BLANK INTENTIONALLY.

TABLE 4-1: MINNESOTA DEPARTMENT OF TRANSPORTATION MNPASS LANES SUMMARY MATRIX

	Performance Category	Performance Metrics	What Measures Are Used	When				Purpose		Importance		Goal/ Application/ Characterization	Source	Notes
				Ongoing	*Before & After*	*Once*	*Irregular*	*Operations*	*Validation*	*Key*	*Secondary*			
Traffic	*Speed & Travel Time*	LOS	X	X					X	X		Leg. Requirement	Interviews	50-55 mph 95% of the time
		Speeds/ average speed	X	X	X			X	X	X		Reliability	I-394 Tech. Eval., Cofiroute MnPass reports, Interviews	Used to derive LOS
		Speed differential (GP vs. HOT lanes)	X	X				X			X	Reliability	Interviews	Feature added to I-35W
		Travel times	X				X		X		X	Show Benefits		Occasionally collected to compare to GP
		Travel time savings	X				X		X		X	Show Benefits		Occasionally collected to compare to GP
		Cost of delay/VOT	X			X			X		X	Public Perception	Attitudinal Panel Survey	3 waves in total; stated preference
	Volume	Vehicle volume (hourly/daily/weekly/monthly)	X	X	X				X		X		I-394 Tech. Eval., Cofiroute MnPass reports	
		Person volume (hourly/daily/weekly/monthly)	X	X							X		HOV quarterly reports	
		Tolled trips/ untolled trips	X	X							X		HOV quarterly reports	
	VMT/VKT	VMT/VKT												
	Congestion	Delay/wait times												
		Congestion coefficient												
		Queue length												
	Mode Share	Mode share (SOV, HOV, transit)	X	X	X				X		X		I-394 Tech. Eval., HOV quarterly reports	
	Occupancy	Avg. vehicle occupancy (auto)	X	X	X				X		X		I-394 Tech. Eval., HOV quarterly reports	
	Bike/Ped	Bike/ped traffic counts												
	Parking	Park-n-ride activity (lot counts)	X	X					X		X	Determine markets for transit		Collected by Metro Transit
		Off-street parking activity (counts/occupancy)												
		On-street parking activity (counts/occupancy)												
		Cost of parking/parking revenue												
		# of resident permits/permit cost												
		Violations/revenue												
Public Perception	*Awareness*	Of the facility/general/how much?	X			X			X		X	Public Perception	Attitudinal Panel Survey	3 waves in total
		Specific features	X			X			X		X	Public Perception	Attitudinal Panel Survey	3 waves in total
		Toll adjustments	X			X			X		X	Public Perception	Attitudinal Panel Survey	3 waves in total
		Future plans	X			X			X		X	Public Perception	Attitudinal Panel Survey	3 waves in total
	Acceptance	General/fairness/equity												
		Specific questions												
	Satisfaction	General/perceived value/how well?	X			X			X		X	Public Perception	Attitudinal Panel Survey	3 waves in total
		Traffic conditions/ reliability												
		Perceived time savings	X			X			X		X	Public Perception	Attitudinal Panel Survey	3 waves in total
		Perceived safety	X			X			X		X	Public Perception	Attitudinal Panel Survey	3 waves in total
		Signage												
		Agency performance/customer service	X	X					X	X			Google, services	Monitored as part of marketing
		Enforcement												
	Effectiveness	Congestion reduction												
	Social Impacts	Specific activities/populations	X	X							X		Cofiroute MnPass reports	
	Media Coverage	No. of articles/reports (positive or negative)	X	X							X		Cofiroute MnPass reports	
	Marketing	Volume/success												
Users	*Transaction Method*	Transponder/video/by-mail/cash	X			X		X			X	Account requirement	Customer	Vehicle type is a field in sign up
	Accounts	Total, open/closed												
		No. of transponders issued	X			X			X	X		Valid accounts	Customer	Part of account data
	User Characteristics	Vehicle classification	X			X			X		X	Public Perception	Attitudinal Panel Survey	3 waves in total
		Vehicle make	X	X				X		X		Operations/reporting	Cofiroute MnPass reports	
		Vehicle registrations (HOV, vanpool, hybrid)												
		Home zip code	X	X				X		X		Operations/reporting	Cofiroute MnPass reports	
		Demographics/socioeconomics												
	Trip Characteristics	Frequency of use	X	X				X	X	X		Leg. Requirement	Cofiroute MnPass reports, Interviews	
		Time of day/departure time	X	X				X	X		X		Cofiroute MnPass reports	
		O-D/ travelshed determination	X	X							X		Cofiroute MnPass reports	
		Toll spending/price paid (self-reported)	X	X				X	X		X	Leg. Requirement	Interviews	
		Trip length	X	X							X		HOV quarterly reports, Interviews	
		Trip purpose	X	X	X				X		X		I-394 Tech. Eval., HOV quarterly reports, Interviews	

TABLE 4-1: MINNESOTA DEPARTMENT OF TRANSPORTATION MNPASS LANES SUMMARY MATRIX (CONTINUED)

				Ongoing	Before & After	Once	Irregular	Operations	Validation	Key	Secondary			
System Operations	*Finance*	Total transactions	X	X	X				X		X		I-394 Tech. Eval., Interviews	
		Revenue (toll/charge)												
		Average toll/ highest toll	X		X				X		X		I-394 Tech. Eval.	
		Revenue (fee)	X	X							X		Cofiroute MnPass reports	
		O&M Cost	X	X							X		Cofiroute MnPass reports	
	Enforcement	Total traffic stops/ responses	X	X							X		Cofiroute MnPass reports	
		Violations/citations/fines	X	X							X		Cofiroute MnPass reports	
	Safety	Collisions/ accidents												
		Incident response time/ duration	X		X				X		X		I-394 Tech. Eval.	
		Speed differential												
	Customer Service	Inquiry activity (call, email)	X		X				X		X		I-394 Tech. Eval.	
		Performance (quantitative measures)												
	System Function	Incidents	X		X				X		X		I-394 Tech. Eval.	Qualitative survey
		Facility availability												
		Equipment availability	X		X				X		X		I-394 Tech. Eval.	Qualitative survey
		Mean time to respond/ repair	X	X							X		HOV quarterly reports	
Environment	*Air Quality*	NAAQS criteria pollutants/VOCs	X	X				X		X				Not tied to mnpass but collected
		GHG/CO2												
	Noise	Noise levels												
	Fuel Consumption	Fuel consumption												
Transit	*Performance*	Travel time/on-time/excess wait												
		Average speed												
	Occupancy	Ridership/ boardings												
		Average vehicle occupancy												
	Finance	Farebox revenue												
		O&M Cost												
	Service	Quality/satisfaction/reliability												
Economics	*General*	Gross regional product/economic indices												
		Benefit-cost analysis												
	Business Impacts	Awareness/importance												
		General performance/openings/closings												
		Specific sectors/services/populations												
		On commercial trucking												
		Business costs and prices												
		Retail traffic & sales												
		Tourists/visitors												
	Property	Residential sales/rentals/values												
		Commercial sales/rentals/values												
Land Use	*Residential*	Housing decisions												
	Commercial	Business locations												

5. Orange County Transportation Authority 91 Express Lanes

The Orange County Transportation Authority (OCTA) is a multimodal transportation agency serving Orange County, California. It provides countywide bus, paratransit, and Metrolink rail service and implements improvements to freeways and local roads. In addition it operates the United States' first HOT lane facility, the 91 Express Lanes, which it purchased in January 2003 for $207.5 million from the California Private Transportation Company (CPTC), the private concession company that had built the lanes. The purpose of the change in ownership of the lanes was to remove a controversial clause in the private partner's concession agreement that prohibited local governments from expanding roadway capacity in the congested SR-91 corridor.

OCTA was created in 1991 with the consolidation of seven separate transportation agencies. In 2009, it had annual revenues of approximately $391.2 million, $43.7 million of which were generated by tolls on the 91 Express Lanes. OCTA is governed by an 18-member Board of Directors comprised of five county supervisors, ten city members, two public members and the Director of Caltrans District 12 who is a non-voting member.

OCTA uses the revenue generated by the lanes to pay the underlying debt it owes on the facility, as well as the costs of operating and maintaining the lanes. OCTA is required by its bond covenants to maintain a debt coverage ratio of 1.3. Any additional revenues generated by the project are invested in other transportation improvements in the corridor. In addition to meeting the debt coverage requirements, OCTA's primary goal for the 91 Express Lanes is to manage the volume of traffic using the facility at a level that allows for travel speeds of 60-65 mph at all times. In addition to the 91 Express Lanes, there are three other toll facilities operating in Orange County, the San Joaquin Hills, Foothill, and Eastern Transportation Corridors, all of which utilize different fixed peak and off-peak toll rates for cash and FasTrak ETC transactions. These facilities are operated by the Transportation Corridors Agency of Orange County.

5.1 Overview of OCTA's Congestion Pricing Program

The 91 Express Lanes is a four-lane express toll lane facility located in the median of SR-91, a heavily traveled eight-lane east-west freeway. SR-91 connects the SR-55 near Anaheim with Riverside County. The SR-91's location is the optimal setting for a HOT lane. The freeway connects rapidly growing residential areas in Riverside and San Bernardino counties with major employment centers in Orange and Los Angeles counties. The corridor itself traverses a rugged and narrow canyon area and is the only route through it. The SR-91 is one of the most congested freeways in Southern California and carries more than 300,000 vehicles per day. This level is expected to increase to more than 425,000 vehicles per day by 2030. In spite of these high demand levels, transit service on the SR-91 is limited, consisting of approximately ten round trip express bus services. Vanpooling is also limited in the corridor.

The HOT facility has no shoulders and is separated from the general purpose lanes by tubular markers. It provides one single point of access and egress. When it opened to service in 1995, the 91 Express Lanes was the first operating HOT lane facility in the United States, the first highway improvement to be built on a public-private partnership basis in California, and the first fully automated toll facility in the world, where all tolls were collected electronically. Tolls on the 91 Express Lanes vary by direction of travel, time-of-day, and day-of-week on a fixed schedule. HOV3 motorists are allowed to use the facility free of charge, with the exception of the P.M. peak period from 4:00 to 6:00 P.M. eastbound, when they are required to carry a transponder and pay 50 percent of the established toll. All other users must carry a transponder and pay the variably priced tolls to use the lanes at all times. Trucks are not allowed to use the lanes at any time.

Because there is only one ingress and egress location on the 91 Express Lanes, toll collection is relatively uncomplicated. Tolls are collected at a single point in the middle of the corridor, where a maintenance and incident response facility is also located. The central location enables OCTA to respond to traffic incidents quickly, which is important because the 91 Express Lanes has no shoulders. The lanes are well maintained and are completely closed once every three weeks on Sunday mornings, when they are swept and any missing channelizer markers are replaced and cracks are sealed.

5.2 What is Monitored?

The full spectrum of OCTA's performance monitoring activities is provided in the accompanying Facility Performance Monitoring Summary Matrix for the 91 Express Lanes. The matrix is a comprehensive record of all current, known metrics used to monitor performance on the facility, organized by evaluation category. It also includes earlier monitoring and evaluation work performed by Cal Poly State University that examined the lanes from prior to inception through mid-1999. Provided in the matrix for each metric used are: frequency of collection; purpose; a simple indication of importance; particular characterizations of the metric that relate back to agency/facility goals or applications; sources of information; and other notes. The matrix is intended to be a visual overview of OCTA's complete monitoring effort, easily comparable to other HOT lane facilities with similar matrix summaries. A more qualitative discussion of how these metrics are applied in practice and which ones are the most significant is provided below. Not all metrics noted in the matrix are discussed here.

OCTA monitors several different performance parameters on the 91 Express Lanes. The most important of these is the number of vehicles on the facility. Traffic volumes are detected automatically for both paying and nonpaying vehicles, together with the time of travel, and tolls collected. This data is collected electronically by Cofiroute, the private sector firm that operates the 91 Express Lanes as a contractor to OCTA. Traffic and revenue data is available to OCTA in real time and Cofiroute provides OCTA with regular summaries reported for a variety of different timeframes.

OCTA monitors safety conditions on the lanes closely. This includes incident data maintained by the CHP, as well as real time images from cameras located along the length of the facility. OCTA also tracks the number of service patrol trips to assist motorists, together with the response times to reach customers in need. Similarly, OCTA tracks enforcement data on the lanes, which is also reported by the CHP and identifies the types of infringement (toll evasion, vehicle occupancy, speeding, and others).

As an agency with a small staff, OCTA relies on contractors to perform many day-to-day services provided to customers on the 91 Express Lanes. These include information on the customer service center, including the number of calls it receives, answer times, and the number of callers that hang up before reaching an agent. Performance data also review violation processing, collections of fines, and the amount of returned mail.

5.3 Other Essential Data Gathering Activities

Shortly after taking over the ownership and operation of the 91 Express Lanes, OCTA implemented a new toll policy. At the time this change was being made, OCTA engaged in an aggressive media effort to educate the public about the policy and that increased rates were not tied to revenue generation, but rather to maintain constant speed flows of 60 to 65 mph. Complaints decreased over time, but there was a resurgence, particularly in the press, when the peak toll rate hit $10.00 in 2007. This level subsided during the economic downturn, but predictably the toll rate reduction did not receive the same level of media coverage. In 2010 peak period traffic levels are rising again, resulting in an eastbound toll rate between 3:00 and 4:00 P.M. on Fridays of $10.25.

OCTA's media relations personnel work with newspapers and others to manage the message, and according to OCTA staff, referring to customer satisfaction surveys, public response is generally favorable because it is understood what is being paid for. Each year OCTA conducts a number of customer surveys. This work follows the same model established by CPTC, with 400 to 500 customers asked to respond to the same set of questions. In 2007 OCTA decided to administer the survey biennially. This change is due to the 91 Express Lanes being regarded favorably and the survey effort being perceived as expensive, even though in reality it was not.

The most recent Customer Satisfaction Survey for the 91 Express Lanes was conducted in September 2009. Respondents were selected based on the number of weekly trips they make on the lanes. Interviews were conducted in person and were designed to assess the following six issues:

- Changes in utilization patterns among users;
- Customer satisfaction;
- Customer expectations and perceptions of OCTA's management of the lanes;
- Customer attitudes regarding the benefits of the lanes, toll policies, and customer service; and
- Customer awareness of existing communication programs and their effectiveness.

The survey found that satisfaction with the lanes has grown, while there has been a modest decrease in the frequency of use due to the current economic climate. Users of all income groups have a positive perception of the Express Lanes.

5.4 Why Performance Evaluation Takes Place and How Performance Monitoring Data is Used

Vehicle volumes are the operative performance metric used to manage the operation of the 91 Express Lanes. While the facility is managed to provide travel speeds of 60-65 mph at all times, speeds are not explicitly measured. Rather, they are inferred from the number of vehicles using the facility. If the number of vehicles across both lanes exceeds 3200 per hour on any given day in any given direction of travel, then the toll rate for that specific period is increased. Maximum capacity is generally achieved on the lanes in the eastbound direction during the afternoon period between 3:00 and 6:00 to 7:00 P.M. when motorists working in Orange County return to their homes in Riverside County and beyond.

The vehicle volume data comes from transaction data rather than loop detectors. The data is collected by Cofiroute and is essentially available in real time and can be summarized in a wide variety of timeframes. Directional traffic volumes of 3,128 vehicles or more are flagged for further review. Toll rates on the 91 Express Lanes are revisited at the end of each quarter. The vehicle volume data for the previous 12 weeks is examined to see if the 3200 vehicles across both lanes, per hour, per direction benchmark was exceeded. If the average hourly volume for both lanes in any given day, hour and direction of travel is greater than 3,200 vehicles, then the toll is increased by $0.75, and if the volume exceeds 3,300 vehicles per hour, then the toll is increased by $1.00. If an adjustment is made, the toll rate for that day, direction and hour is frozen for six months, and even if the volume thresholds are exceeded in the following quarter, the toll rate is not changed. This policy is designed to give drivers time to adjust to the new toll rate and take it into account when making their travel decisions.

The toll policy described above is articulated in the 91 Express Lanes Procedures Manual and has been in place since 2003. The only aspects that have required adjustment are the mechanics of implementing toll decreases, which occurred as volumes on the lanes decreased during the financial crisis. Changes in toll rates are communicated to OCTA's Board and the public 10 days in advance of implementation. The Board is not involved in the toll adjustment process, which has been an asset with regard to customer relations.

OCTA uses the various pieces of data it collects on incident management, violations processing, and the customer service center to evaluate the performance of its contractors, and take any corrective measures that may be warranted. Lastly, OCTA uses the information gained from its regular customer satisfaction surveys to hone its outreach efforts to its customer base. For example, while the September 2009 survey found that overall satisfaction scores were higher than in previous years and that more respondents indicated that they had no complaints, the results also suggested that the current economic environment is impacting the 91 Express Lanes: "The results indicate that customers are spending less on the 91 Express Lanes, using this toll road less often, and this purchase decision may have become a discretionary item rather than a routine purchase."[10]

As a result of this dynamic, the Customer Satisfaction Survey suggests that the downturn in utilization, "…may impact how OCTA promotes the 91 Express Lanes, toll charges, and the messages being sent to customers." In response to this, the firm preparing the report—Insights Worldwide Research—made the following suggestions to OCTA:

- Build on the convenience factor of the 91 Express Lanes—this year respondents indicated that convenience is as important to them as free-flowing lanes. Promote the convenience of the lanes and the impact it has in the lives 91 Express Lanes customers;
- Promote the fact that OCTA has reduced tolls on the 91 Express Lanes in these hard economic times; and
- Capitalize on the trend toward e-mail and the desire of customers to have access to real-time traffic information on the 91 Express Lanes through text alerts.

5.5 What Additional Performance Metrics or Data Would be Helpful to OCTA or Other Agencies Considering Congestion Pricing?

The 91 Express Lanes was the first operating HOT lane facility in the United States. As such, it was the original trail blazer and was opened without the benefit of performance metrics or operational norms from other priced facilities. OCTA inherited the facility and its pricing and operational structures from CPTC, that private concession company that built the 91 Express Lanes. Upon assuming ownership, OCTA adapted the toll policy on the 91 Express Lanes to create an adjustment process that was "less political." The policy was developed internally by OCTA staff with the assistance of consultants. At the time there were no other comparable priced facilities with which to make comparisons. OCTA staff believe that it would have been helpful to understand the policies of other comparable facilities at the time, but this was not possible.

OCTA staff believe that it is not worth revisiting toll policies to make minor adjustments, as they have the potential to raise other larger concerns. For example, on the 91 Express Lanes, the afternoon peak

[10] Insights Worldwide Research, *2009 91 Express Lanes Customer Satisfaction Survey*, Orange County Transportation Authority, September 2009, p. 17.

encompasses the period from 3:00 to 7:00 P.M., eastbound. However, HOV3 vehicles are only required to pay the half priced toll from 4:00 to 6:00 P.M. and at other times use the lanes at no cost. While OCTA recognizes the rationale for extending tolls for HOV3 vehicles to the entire 3:00 to 7:00 P.M. peak period, there has not been much pressure to change this policy, so OCTA has left it as is rather than risk raising other unforeseen issues. OCTA staff also stressed the important of its customer service patrols and quick incident management on given that the 91 Express Lanes have no shoulders. Other HOT lanes also tend to have limited shoulders, and when this is the case, quick incident clearance is essential to maintaining reliable conditions on the HOT lanes.

One final lesson learned that can be derived from the 91 Express Lanes is the importance placed on regular and ongoing customer satisfaction surveys. The genesis for OCTA's emphasis on customer satisfaction stems from the fact that the 91 Express Lanes was the first priced highway facility to open in the United States, and with no prior knowledge on how the public would react to congestion pricing, surveys were essential. In addition, the 91 Express Lanes was developed by a private concession company which knew firsthand how important customer satisfaction was from its 20-year experience operating toll roads in Europe. As a result of this dynamic, CPTC established the precedent of conducting annual customer satisfaction surveys where 400 to 500 respondents were ask to respond to a set list of questions. Over time, the data compiled from this effort allowed CPTC and later OCTA to track changes in opinion and satisfaction among 91 Express Lane customers and make appropriate adjustments in response.

OCTA has continued CPTC's customer satisfaction survey practices and continues to use the results of its survey efforts to adjust its outreach messages and practices to its customer base. It is important—if not essential—for an agency that charges customers as much as $10.25 to make a 10-mile trip to know how its customers feel about the service it provides. It is also interesting to note that the 2009 survey marks the first biennial publication year. The impetus behind this change is the fact that OCTA does not want its customers to perceive its survey efforts as being excessive or overly expensive. It can also be argued that the change is possible because of the high level of satisfaction with the 91 Express Lanes. Other agencies operating priced facilities should benefit from OCTA's use of regular customer satisfaction surveys and its ability to standardize their results to facilitate meaningful comparisons and trend analyses.

THIS PAGE LEFT BLANK INTENTIONALLY.

TABLE 5-1: ORANGE COUNTY TRANSPORTATION AUTHORITY 91 EXPRESS LANES SUMMARY MATRIX

	Performance Category	Performance Metrics	What Measures Are Used	When				Purpose		Importance		Goal/ Application/ Characterization	Source	Notes
				Ongoing	*Before & After*	*Once*	*Irregular*	*Operations*	*Validation*	*Key*	*Secondary*			
Traffic	*Speed & Travel Time*	LOS												
		Speeds/ average speed	X	X	*			X		X		Maintain throughput (60-65 mph)	Interviews	Calculated from volumes
		Speed differential (GP vs. HOT lanes)												
		Travel times			*									
		Travel time savings			*									
		Cost of delay/VOT			*									
	Volume	Vehicle volume (hourly/daily/weekly/monthly)	X	X	*			X		X		Maintain throughput (60-65 mph)	Interviews	
		Person volume (hourly/daily/weekly/monthly)												
		Tolled trips/ untolled trips			*									
	VMT/VKT	VMT/VKT												
	Congestion	Delay/wait times			*									
		Congestion coefficient												
		Queue length												
	Mode Share	Mode share (SOV, HOV, transit)			*									
	Occupancy	Avg. vehicle occupancy (auto)			*									
	Bike/Ped	Bike/ped traffic counts												
	Parking	Park-n-ride activity (lot counts)			*									
		Off-street parking activity (counts/occupancy)												
		On-street parking activity (counts/occupancy)												
		Cost of parking/parking revenue												
		# of resident permits/permit cost												
		Violations/revenue												
Public Perception	*Awareness*	Of the facility/general/how much?	X	X					X		X		Customer Satisfaction Survey 2009	Annual 1998-2007, now biennial (applies to all)
		Specific features	X	X					X		X		Customer Satisfaction Survey 2009	
		Toll adjustments	X	X					X		X		Customer Satisfaction Survey 2009	
		Future plans	X	X					X		X		Customer Satisfaction Survey 2009	
	Acceptance	General/fairness/equity			*									
		Specific questions			*									
	Satisfaction	General/perceived value/how well?	X	X					X		X		Customer Satisfaction Survey 2009	
		Traffic conditions/ reliability	X	X					X		X		Customer Satisfaction Survey 2009	
		Perceived time savings	X	X					X		X		Customer Satisfaction Survey 2009	
		Perceived safety	X	X					X		X		Customer Satisfaction Survey 2009	
		Signage												
		Agency performance/customer service	X	X					X		X		Customer Satisfaction Survey 2009	
		Enforcement												
	Effectiveness	Congestion reduction												
	Social Impacts	Specific activities/populations												
	Media Coverage	No. of articles/reports (positive or negative)												
	Marketing	Volume/success												
Users	*Transaction Method*	Transponder/video/by-mail/cash												
	Accounts	Total, open/closed												
		No. of transponders issued			*									
	User Characteristics	Vehicle classification			*									
		Vehicle make												
		Vehicle registrations (HOV, vanpool, hybrid)												
		Home zip code												
		Demographics/socioeconomics	X	X	*				X		X		Customer Satisfaction Survey 2009	
	Trip Characteristics	Frequency of use	X	X	*				X		X		Customer Satisfaction Survey 2009	Includes reasons for any changes in driving habits
		Time of day/departure time			*									
		O-D/ travelshed determination	X	X	*				X		X		Customer Satisfaction Survey 2009	By zip code
		Toll spending/price paid (self-reported)	X	X					X		X		Customer Satisfaction Survey 2009	
		Trip length			*									
		Trip purpose			*									

TABLE 5-1: ORANGE COUNTY TRANSPORTATION AUTHORITY 91 EXPRESS LANES SUMMARY MATRIX (CONTINUED)

	Performance Category	Performance Metrics	What Measures Are Used	When				Purpose		Importance		Goal/ Application/ Characterization	Source	Notes
				Ongoing	*Before & After*	*Once*	*Irregular*	*Operations*	*Validation*	*Key*	*Secondary*			
System Operations	*Finance*	Total transactions												
		Revenue (toll/charge)	X	X				X		X		Meet DCR of 1.3	Interviews	
		Average toll/ highest toll												
		Revenue (fee)												
		O&M Cost	X	X					X		X	Evaluate contracted services	Interviews	
	Enforcement	Total traffic stops/ responses												
		Violations/citations/fines	X	X					X		X	Evaluate contracted services	Interviews	
	Safety	Collisions/ accidents			*									
		Incident response time/ duration	X	X					X		X	Evaluate contracted services	Interviews	
		Speed differential												
	Customer Service	Inquiry activity (call, email)	X	X					X		X	Evaluate contracted services	Interviews	
		Performance (quantitative measures)	X	X					X		X	Evaluate contracted services	Interviews	
	System Function	Incidents												
		Facility availability												
		Equipment availability												
		Mean time to respond/ repair												
Environment	*Air Quality*	NAAQS criteria pollutants/VOCs												
		GHG/CO2												
	Noise	Noise levels												
	Fuel Consumption	Fuel consumption												
Transit	*Performance*	Travel time/on-time/excess wait												
		Average speed												
	Occupancy	Ridership/ boardings			*									
		Average vehicle occupancy												
	Finance	Farebox revenue												
		O&M Cost												
	Service	Quality/satisfaction/reliability												
Economics	*General*	Gross regional product/economic indices												
		Benefit-cost analysis												
	Business Impacts	Awareness/importance			*									
		General performance/openings/closings			*									
		Specific sectors/services/populations			*									
		On commercial trucking												
		Business costs and prices												
		Retail traffic & sales												
		Tourists/visitors												
	Property	Residential sales/rentals/values												
		Commercial sales/rentals/values												
Land Use	*Residential*	Housing decisions												
	Commercial	Business locations												

Metrics denoted with a * in the "When" column were collected as part of a four-year, Caltrans and USDOT-sponsored study performed by Cal Poly State University and concluded in 2000.
Other details of the metrics collected in that study are not provided because they are not part of OCTA's current monitoring program.
At the time the study was performed, the 91 Express Lanes were leased from the state and operated by California Private Transportation Company. The facility was sold to OCTA in 2002, who took possession in January 2003.

6. San Diego Association of Governments I-15 Express Lanes

The San Diego Association of Governments (SANDAG) is the metropolitan planning organization (MPO) for the San Diego County region, which comprises 18 cities and county governments. SANDAG serves as the regional decision-making body responsible for transportation planning and development. As part of these duties, SANDAG administers the local half-cent sales tax—*TransNet*—providing funding for transportation projects. The sales tax was first approved by voters in 1988 and was extended in 2004 for another 40 years. During the program's 60-year span, it will generate over $17 billion, which will be distributed between highway, transit, and local road projects in approximately equal thirds. In 2009 SANDAG collected over $1.1 billion in revenue, approximately 25 percent of which was generated by the *TransNet* sales tax.

There are two operating toll facilities in the San Diego region: the I-15 Express Lanes, the first dynamically priced HOT lane, and the South Bay Expressway, a 9-mile privately financed toll road with fixed pricing. SANDAG has been a leading innovator in the use of congestion pricing and is dedicating a significant portion of the *TransNet* highway proceeds to developing a 75- to 80-mile network of managed lanes across four highway corridors identified in MOBILITY 2030, its $42 billion regional transportation plan for San Diego County. San Diego has the distinction of being the first metropolitan area in the United States to establish a long-range transportation plan featuring a regional network of managed lanes as one of its primary strategies to meet future mobility needs.

SANDAG's primary goal in using pricing is to move people and goods more efficiently rather than raise

- Minimizing drive-alone travel by making it safer, more convenient, and efficient to carpool, vanpool, ride transit, walk and bike;

barrier separated HOT lane facility with multiple access and egress points. The expanded express lanes will feature a movable barrier allowing for three travel lanes in the predominant direction of travel during peak periods, as well as direct access to three transit centers with large park-and-ride lots. The expansion is being implemented in three phases. The first, which opened to service in spring 2009, is an eight-mile segment immediately north of the original I-15 Express Lanes between SR 56/Ted Williams Parkway and Centre City Parkway in Escondido. The second phase will extend the lanes north by six miles from Centre City Parkway to SR 78 and is slated for completion in 2011. The final phase of the project will involve the retrofit of the original eight-mile segment between SR 56/Ted Williams Parkway and Kearny Mesa. The entire construction of the facility is expected to be completed by 2012 and will operate 24 hours a day, 7 days a week.

The I-15 Express Lanes are available at no cost to HOV2 motorists, as well as transit vehicles, motorcyclists and approved low emission vehicles, none of which are required to have ETC transponders to use the lanes. SOV motorists must pay to use the Express Lanes, which feature dynamic pricing with toll rates adjusted in three-minute intervals. Tolls have been distance-based since March 2009, with per-mile fees levied based upon entry point. Toll levels are communicated to motorists on variable message signs located upstream of entrances to the I-15 Express Lanes, providing SOV drivers with the information and time they need to decide whether to use the facility. While toll rates vary in real time, the minimum and maximum toll rates are capped at $0.50 and $8.00 per trip, respectively, with a provision for HOV-only operation if less than LOS C conditions on the lanes result even with the maximum allowable toll rate in place.

6.2 What is Monitored?

The full spectrum of SANDAG's performance monitoring activities is provided in the accompanying Facility Performance Monitoring Summary Matrix for the I-15 Express Lanes. The matrix is a comprehensive record of all current, known metrics used to monitor performance on the facility, organized by evaluation category. It also includes earlier monitoring and evaluation work performed by San Diego State University from late 1996 through 1999. Provided in the matrix for each metric used are: frequency of collection; purpose; a simple indication of importance; particular characterizations of the metric that relate back to agency/facility goals or applications; sources of information; and other notes. The matrix is intended to be a visual overview of SANDAG's complete monitoring effort, easily comparable to other HOT lane facilities with similar matrix summaries. A more qualitative discussion of how these metrics are applied in practice and which ones are the most significant is provided below. Not all metrics noted in the matrix are discussed here.

SANDAG monitors several different performance parameters on the I-15 Express Lanes. Using data reported automatically by its system operator TransCore, SANDAG tracks the number of vehicles entering and exiting the I-15 Express Lanes, together with travel speeds, level of service, vehicle density and the distribution of paid and non-paid trips. SANDAG also monitors revenue data reported by TransCore. All this data can be reported at different time intervals and directions of travel.

The parameters described above are used to manage the I-15 Express Lanes and maintain operations at LOS C or better at all times. SANDAG staff stated that by doing so they also deliver consistent travel times on the I-15 Express Lanes. SANDAG stated the term "reliable" tends to be qualitative, because customers' expectation when driving the road goes beyond travel time. Focus groups have shown that I-15 FasTrak customers feel safer and experience a more relaxing, consistent trip using the facility versus the general purpose lanes.

Given that SANDAG is in the process of expanding what was an eight-mile, two-lane facility with single points of access and egress to a far more complex facility, it is also expanding its capabilities to monitor conditions, through a $9 million I-15 Integrated Corridor Management contract awarded in January 2010. The capabilities and requirements of the new performance monitoring systems are currently being identified as the research for NCHRP 08-75 is being compiled. One additional capability being implemented as part of this effort is the ability to classify vehicles by type.

6.3 Other Essential Data Gathering Activities

SANDAG strives for transparency through an extensive outreach program including focus groups, public meetings, forums, and pricing discussions. SANDAG's most recent comprehensive customer survey on the I-15 Express Lanes dates from 2001 and involved both quantitative and attitudinal studies. The survey found that customers were "very happy" with the I-15 facility. Given that it has been operating since 1996, FasTrak customer in the San Diego region understand the complexities of the pricing algorithm, so there are limited questions and inquiries about it. The survey confirmed that equity was not a concern among I-15 customers and stakeholders and that the issue had been addressed through SANDAG's public information activities.

Subsequent survey work after the opening of the first segment of the expansion has not been done because of the extensive construction activities in the corridor. Nonetheless, positive user satisfaction with the HOT lanes continues to be achieved as evidenced by the lack of complaints received by SANDAG or critical press. At the state level, there is some concern that HOV facilities are not used as efficiently as they might be, and SANDAG has fielded questions about the I-15 Express Lanes as a leader after which to model other facilities. SANDAG has also received inquiries regarding the effect of HOT lanes on greenhouse gas reduction and supporting regional transit with regard to the potential expansion of HOT lanes in the Bay Area.

As needs arise, SANDAG also assembles focus groups and small targeted surveys to learn more about public opinion on specific performance issues, such as opinions on enforcement technology and violation rates, and different account plan options.

6.4 Why Performance Evaluation Takes Place and How Performance Monitoring Data is Used

As this research is being completed, the I-15 Express Lanes is at an important, yet protracted crossroads. The facility has been operating since 1996 and has demonstrated its performance and utility to the region and local residents are used to it. This overall satisfaction with the I-15 Express Lanes was arguably a contributing factor to the 2004 vote to extend the *TransNet* sales tax to support the implementation of an aggressive package of transportation improvements which were identified and widely publicized before the voting took place, including over 70 miles of new HOT lanes.

SANDAG is currently in the middle of a five-year construction program to expand the I-15 Express Lanes. Its current focus is on defining the monitoring metrics it will need to have in place in order to manage the expanded facility when it is completed in 2012. In the meantime, the two-lane reversible lanes continue to operate as they have for the past 14 years, and a new, much more complex segment has opened. At the same time, extensive construction activities in the I-15 corridor continue, impacting the operation of the general purpose and managed lanes alike. More performance data is available than ever before and is being used by SANDAG to operate a growing facility under dynamic circumstances.

Current performance monitoring activities are used to ensure that policy and business rules are maximizing the facility's efficiency, i.e. to manage traffic service on the HOT lanes at LOS C or better and document that project revenues are adequate to cover the cost of operating the facility. Using data obtained from ETC equipment and other detection devices installed at tolling points on the lanes, toll rates are set in real time and reflect current traffic conditions detected in three-minute intervals. Traffic densities are calculated on a zonal basis to determine if congestion is increasing. If so, an algorithm determines if other zones are experiencing congestion and sets the price accordingly to manage the flow of traffic entering the facility using per-mile toll rate adjustments. As congestion decreases, the algorithm lowers to attract additional traffic.

The maximum and minimum toll parameters that the algorithm uses to maintain LOS C on the express lanes is mandated by policies established by SANDAG's Board. Meeting the traffic service standard on the original eight-mile facility was straightforward. However, now that SANDAG is operating a 16-mile facility, there are some notable limitations with the toll policies. Even so, SANDAG has found that changing the established rates is not easy. For example, SANDAG's recent attempt to increase the minimum toll from $0.50 to $1.00 was met with resistance from the public as well as local radio personalities who argued that since the lanes are not a money-making venture it was inappropriate to increase tolls. This dynamic is likely to continue as additional segments of the expanded facility are completed. However, SANDAG will have the benefit of the performance data from its expanded monitoring program to make the case for adjustments to the toll limits.

As mentioned earlier, SANDAG also uses focus groups and targeted surveys to study public perception of specific issues and then uses the information gained to inform decisions. In addition, SANDAG will likely complete extensive public opinion surveys following the completion of the expanded I-15 Express Lanes. The region's positive opinion of the project could help to validate the continued expansion of HOT lanes and congestion pricing in San Diego County.

6.5 What Additional Performance Metrics or Data Would be Helpful to SANDAG or Other Agencies Considering Congestion Pricing?

Enforcement is difficult given that HOV and transit vehicles are not required to be equipped with transponders. While SANDAG has an anecdotal understanding of the impact of I-15 Express Lanes, in retrospect staff wishes they had a quantifiable, measurable approach to document the impact of pricing on such basic issues as traffic levels in the general purpose lanes and formation of carpools. SANDAG staff observed that the data they have collected on the existing I-15 Express Lanes only enable them to determine the effects of congestion pricing on SOV utilization of the managed lanes.

SANDAG's experience with the expansion of the I-15 from its straightforward original configuration to a complex 20-mile facility will be invaluable to other locations considering evolving existing HOT lane facilities into more complex managed lane systems. SANDAG staff report that it has been challenging to manage the multiple new exit and entrance points, each of which have different toll implications. They do not know if customers truly understand the price per mile that they pay to use the lanes. Given the space constraints and safety implications, signage conveying toll rates is particularly challenging for a complex facility such as the expanded I-15 Express Lanes. One possible approach for addressing this issue may be to use a matrix approach to display toll rates by exit. The physical creation of many new entrances and exits to the managed lanes as a result of the ongoing expansion impacts monitoring metrics and procedures. SANDAG is currently enhancing its monitoring capabilities in order to manage and operate the expanded I-15 Express Lanes to its full potential when construction is completed.

TABLE 6-1: SAN DIEGO ASSOCIATION OF GOVERNMENTS I-15 EXPRESS LANES SUMMARY MATRIX

	Performance Category	Performance Metrics	What Measures Are Used	When				Purpose		Importance		Goal/ Application/ Characterization	Source	Notes
				Ongoing	*Before & After*	*Once*	*Irregular*	*Operations*	*Validation*	*Key*	*Secondary*			
Traffic	*Speed & Travel Time*	LOS	X	X	*			X		X		VPP req'ment; reliability	Interviews	
		Speeds/ average speed	X	X	*			X		X		VPP req'ment	Interviews	
		Speed differential (GP vs. HOT lanes)												
		Travel times			*									
		Travel time savings			*									
		Cost of delay/VOT			*									
	Volume	Vehicle volume (hourly/daily/weekly/monthly)	X	X	*			X		X		VPP req'ment	Interviews	Density is also tracked
		Person volume (hourly/daily/weekly/monthly)												
		Tolled trips/ untolled trips												
	VMT/VKT	VMT/VKT												
	Congestion	Delay/wait times			*									
		Congestion coefficient												
		Queue length												
	Mode Share	Mode share (SOV, HOV, transit)			*									
	Occupancy	Avg. vehicle occupancy (auto)			*									
	Bike/Ped	Bike/ped traffic counts												
	Parking	Park-n-ride activity (lot counts)			*									
		Off-street parking activity (counts/occupancy)												
		On-street parking activity (counts/occupancy)												
		Cost of parking/parking revenue												
		# of resident permits/permit cost												
		Violations/revenue												
Public Perception	*Awareness*	Of the facility/general/how much?				*								
		Specific features												
		Toll adjustments												
		Future plans												
	Acceptance	General/fairness/equity				*								
		Specific questions				*								
	Satisfaction	General/perceived value/how well?				*								
		Traffic conditions/ reliability				*								
		Perceived time savings												
		Perceived safety												
		Signage												
		Agency performance/customer service												
		Enforcement	X			X			X		X		Interviews	Recent survey
	Effectiveness	Congestion reduction				*								
	Social Impacts	Specific activities/populations												
	Media Coverage	No. of articles/reports (positive or negative)			*									
	Marketing	Volume/success			*									
Users	*Transaction Method*	Transponder/video/by-mail/cash												
	Accounts	Total, open/closed												
		No. of transponders issued												
	User Characteristics	Vehicle classification			*									
		Vehicle make												
		Vehicle registrations (HOV, vanpool, hybrid)			*									12/96 - 3/98 ExpressPass Program
		Home zip code												
		Demographics/socioeconomics				*								
	Trip Characteristics	Frequency of use				*								
		Time of day/departure time				*								
		O-D/ travelshed determination												
		Toll spending/price paid (self-reported)												
		Trip length												
		Trip purpose												

TABLE 6-1: SAN DIEGO ASSOCIATION OF GOVERNMENTS I-15 EXPRESS LANES SUMMARY MATRIX (CONTINUED)

	Performance Category	Performance Metrics	What Measures Are Used	When				Purpose		Importance		Goal/ Application/ Characterization	Source	Notes
				Ongoing	*Before & After*	*Once*	*Irregular*	*Operations*	*Validation*	*Key*	*Secondary*			
System Operations	*Finance*	Total transactions	X	X					X		X		Interviews	
		Revenue (toll/charge)	X	X					X	X		Finance - cover operating costs	Interviews	
		Average toll/ highest toll	X	X				X		X			Interviews	
		Revenue (fee)												
		O&M Cost	X	X					X	X		Finance - cover operating costs	Interviews	
	Enforcement	Total traffic stops/ responses												
		Violations/citations/fines			*									
	Safety	Collisions/ accidents												
		Incident response time/ duration												
		Speed differential												
	Customer Service	Inquiry activity (call, email)												
		Performance (quantitative measures)												
	System Function	Incidents												
		Facility availability												
		Equipment availability												
		Mean time to respond/ repair												
Environment	*Air Quality*	NAAQS criteria pollutants/VOCs			*									
		GHG/CO2												
	Noise	Noise levels												
	Fuel Consumption	Fuel consumption												
Transit	*Performance*	Travel time/on-time/excess wait												
		Average speed												
	Occupancy	Ridership/ boardings			*									Express and feeder bus service
		Average vehicle occupancy												
	Finance	Farebox revenue												
		O&M Cost												
	Service	Quality/satisfaction/reliability												
Economics	*General*	Gross regional product/economic indices												
		Benefit-cost analysis												
	Business Impacts	Awareness/importance			*									
		General performance/openings/closings												
		Specific sectors/services/populations												
		On commercial trucking												
		Business costs and prices												
		Retail traffic & sales												
		Tourists/visitors												
	Property	Residential sales/rentals/values												
		Commercial sales/rentals/values												
Land Use	*Residential*	Housing decisions			*									
	Commercial	Business locations												

Metrics denoted with a * in the "When" column were collected as part of the three-year SDSU monitoring and evaluation study performed from 12/96 - 12/99 and published in 2001.
Metrics marked as being measured "Once" were collected through attitudinal panel surveys administered five times following the facility's opening.
Other details of the metrics collected in that study are not provided because they are not part of SANDAG's current monitoring program.
The purpose of the SDSU study was validation (see: Analysis of Domestic and International Literature).

7. Washington Department of Transportation SR 167 HOT Lanes

The Washington Department of Transportation (WSDOT) operates a total of 764 centerline miles of Interstate highway out of a statewide network of 174,430 miles of roads. There are currently only two toll facilities in Washington State: the Tacoma Narrows Bridge and the SR 167 HOT lanes, which is the subject of this case study. Toll revenues represented approximately 4 percent of WSDOT total revenues of $3.2 billion in 2007, nearly all of which was generated by the Tacoma Narrows Bridge.[11] The bridge's tolls are being used to repay revenue bonds used to finance its construction, a mechanism used many times in the past by Washington State. WSDOT plans to introduce congestion pricing on the SR-520 Evergreen Point Floating Bridge with the support of a $154.5 million UPA grant from USDOT and is also exploring the use of congestion pricing on other major highway facilities in the Puget Sound region.

In 2003 the Washington State Transportation Commission directed WSDOT to assess the possible conversion of HOV facilities in the state to HOT lane operation. WSDOT identified the SR 167 as a suitable pilot project for a HOV-to-HOT conversion because of congested conditions in the general purpose lanes and unused capacity in the HOV lane. On May 16, 2005 Governor Christine Gregoire signed State Highway Bill 1179 which called for a four-year conversion demonstration. The bill also identified performance data and supporting information to be included in an annual report to the State Legislature documenting the performance of the SR 167 HOT lanes. The bill states that:

> "The department shall monitor the state route 167 high occupancy toll lane pilot project and shall annually report to the transportation commission and the legislature on operations and findings. At a minimum, the department shall provide facility use data and review the impacts on:
>
> a. Freeway efficiency and safety;
> b. Effectiveness for transit;
> c. Person and vehicle movements by mode;
> d. Ability to finance improvements and transportation services through tolls; and
> e. The impacts on all highway users.
>
> The department shall analyze aggregate use data and conduct, as needed, separate surveys to assess usage of the facility in relation to geographic, socioeconomic, and demographic information within the corridor in order to ascertain actual and perceived questions of equitable use of the facility."

The four-year demonstration will conclude on May 3, 2012, at which time the Washington State Legislature will have to act to make the authorization permanent.

7.1 Overview of the WSDOT's Congestion Pricing Program

The SR 167 HOT lanes opened to service on May 3, 2008. A single HOT lane runs in each direction of SR 167 between Renton and Auburn in southern Kings County. The northbound lane, approximately 11 miles in length, begins at 15th Street SW in Auburn and terminates at I-405 in Renton, while the southbound lane, nine miles in length, begins at I-405 and terminates at 15th Street NW. The two general purpose

[11] AASHTO Center for Excellence in Project Finance

lanes in each direction remain toll-free and open to all vehicles. Carpools of two or more people, vanpools, transit vehicles, and motorcycles may use the HOT lanes at no cost, and they may enter the lanes without a transponder. Single occupant passenger vehicles may pay to use the HOT lanes from 5 A.M. to 7 P.M. daily and must be equipped with a WSDOT "*Good To Go!*" electronic toll collection (ETC) tag use the lanes. The SR 167 features dynamic tolling with rates adjusted every five minutes based on real time congestion levels to ensure that traffic in the HOT lane always flows smoothly and that buses and carpools enjoy the same trip as they did prior to their conversion to HOT operation. The HOT lane is separated from the general purpose lanes by a solid double white line, which is illegal to cross. Access in and out of the HOT lane is restricted to access zones identified by a dashed line. There are six northbound and four southbound access zones. Prior to the conversion, motorists using the SR 167 HOV had continuous access to the lanes and could enter or exit the lanes at any location.

7.2 What is Monitored?

The full spectrum of WSDOT's performance monitoring activities is provided in the accompanying Facility Performance Monitoring Summary Matrix for the SR 167 HOT Lanes. The matrix is a comprehensive record of all current, known metrics used to monitor performance on the facility, organized by evaluation category. Provided in the matrix for each metric used are: frequency of collection; purpose; a simple indication of importance; particular characterizations of the metric that relate back to agency/facility goals or applications; sources of information; and other notes. The matrix is intended to be a visual overview of WSDOT's complete monitoring effort, easily comparable to other HOT lane facilities with similar matrix summaries. A more qualitative discussion of how these metrics are applied in practice and which ones are the most significant is provided below. Not all metrics noted in the matrix are discussed here.

WSDOT collects a comprehensive set of monitoring parameters for the SR 167 HOT lane facility. These include automated data on traffic volumes and speeds in both the managed and general purpose lanes collected by loop detectors. WSDOT tracks volume and speed data in multiple timeframes and compares conditions in the general purpose and managed lanes, as well as the peak and non-peak direction of traffic. In addition to the data it collects from loop detectors in the corridor, WSDOT receives comprehensive data on toll transactions reported in a standard format by its toll operator. This includes information on the number of toll transactions, toll rates and revenue, which are reported by time-of-day and direction of travel. This information can be aggregated or broken down into intervals as small as five minutes.

The SR 167 HOT lane enabling authorization requires that average travel speeds during peak hours (7:00–8:00 A.M. and 4:00–5:00 P.M.) of at least 45 mph are maintained at least 90 percent of the time. Monitoring data from the first year of operation demonstrates that the facility exceeds this requirement, meeting the speed threshold 99.2 percent of the time. WSDOT also utilizes end-to-end travel times as a measure of reliability. For example, it measured that the northbound peak-hour (7:00–8:00 A.M.) travel time in the HOT lane was 11 minutes on average. Its data indicate that the 95th percentile travel time was also 11 minutes. This means that motorists traveling northbound during the peak hour will experience an 11-minute travel time 95 percent of the time. The southbound lane demonstrated similar travel reliability, with an average travel time of eight minutes, for which the 95th percentile travel time is also eight minutes.

WSDOT makes a compelling case for the reliability of the HOT lane by comparing travel metrics to those on the general purpose lanes, where the average weekday northbound peak-hour travel time was 19 minutes, with a 95th percentile travel time of 26 minutes, and a southbound peak-hour travel time of 12 minutes, with a 95th percentile travel time of 19 minutes. WSDOT also tracks travel time savings between the managed and general purpose lanes, which were found to be on average eight minutes northbound in the A.M. peak and four minutes southbound in the P.M. peak.

In addition to traffic operations data, WSDOT also tracks the overall number of tolled trips made on the SR 167 HOT lanes. This information is generated by the automated toll collection system operated by WSDOT's toll vendor, Electronic Transaction Consultants (ETCC). Paid trips are broken down by time, day and direction of travel, as well as toll rate. WSDOT also tracks toll revenue, which it generally reports as a monthly total. WSDOT often presents revenue data together with operational costs for the SR 167, which include, monitoring, shared maintenance, enforcement, transaction processing, emergency response, customer service, and traffic management center and tolling operations. As of early 2010, average monthly operational costs for the SR 167 are approximately $97,600 and exceed average monthly revenues of $32,700 by a factor of three. However, WSDOT has anticipated that over the four-year pilot, overall expenses would be covered by toll revenues and is projecting that revenues will begin to exceed expenses in early 2011. Nonetheless, as discussed later in this report, the objective of the SR 167 HOT lane project is congestion reduction rather than revenue generation.

WSDOT also tracks information provided by other agencies. This includes transit performance data of travel times and ridership levels provided by Sound Transit, which operates two bus routes on the corridor, as well as the South Sounder commuter rail service. Sound Transit confirms that travel times for its bus service did not change after the HOT conversion and that transit ridership has actually increased 8.4 percent since the opening of the HOT lanes. WSDOT also tracks enforcement and safety data maintained by the Washington State Patrol. This includes information on occupancy and toll violations, as well as information on crashes and instances where roadside assistance of any kind is provided, together with response times. It should be noted that the WSP has maintained an increased presence in the corridor since the conversion, a factor which needs to be considered when making before-and-after comparisons.

WSDOT also monitors conditions on the SR 167 at its Traffic Management Center using remote control cameras and data collected from traffic speed and volume sensors. This information is displayed on a dashboard showing multiple tracking metrics, including traffic volumes, lane speed and toll rates. If any anomalies are seen, Traffic Management Center staff coordinate with the WSDOT Maintenance. Lastly, WSDOT also utilizes the *Good To Go!* Customer Service Center database to compile additional information on motorists paying to use the lanes, including residential zip codes and trips by vehicle make.

7.3 Other Essential Data Gathering Activities

WSDOT's performance monitoring program for the SR 167 HOT lanes has also included different survey efforts to track various parameters. Some of this work was completed prior to the opening of the HOT lanes and some was completed following the conversion.

In January 2007, WSDOT completed a study of social, economic and environmental justice for the SR 167 HOT lane conversion to review effects the project may have on communities along the corridor and the fairness and equity of the project. The study captured the findings of WSDOT's comprehensive outreach efforts associated with the conversion, including opinion surveys, open houses, and public outreach events. The study found that the conversion would provide drivers of all income levels with a new option to make faster and more reliable trips and that a cash payment program option for toll accounts would enhance access to the system for low-income drivers.

In January 2009, WSDOT conducted two focus group sessions designed to complete earlier work the Department began in 2006. The earlier work, which involved six focus group sessions, gauged initial perceptions of the SR 167 HOT lanes and compared responses by low-income and typical drivers, as well as service employees or those who are self employed. The January 2009 focus groups helped WSDOT to learn how the operation of the new HOT lanes is affecting drivers in general, specifically low-income drivers. The focus groups explored the following issues:

- Acceptance of the lanes as a congestion-management tool
- Use of and access to the HOT lanes
- Potential obstacles to HOT lane use and the magnitude of those obstacles
- Equity issues related to access, mode use, opportunity, income and geography, and difference in perceptions and responses between people in low-income groups and others
- Difference in perceptions and responses to the lanes by people who have transponders and those who do not

In May 2009, an online survey was sent to 22,000 *Good To Go!* account holders who had a valid e-mail address and had driven the SR 167 HOT lanes at least once, of whom some 3,000 responded. The intent of the survey was to gain information on the age and income profiles of drivers paying to use the lanes and determine whether it is consistent with the findings from WSDOT's earlier 2005 Baseline Survey Report. The 2009 user survey addressed issues ranging from general satisfaction, to opinions on the extension of the demonstration, access treatments, and the shields that HOV motorists with *Good To Go!* Tags use in their vehicle to avoid being charged for their trips.

7.4 Why Performance Evaluation Takes Place and How Performance Monitoring Data is Used

WSDOT utilizes the monitoring data it collects on the SR 167 HOT lane for a variety of purposes. These are described in further detail below.

Maintaining Traffic Service and Speed Levels on the HOT Lanes. As described earlier, WSDOT uses dynamic tolling on the SR 167, where toll levels are adjusted every five minutes in order to maintain traffic service and speed levels on the HOT lanes using real time information on travel conditions in the corridor. The algorithm used to calculate toll rates on the SR 167 HOT lanes is proprietary to WSDOT's system operator, ETCC, and relies on real time information on speeds, traffic volumes, and the distribution of non-paying HOV and tolled SOV vehicles on the facility. The algorithm – which some industry sources believe is the most sophisticated in use today in the United States – also takes into account monthly incidents on the lanes.[12] Each of these factors is governed by coefficients that can be adjusted to alter their influence on the toll rate.

The algorithm adjusts toll rates based on volumes and speed data, together with the rates at which volumes and speeds were changing. The toll rate is adjusted in 5-minute intervals and is driven by changes between the number of new vehicles actually entering the facility and the number of vehicles predicted by the algorithm. Toll rates can vary between a low of $0.50 and high of $9.00. If conditions on the SR 167 exceed the $9.00 maximum toll, the facility reverts to HOV-only operation.

During its first year of operation, the average toll rate on the SR 167 was $0.96, and following the adjustments to the dynamic-pricing algorithm, the highest toll paid to use the lanes was $2.25, which occurred in April 2009.

[12] This approach is different from the dynamic pricing system used by MnDOT on the I-35W and I-394 MnPASS lanes, which uses a look-up table that has established toll rates based on speeds and volumes.

Fulfilling Legislatively Mandated Reporting Requirements. State legislation enabling the four-year HOT demonstration on the SR 167 requires that WSDOT provide an annual report to the Washington Transportation Commission and the State Legislature on the operations of the facility. WSDOT is required to provide data on the use of the HOT lanes and review impacts on efficiency and safety in the corridor; transit effectiveness; vehicle and person movements by mode; and equity issues. WSDOT is also required to provide financial data that demonstrate to what extent project proceeds are able to support other transportation services and improvements.

The metrics used by WSDOT to document the performance of the SR 167 HOT lane demonstration have been selected to enable the Department's ability to fulfill these reporting requirements. WSDOT prepared six- and eight-month performance summary reports, in addition to its First Annual Performance Summary for the SR 167 HOT lanes. All these documents are available to the public on WSDOT's SR 167 website, together with other technical reports, at the following location: http://www.wsdot.wa.gov/Tolling/SR167HotLanes/publications.htm

Improving Operational Performance. The performance monitoring and user satisfaction data WSDOT collects enables it to assess the operational performance and safety of the HOT lanes and identify potential adjustments to them. As mentioned earlier, there are two challenging situations that WSDOT has had to address with the SR 167 conversion: access to the facility and providing transponder shields to HOV motorists who have *Good To Go!* tags in their vehicles for use on the Tacoma Narrows Bridge.

As a result of its survey work and focus group sessions, WSDOT has provided additional signage with information on the location of upcoming access and egress points to and from the HOT lanes. The purpose of this change was to address confusion over these locations, exacerbated by HOV vehicles users being accustomed to having continuous access in or out of the lanes at any point prior to the conversion.

In addition, WSDOT's outreach efforts have focused on the effectiveness and ease of use of the tag shields. WSDOT officials had to take into account the timing of the new Tacoma Narrows Bridge opening which occurred in July 2007, just ten months before the activation of the SR 167 HOT conversion. Because the new bridge is tolled, nearly all regular bridge users have obtained *Good to Go!* transponders. For example, there is a 96 percent penetration rate of transponder users in the Gig Harbor zip code—a city just adjacent to the entrance to the Tacoma Narrows Bridge. However, when the SR 167 conversion took place, no HOV users who had obtained a transponder for use on the bridge had the transponder shield required to avoid being tolled on the HOT lane. This situation introduced a significant outreach challenge for the SR 167 conversion.

Documenting Changes in Travel Behavior and Traffic Conditions. The performance monitoring data document changes in travel behavior by different user groups and the resulting changes in operational and congestion conditions on the SR 167 corridor. The improvements in congestion levels on the SR 167 as a result of the conversion are dramatic. WSDOT's before-and-after monitoring data during the A.M. and P.M. peak periods for 2007 and 2009 document a dramatic 21.5 percent increase in average speeds on the general purpose lanes and an 11 percent increase in average volumes. Speeds also increased 6 percent on the HOT lanes, which also saw a 4 percent increase in northbound volumes during the A.M. peak and stable volumes southbound during the P.M. peak. However, because SR 167 provides two general purpose lanes and one HOT lane in each direction, it would be anticipated that a volume lane movement from the general purpose lanes to the HOT lanes would immediately result in increased speeds in the general purpose lanes.

Validating the Case for Congestion Pricing. Lastly, the collective data derived from the performance monitoring program enable WSDOT to validate the performance of the SR 167 HOT lanes to its stakeholders. This will be essential for the decision whether to extend the operation of the SR 167 lanes beyond the demonstration period's May 2012 expiration. It will also be essential to WSDOT's ambitious plans to introduce congestion pricing on the SR 520 Evergreen Point Floating Bridge, and possibly the I-90 Lake Washington crossing.

7.5 What Additional Performance Metrics or Data Would be Helpful to WSDOT or Other Agencies Considering Congestion Pricing?

WSDOT has a well established culture of collecting comprehensive performance monitoring data, and the SR 167 HOT lane facility is no exception. While WSDOT officials had access to comprehensive real time traffic data derived from an extensive network of loop detectors and are accustomed to conducting before-and-after analysis for new improvements, they found it challenging to identify the right combination of performance metrics that would make a compelling case for congestion pricing's use. WSDOT officials felt that they were on their own to identify the best set of metrics to justify the need for and to track the performance of congestion pricing in the state. They also found that they lacked standard data on priced facilities in other locations for comparison to their own state. As a result of these gaps, WSDOT officials helped to initiate the effort to undertake the research performed in NCHRP 08-75 and hope that the findings of the study will help fill this void.

One particular challenge cited by WSDOT officials has been identifying appropriate measures of travel reliability on the SR 167 corridor. While WSDOT has done an effective job of communicating improvements in travel speeds and throughput as a result of the conversion, it remains to be seen whether its reliability metric of the 95th percentile end-to-end travel time carries the same impact. Communicating the meaning of the 95th percentile travel time metric to the public is also challenging.

Another major challenge that WSDOT has faced with the SR 167 demonstration is that the intent of the conversion was not to generate revenue but rather to manage the operation of its existing infrastructure to improve traffic service, travel speeds, and the overall efficiency of the SR 167 corridor. Even so, the enabling legislation for the SR 167 demonstration requires WSDOT to report on the "ability to finance improvements and transportation services through tolls [collected on the SR 167 HOT lanes]." The reality is that the SR 167 HOT lanes operate at a deficit. Operating costs exceed average monthly toll proceeds of approximately $32,700 by a factor of three. This may cause elected officials and the public to question the rationale behind the conversion. However, the reality is that for a modest investment of $60,000 per month, or $720,000 per year, WSDOT has bought a 21.5 percent increase in average peak period speeds on the congested general purpose lanes and an 11 percent increase in average volumes. This leaves WSDOT with the challenge of communicating what the cost of implementing physical enhancements to SR 167 would have to have been to achieve the same congestion reduction effect as the HOV-to-HOT conversion.

TABLE 7-1: WASHINGTON DEPARTMENT OF TRANSPORTATION SR 167 HOT LANES SUMMARY MATRIX

				Ongoing	*Before & After*	*Once*	*Irregular*	*Operations*	*Validation*	*Key*	*Secondary*			
Traffic	*Speed & Travel Time*	LOS												
		Speeds/ average speed	X	X				X	X	X		Reliability	Annual Report, Interviews	Formerly also measured in GP lanes
		Speed differential (GP vs. HOT lanes)												
		Travel times	X	X					X		X	Reliability; Efficiency	Annual Report	Also measured in GP lanes
		Travel time savings	X	X					X		X	Reliability; Efficiency	Annual Report, Interviews	GP lanes also; would like to improve
		Cost of delay/VOT											Interviews	Would like to improve
	Volume	Vehicle volume (hourly/daily/weekly/monthly)	X	X				X	X	X		Reliability	Annual Report, Interviews	Formerly also measured in GP lanes
		Person volume (hourly/daily/weekly/monthly)												
		Tolled trips/ untolled trips	X	X					X		X	Operations	Annual Report	Max vs. avg. usually reported monthly
	VMT/VKT	VMT/VKT												
	Congestion	Delay/wait times												
		Congestion coefficient												
		Queue length												
	Mode Share	Mode share (SOV, HOV, transit)												
	Occupancy	Avg. vehicle occupancy (auto)												
	Bike/Ped	Bike/ped traffic counts												
	Parking	Park-n-ride activity (lot counts)												
		Off-street parking activity (counts/occupancy)												
		On-street parking activity (counts/occupancy)												
		Cost of parking/parking revenue												
		# of resident permits/permit cost												
		Violations/revenue												
Public Perception	*Awareness*	Of the facility/general/how much?	X			X			X		X	Equity, Public Perception	Focus Groups	
		Specific features												
		Toll adjustments												
		Future plans												
	Acceptance	General/fairness/equity	X		X				X		X	Equity, Public Perception	EJ Report, Focus Groups	
		Specific questions												
	Satisfaction	General/perceived value/how well?	X			X			X		X	Public Perception	Focus Groups	
		Traffic conditions/ reliability												
		Perceived time savings												
		Perceived safety												
		Signage												
		Agency performance/customer service												
		Enforcement												
	Effectiveness	Congestion reduction												
	Social Impacts	Specific activities/populations												
	Media Coverage	No. of articles/reports (positive or negative)												
	Marketing	Volume/success												
Users	*Transaction Method*	Transponder/video/by-mail/cash												
	Accounts	Total, open/closed	X	X									Annual Report	
		No. of transponders issued	X	X									Annual Report	
	User Characteristics	Vehicle classification												
		Vehicle make	X	X					X	X		Equity	Annual Report	
		Vehicle registrations (HOV, vanpool, hybrid)												
		Home zip code	X										Annual Report	
		Demographics/socioeconomics	X		X				X		X	Equity	Annual, EJ Report	Income, age, etc.
	Trip Characteristics	Frequency of use												
		Time of day/departure time												
		O-D/ travelshed determination	X			X			X		X	Equity	EJ Report	
		Toll spending/price paid (self-reported)												
		Trip length												
		Trip purpose												

TABLE 7-1: WASHINGTON DEPARTMENT OF TRANSPORTATION SR 167 HOT LANES SUMMARY MATRIX (CONTINUED)

	Performance Category	Performance Metrics	What Measures Are Used	When				Purpose		Importance		Goal/ Application/ Characterization	Source	Notes
				Ongoing	*Before & After*	*Once*	*Irregular*	*Operations*	*Validation*	*Key*	*Secondary*			
System Operations	*Finance*	Total transactions												
		Revenue (toll/charge)	X	X					X				Annual Report	
		Average toll/ highest toll	X	X				X	X	X			Annual Report	
		Revenue (fee)												
		O&M Cost												
	Enforcement	Total traffic stops/ responses	X	X					X		X	Safety	Annual Report	
		Violations/citations/fines	X	X					X		X	Safety	Annual Report	
	Safety	Collisions/ accidents	X	X					X		X	Safety	Annual Report	
		Incident response time/ duration	X	X					X		X	Safety	Annual Report	
		Speed differential												
	Customer Service	Inquiry activity (call, email)	X	X					X		X		Annual Report	
		Performance (quantitative measures)												
	System Function	Incidents												
		Facility availability												
		Equipment availability	X	X					X		X		Interviews	
		Mean time to respond/ repair	X	X					X		X		Interviews	
Environment	*Air Quality*	NAAQS criteria pollutants/VOCs												
		GHG/CO2												
	Noise	Noise levels												
	Fuel Consumption	Fuel consumption												
Transit	*Performance*	Travel time/on-time/excess wait	X	X					X		X	Secondary effects	Annual Report	
		Average speed												
	Occupancy	Ridership/ boardings	X	X					X		X	Secondary effects	Annual Report	
		Average vehicle occupancy												
	Finance	Farebox revenue												
		O&M Cost												
	Service	Quality/satisfaction/reliability												
Economics	*General*	Gross regional product/economic indices												
		Benefit-cost analysis												
	Business Impacts	Awareness/importance												
		General performance/openings/closings												
		Specific sectors/services/populations												
		On commercial trucking												
		Business costs and prices												
		Retail traffic & sales												
		Tourists/visitors												
	Property	Residential sales/rentals/values												
		Commercial sales/rentals/values												
Land Use	*Residential*	Housing decisions												
	Commercial	Business locations												

Toll Facilities with Variable Pricing

8. Ontario Ministry of Transportation Highway 407 Express Toll Route

The Ministry of Transportation of Ontario (MTO) is responsible for maintaining the transportation infrastructure of Canada's largest province. The MTO establishes transportation policy in Ontario and operates with a great deal of freedom from the central government. The MTO's budget in fiscal year 2004 was approximately $1.6 billion CAD and it maintains a provincial highway network of approximately 16,525 centerline kilometers (10,268 miles), of which approximately 1,767 kilometers (1,097 miles) are 400-series highways built to standards similar to that of the United States Interstate Highway System.

8.1 Overview of MTO's Congestion Pricing Program

Ontario Highway 407—known as 407 Express Toll Route or "407 ETR"—forms a 108-kilometer (67-mile) bypass through the northern flank of greater Toronto, relieving traffic on Highway 401 and Queen Elizabeth Way. It is Ontario's only toll highway and was the first highway to use electronic toll collection exclusively for its entire length. Planning for the 407 dates back to the 1950s, but the actual implementation of the roadway was very slow. In the early 1990s, the MTO considered implementing the original 69-kilometer segment as a public-private partnership, but public borrowing costs were favorable leading the MTO to complete the project under a design-build procurement. However, MTO did outsource the operation of the highway, which was completed just as transponder technology became widely available. The facility was operated toll-free for the first six months, after which electronic tolls were charged to all motorists using a combination of transponder and character recognition video technology. From the inception of tolling on the facility, there was a differential in price for peak and off-peak travel, as well as among different vehicle classes.

While the 407 ETR was intended to act as a relief for other major east-west highways, the facility quickly generated it own additional traffic, has been heavily utilized since its inception, and operates at capacity during peak periods. A downturn in the economy in the late 1990s led the Government of Ontario to privatize the facility, allowing it to recoup a one-time fee of $3 billion CAD, which helped to balance the provincial budget. In 1997, the MTO awarded a 99-year concession to operate and expand the 407 ETR to Highway 407 International Inc., a concession company comprised of Cintra Infraestructuras S.A., Intoll, and SNC-Lavalin. Following the privatization, the concession company extended the facility 40 kilometers to the west and 15 kilometers to the east, at a cost of approximately $500 million CAD. In addition, Highway 407 International Inc. also invested an additional $500 million CAD on widening portions of the original 69-kilometer segment and enhancing the facility's electronic toll collection systems.

The 407 ETR toll structure varies by distance traveled, time-of-day, mode of payment, and overall congestion level of the segments traveled. The 407 ETR charges peak toll rates from 6:00 to 10:00 A.M. and 3:00 to 7:00 P.M. on weekdays. As of 2010, a peak-period rate of 21.35¢ CAD per kilometer is charged for travel on "regular zone" sections of the facility, while a slightly lower rate of 21.10 cents per kilometer is charged on "light zone peak" sections. An off-peak rate of 18.35¢ CAD is charged at all other time on all segments of the facility. Motorists without a transponder are charged a video toll fee of $3.60 CAD for each trip made on the 407 ETR, regardless of the time of travel, and both transponder and non-transponder vehicles must pay other fixed fees of 40¢ CAD per transaction and $2.50 CAD per month. ETC holders must also pay an annual transponder lease fee of $21.50 CAD.

The distinction between peak and off-peak toll rates was initiated by MTO upon opening Highway 407, and Highway 407 International Inc. retained this precedent when it took over the operation of the facility. MTO has examined the possibility of HOV-to-HOT conversions on other highway facilities in Ontario, but concluded that there was no business case for such conversions because of limited off-peak demand and the costs of implementing and enforcing HOT lanes.

8.2 What is Monitored?

The concessionaire's monitoring requirements are identified in the Concession and Ground Lease Agreement (GLA) allowing it to operate the 407 ETR. The concessionaire is required to provide quarterly Traffic Characteristics Reports to MTO within 20 days of the close of each quarter. These include forecasts of anticipated traffic volumes by vehicle type for the next three-month period, traffic volume forecasts for the next year, and actual traffic counts for the past three-month period. In addition, the concessionaire is required to make real time traffic data reports available to MTO for purposes of the Freeway Traffic Management System of the Province of Ontario. The traffic data is reviewed and verified by an independent auditor. MTO also performs some pre-programmed common sense tests on the volume data to crosscheck the results with other data sources it maintains.

Similarly, the concessionaire is obligated to provide quarterly Incident Management Reports. These include the following information on all traffic incidents on the 407 ETR:

- Type of incident (bodily injury, death, property damage);
- Classification of incident (road-related, barrier hit, right-of-way, other);
- Number of incidents by type and classification;
- Number of claims and revenue received by type and classification of incident; and,
- Cost to correct incidents by type and classification.

The concessionaire is also required to submit Environmental Incident Reports to MTO within seven business days reporting any discharge, dumping, or spilling of hazardous substances on the 407 ETR, together with the location and time of the incident, description of the damage involved, listing of the agencies involved, and description of any remedial actions that were taken.

The GLA also contains provisions for checking a number of highway design parameters such as shoulder grade, super-elevation, friction, sightlines, and lane width, as well as other metrics related to safety, including the clear zone beyond the edge of the roadway and the flattening of slopes along the shoulder. Safety metrics indicate that the roadway is more than twice as safe as other Ontario highways. Standards of maintenance have evolved with the changing government trend towards outsourcing and privatization. Newer metrics pertain to illumination, signage and construction and are audited 10 to 12 times per year.

The Ontario Provincial Police (OPP) is responsible for enforcing the 407 ETR and contracted at cost. They maintain their own enforcement data, per their own internal established procedures.

8.3 Other Essential Data Gathering Activities

Highway 407 International Inc. was tasked with improving customer service upon assuming the operation of the 407 ETR. It employs approximately 60 customer service representatives. MTO staff report that the level of customer complaints has decreased over time.

8.4 Why Performance Evaluation Takes Place and How Performance Monitoring Data is Used

The primary purpose for MTO's performance monitoring on the 407 ETR is to maintain the Province's Freeway Traffic Management System and verify that Highway 407 International Inc.'s performance meets the standards established in the GLA. There are no established performance thresholds for peak and off-peak periods, nor are toll rates changed in response to congestion on the facility. Toll rates remain at the discretion of the concession company, although certain traffic thresholds must be met in order to justify a change in rates. MTO has the right to assess severe penalties if toll rates are changed without the corresponding threshold having been met.

8.5 What Additional Performance Metrics or Data Would be Helpful to MTO or Other Agencies Considering Congestion Pricing?

MTO had no additional comments to offer on performance monitoring issues.

THIS PAGE LEFT BLANK INTENTIONALLY.

TABLE 8-1: ONTARIO MINISTRY OF TRANSPORTATION HIGHWAY 407 EXPRESS TOLL ROUTE SUMMARY MATRIX

	Performance Category	Performance Metrics	What Measures Are Used	When				Purpose		Importance		Goal/ Application/ Characterization	Source	Notes
				Ongoing	*Before & After*	*Once*	*Irregular*	*Operations*	*Validation*	*Key*	*Secondary*			
Traffic	*Speed & Travel Time*	LOS												
		Speeds/ average speed												
		Speed differential (GP vs. HOT lanes)												
		Travel times												
		Travel time savings												
		Cost of delay/VOT												
	Volume	Vehicle volume (hourly/daily/weekly/monthly)	X	X				X		X		GLA traffic threshold req'ment	GLA Article 10 and Schedule 22; Interviews	
		Person volume (hourly/daily/weekly/monthly)												
		Tolled trips/ untolled trips												
	VMT/VKT	VMT/VKT	X	X					X		X		Website	
	Congestion	Delay/wait times												
		Congestion coefficient												
		Queue length												
	Mode Share	Mode share (SOV, HOV, transit)												
	Occupancy	Avg. vehicle occupancy (auto)												
	Bike/Ped	Bike/ped traffic counts												
	Parking	Park-n-ride activity (lot counts)												
		Off-street parking activity (counts/occupancy)												
		On-street parking activity (counts/occupancy)												
		Cost of parking/parking revenue												
		# of resident permits/permit cost												
		Violations/revenue												
Public Perception	*Awareness*	Of the facility/general/how much?												
		Specific features												
		Toll adjustments												
		Future plans												
	Acceptance	General/fairness/equity												
		Specific questions												
	Satisfaction	General/perceived value/how well?												
		Traffic conditions/ reliability												
		Perceived time savings												
		Perceived safety												
		Signage												
		Agency performance/customer service												
		Enforcement												
	Effectiveness	Congestion reduction												
	Social Impacts	Specific activities/populations												
	Media Coverage	No. of articles/reports (positive or negative)												
	Marketing	Volume/success												
Users	*Transaction Method*	Transponder/video/by-mail/cash												
	Accounts	Total, open/closed												
		No. of transponders issued												
	User Characteristics	Vehicle classification												
		Vehicle make												
		Vehicle registrations (HOV, vanpool, hybrid)												
		Home zip code												
		Demographics/socioeconomics												
	Trip Characteristics	Frequency of use												
		Time of day/departure time												
		O-D/ travelshed determination												
		Toll spending/price paid (self-reported)												
		Trip length												
		Trip purpose												

TABLE 8-1: ONTARIO MINISTRY OF TRANSPORTATION HIGHWAY 407 EXPRESS TOLL ROUTE SUMMARY MATRIX (CONTINUED)

	Performance Category	Performance Metrics	What Measures Are Used	When				Purpose		Importance		Goal/ Application/ Characterization	Source	Notes
				Ongoing	*Before & After*	*Once*	*Irregular*	*Operations*	*Validation*	*Key*	*Secondary*			
System Operations	*Finance*	Total transactions												
		Revenue (toll/charge)												
		Average toll/ highest toll												
		Revenue (fee)												
		O&M Cost												
	Enforcement	Total traffic stops/ responses												
		Violations/citations/fines												
	Safety	Collisions/ accidents	X	X					X		X		GLA Article 10	Also reporting on environmental incidents (hazmat spills, etc.)
		Incident response time/ duration												
		Speed differential												
	Customer Service	Inquiry activity (call, email)												
		Performance (quantitative measures)												
	System Function	Incidents												
		Facility availability												
		Equipment availability												
		Mean time to respond/ repair												
Environment	*Air Quality*	NAAQS criteria pollutants/VOCs												
		GHG/CO2												
	Noise	Noise levels												
	Fuel Consumption	Fuel consumption												
Transit	*Performance*	Travel time/on-time/excess wait												
		Average speed												
	Occupancy	Ridership/ boardings												
		Average vehicle occupancy												
	Finance	Farebox revenue												
		O&M Cost												
	Service	Quality/satisfaction/reliability												
Economics	*General*	Gross regional product/economic indices												
		Benefit-cost analysis												
	Business Impacts	Awareness/importance												
		General performance/openings/closings												
		Specific sectors/services/populations												
		On commercial trucking												
		Business costs and prices												
		Retail traffic & sales												
		Tourists/visitors												
	Property	Residential sales/rentals/values												
		Commercial sales/rentals/values												
Land Use	*Residential*	Housing decisions												
	Commercial	Business locations												

9. The Port Authority of New York and New Jersey Congestion Pricing Program

The Port Authority of New York and New Jersey (Port Authority) was established in 1921 as the first interstate agency created under Article I, Section 10 of the U.S. Constitution. The Port Authority has the power to construct and operate seaports, airports, and interstate bridge and tunnel crossings in a 1,500–square-mile "Port District" in New York City and New Jersey. Together the Port Authority's six toll crossings accommodated over 240 million vehicle trips in 2009, making it one of the largest toll operators in the United States. Its toll facilities include the George Washington Bridge, which is the most heavily traveled bridge crossing in the United States.

The Port Authority is a self-supporting agency with the power to levy tolls and fees associated with the use of the facilities it operates. It receives no tax revenues and has no taxing powers of its own. The Port Authority relies on the revenues generated by the facilities and services it operates to cover operational costs and to back the bonds it issues to finance capital projects. In 2008, toll revenue from these facilities generated $991 million out of the Port Authority's net income of $3.5 billion. The agency's other revenue sources include rent, aviation and port fees, and transit fares.

The process of adjusting toll rates requires political support and involves gaining approvals from the Port Authority's Board; it is also subject to veto by the governors of New York and New Jersey. When contemplating such a change, the Port Authority's establishes an overall revenue target it seeks to raise in order to meet the agency's operating and capital investment plans. Agency staff has had the flexibility to assess alternative approaches to reach the revenue target, while addressing other policy and mobility objectives. It is within these carefully scripted parameters that the Port Authority has been successful in implementing a toll structure with rates that vary by time of day and method of payment.

9.1 Overview of the Port Authority's Congestion Pricing Program

The Port Authority introduced congestion pricing on the four bridges and two toll tunnels connecting New Jersey with New York City in March of 2001. At that time, the Port Authority had just announced a capital investment plan totaling more than $14 billion in capital projects over the coming ten years. The prime objective of the toll change was to raise the revenue required to support the regional investment plan. However, by introducing discounts for traveling in off-peak periods and for using electronic toll collection (ETC) payment rather than cash, the new structure also provided an important opportunity to achieve additional traffic management and congestion reduction objectives. These included:

- Encouraging temporal shifts in crossing trips to less congested off-peak travel periods;
- Increasing the use of electronic toll collection;
- Encouraging the use of mass transit and carpooling;
- Creating incentives for commercial traffic to travel during the least congested overnight period;
- Eliminating high-frequency commuter discounts; and,
- Simplifying operations by making toll rates and policies easier to communicate, and tolls themselves easier to collect.

Prior to 2001, eastbound round-trip toll rates on all Port Authority crossings were $4.00 for passenger vehicles, $4.00 per axle for trucks, and $3.00 for motorcycles and buses. (Port Authority tolls are collected in a single direction at tolling points in the New York-bound direction at all six crossings.) These rates were reduced by 10 percent for ETC users and additional discounts were available to frequent travelers on any of the three bridges connecting Staten Island and New Jersey.

The new 2001 toll structure introduced the following changes:

- It established a $6.00 toll rate for cash transactions at all times, while providing $1.00 discounts to ETC users during peak periods and $2.00 discounts for ETC customers at all other times. The peak toll rates were in effect from 6:00 to 9:00 A.M. and 4:00 to 7:00 P.M. on weekdays, as well as on weekends from 12:00 noon until 8:00 P.M.
- For trucks, it provided a $1.00 per axle discount during the midday and evening hours, as well as a deep 42 percent reduction of $2.50 per axle during the weekday overnight period between midnight at 6:00 A.M.

The Port Authority modified its toll regime again in March 2008, with the primary goal of revenue generation to support capital improvements. The new toll schedule also strengthened the agency's commitment to congestion pricing by removing the $1.00 peak period discount for ETC users and charging all autos an $8.00 toll during peak periods. Cash tolls remain at $8.00 for passenger cars at all times of the day, while ETC users receive a $2.00 discount in off-peak periods. Additional discount programs are also available for registered carpool and low emission vehicles using ETC. Truck toll rates continue to provide modest discounts during midday and evening off-peak periods and deep reductions in overnight tolls. The elimination of the peak-period discount for ETC customers established a policy of charging the highest toll rates during the most congested travel periods, regardless of payment method. The change also created a greater peak vs. off-peak price differential (i.e., $2.00) making the price signal for temporal travel shifts more compelling.

9.2 What is Monitored?

The full spectrum of the Port Authority's performance monitoring activities is provided in the accompanying Facility Performance Monitoring Summary Matrix. The matrix is a comprehensive record of all current, known metrics used to monitor performance on the Port Authority crossings, organized by evaluation category. It also includes earlier FHWA-sponsored evaluation work performed by a three-university team published in 2005 looking at the 2000-2004 period. Provided in the matrix for each metric used are: frequency of collection; purpose; a simple indication of importance; particular characterizations of the metric that relate back to agency/facility goals or applications; sources of information; and other notes. The matrix is intended to be a visual overview of the Port Authority's complete monitoring effort, easily comparable to other fully variable-priced facilities with similar matrix summaries. A more qualitative discussion of how these metrics are applied in practice and which ones are the most significant is provided below. Not all metrics noted in the matrix are discussed here.

Given the innovative nature of the new toll structure and the multiple goals behind it, the Port Authority has implemented a comprehensive program to monitor its performance and understand its effects on regional mobility patterns. As a mature toll operator, the Port Authority had already developed standard metrics to monitor the performance of its toll facilities. These are the basic pieces of information that any major toll operator needs to know in order to make informed decisions about its ongoing operations. The most fundamental of these is revenue generation, which is tracked closely and compared with the estimates generated by the agency's sophisticated and well-calibrated traffic and revenue forecasting tools. Toll revenue generation is directly related to traffic activity levels. As part of its standard accounting and business procedures, the Port Authority tracks the overall number toll transactions for each of its crossings by vehicle class, time of day, and payment method. This detailed and historic time series data has enabled the Port Authority to study what effects the introduction of congestion pricing had on travel patterns for motorists using its crossings and heightened its focus on variations in the time of day of travel by vehicle type and toll facility.

In addition to the transaction data generated by its ETC and manual toll collection systems, the Port Authority conducts regular westbound counts of traffic at all its bridges and tunnels. These counts include vehicle classifications by approach, origin-destination information based on registration data and the general travel shed the crossing serves, and vehicle occupancy. The introduction of congestion pricing has not changed the metrics included in the Port Authority's manual traffic counts.

In addition to the revenue, transaction, and traffic volume measures described above, the Port Authority also tracks queue lengths and wait times at each of its toll plazas three times per year. This is accomplished using a combination of aerial photographs, travel time runs in test vehicles, and information generated by the regional TRANSMIT (TRANSCOM's System for Managing Incidents & Traffic), a system which uses ETC readers and a E-ZPass transponders as anonymous vehicle probes to provide link travel times and road speeds to roadway operators in the New York-New Jersey region.

The Port Authority also tracks safety on its toll facilities and toll plazas. They look at current and historic crash data, and track the progress of operational and physical changes to reduce crashes at the crossing and their approaches. The Port Authority also tracks the overall use of ETC versus cash tolls, and the location of trucks and buses using the crossings. The interplay of the placement of ETC and cash booths, the number of large vehicles traversing the toll plazas, and the method of payment used by trucks and buses all have a bearing on safety at the toll plazas.

The Port Authority also has a well-established ongoing program to monitor customer satisfaction at its crossings. The agency employs a biennial customer satisfaction survey than is designed to track multiple standard measures over time. While not targeted to toll policy per se, these surveys do address bridge and tunnel operations, signing and communication, safety and security, and overall facility appearance as critical measures that help evaluate the relationships between capital and operating improvements and customer satisfaction and align future investments with areas most important to customer satisfaction. In addition, the Port Authority conducts focus groups and stated preference surveys from time to time, usually in association with specific projects or improvements. While the information gathered may not be specifically targeted to congestion pricing, the results often help shape the policy and mobility agenda that is supported through the toll pricing structure. While the Port Authority's outreach efforts have confirmed that users support the use of varying toll pricing by time of day, motorists have reacted more positively to messages of toll discounts rather than peak prices. One shortcoming of the Port Authority's current toll system is there is no driver feedback from E-ZPass electronic toll customers about the price paid at any point of time, limiting the ability to reinforce the price signals at the time of the transaction.

9.3 Other Essential Data Gathering Activities

In addition to these monitoring activities, the Port Authority conducted essential data gathering activities prior to implementing its congestion pricing program, which greatly facilitated the ability to advance the program. In the mid-1990s, the Port Authority conducted stated preference survey research to understand how motorist behavior would change as a result of time-of-day pricing. The resulting price elasticities were then incorporated into traffic and revenue forecasting tools that the Port Authority used to assess the possible implementation of congestion pricing at the interstate crossings. This same research was also used to estimate ETC participation rates.[13] The stated preference surveys cannot be

[13] Mark Murriello and Danny Jiji, "The Value Pricing Toll Program at the Port Authority of New York & New Jersey: Revenue for Transportation Investment and Incentives for Traffic management," Transportation Research Board 2004 Annual Proceedings.

classified as monitoring activities. However, they were essential to the Port Authority's ability to model the effects of congestion pricing on toll revenues and traffic patterns. Absent this key capability, it would not have been possible for the Port Authority to demonstrate the revenue implications of time-of-day tolling or convince other transportation operators and stakeholders that traffic diversions would be manageable. These tools were essential in garnering the political and public support needed to gain the approval of the Port Authority Board and the governors of two states to implement congestion pricing on its toll crossings.

The Port Authority also launched an aggressive public outreach campaign prior to the initial implementation of congestion pricing in 2001. Port Authority officials met with elected officials, editorial boards, other toll agencies, departments of transportation, community groups, and known opponents of congestion pricing to elicit their opinions on different aspects of the proposed program. The outreach effort provided an opportunity to educate stakeholders on the rationale for using congestion pricing, the anticipated results of doing so, and the mechanics of how the system would operate. This survey work enabled the Port Authority to document public perceptions on congestion pricing prior to its implementation on the New York-New Jersey crossings. It also enabled the agency to develop a better understanding of the concerns of different stakeholder groups and reflect those concerns in the different decisions that needed to be made regarding the ways in which the new pricing system would function.

9.4 Why Performance Evaluation Takes Place and How Performance Monitoring Data is Used

The Port Authority has implemented a comprehensive effort to monitor the performance of its toll facilities following the implementation of congestion pricing. The process serves a variety of important needs.

- **Documenting Toll Revenues and Financial Objectives**
  First, and most importantly, performance data allow the agency to document revenue generation following the implementation of the new congestion pricing toll regimes in both 2001 and 2008. This information was also essential for accounting and financial planning purposes, and providing information on the agency's financial performance to bondholders.
- **Improving Traffic and Revenue Forecasting Capabilities**
  The performance monitoring data allow the Port Authority to identify variations in traffic and toll revenue collections from its forecasts, and then use that information to improve the accuracy of its traffic and revenue forecasting tools.
- **Improving Operational Performance**
  The performance monitoring data enable the Port Authority to assess the operational performance and safety of is its toll plazas and crossings and identify potential adjustments to improve performance in these areas.
- **Documenting Changes in Travel Behavior**
  The performance monitoring data document changes in travel patterns and behavior by different user groups and allow stakeholders to understand the effects of time-of-day pricing and other toll-related policies on regional traffic and congestion. This information has been essential to informing ongoing decisions on toll and congestion management policies, including the refinements to the Port Authority's congestion pricing program implemented in 2008.
- **Validating the Case for Congestion pricing**
  Lastly, the collective data derived from the performance monitoring program enables the Port Authority to validate all aspects of the performance of the congestion pricing program—from revenue

generation to congestion management and safety—for the different decision makers, communities, and stakeholders affected by it. Performance validation has been essential in garnering support for the ongoing operation of congestion pricing on the Port Authority's.

9.5 What Additional Performance Metrics or Data Would be Helpful to Agencies Considering Congestion Pricing?

Port Authority staff believe that guidance on quantifying and measuring traffic and congestion reduction benefits would be helpful, particularly for commercial traffic which represents a key constituency group. Given that the vast majority of performance measurement efforts in the United States have involved HOT lanes, which are generally not available for use by trucks and most commercial vehicles, there is very little data available on the response of commercial traffic to congestion pricing and effective metrics for measuring it. Guidance on the performance measures for pricing would be useful in moving beyond the consideration of congestion pricing on managed lanes to the use of congestion pricing on much more heavily traveled toll facilities where truck volumes have a fundamental effect on overall congestion and system performance.

The Port Authority is also beginning to work on an approach to measure travel time reliability, focusing on the variability of travel times. Part of the challenge of measuring travel time reliability is that the amount of time motorists spend on Port Authority crossings represents only a small portion of the overall length of the trips made. This is a common challenge for many agencies operating priced facilities.

The Port Authority has also found that as a result of the combination of electronic toll collection and variably priced tolls, motorists often are not aware of the exact price they pay to make trips on the Port Authority's toll facilities. Toll levels are not communicated to ETC users at the time the actual transaction is made. In addition, motorists' awareness of actual toll rates is further blurred by the complex network of toll facilities in the greater New York-New Jersey region, and the many different discount programs available by the different toll agencies. This dynamic presents a communication challenge and also has a direct impact on the results of congestion pricing, given that the ability of motorists to modify decisions on their choice of route, mode, and time of travel are based on their knowledge of tolls they pay and the cost implications of changing their travel behavior.

THIS PAGE LEFT BLANK INTENTIONALLY.

TABLE 9-1: PORT AUTHORITY OF NEW YORK AND NEW JERSEY CONGESTION PRICING PROGRAM SUMMARY MATRIX

	Performance Category	Performance Metrics	What Measures Are Used	When				Purpose		Importance		Goal/ Application/ Characterization	Source	Notes
				Ongoing	*Before & After*	*Once*	*Irregular*	*Operations*	*Validation*	*Key*	*Secondary*			
Traffic	*Speed & Travel Time*	LOS												
		Speeds/ average speed												
		Speed differential (GP vs. HOT lanes)												
		Travel times	X	X					X		X	Reliability; indirectly related to pricing	Interviews	Derived from TRANSMIT data
		Travel time savings												
		Cost of delay/VOT												
	Volume	Vehicle volume (hourly/daily/weekly/monthly)	X	X					X		X	Peak period congestion relief	Interviews	Demand distribution as a percentage of total traffic
		Person volume (hourly/daily/weekly/monthly)												
		Tolled trips/ untolled trips												
	VMT/VKT	VMT/VKT												
	Congestion	Delay/wait times	X	X					X		X	Peak period congestion relief	Interviews	
		Congestion coefficient												
		Queue length	X	X					X		X	Peak period congestion relief	Interviews	
	Mode Share	Mode share (SOV, HOV, transit)												
	Occupancy	Avg. vehicle occupancy (auto)	X	X					X		X	Indirectly related to pricing	Interviews	Annual, manual counts
	Bike/Ped	Bike/ped traffic counts												
	Parking	Park-n-ride activity (lot counts)												
		Off-street parking activity (counts/occupancy)												
		On-street parking activity (counts/occupancy)												
		Cost of parking/parking revenue												
		# of resident permits/permit cost												
		Violations/revenue												
Public Perception	*Awareness*	Of the facility/general/how much?												
		Specific features				*								
		Toll adjustments				*								
		Future plans												
	Acceptance	General/fairness/equity				*								
		Specific questions				*								
	Satisfaction	General/perceived value/how well?	X	X					X		X		Interviews	Formerly annual, now biennial
		Traffic conditions/ reliability				*								
		Perceived time savings												
		Perceived safety												
		Signage												
		Agency performance/customer service												
		Enforcement												
	Effectiveness	Congestion reduction				*								
	Social Impacts	Specific activities/populations												
	Media Coverage	No. of articles/reports (positive or negative)			*									
	Marketing	Volume/success				*								
Users	*Transaction Method*	Transponder/video/by-mail/cash	X		X				X		X	Increase E-ZPass market share	Interviews; Published literature	Measures E-Zpass market share
	Accounts	Total, open/closed												
		No. of transponders issued												
	User Characteristics	Vehicle classification	X	X					X		X	Indirectly related to pricing	Interviews	Annual, manual counts
		Vehicle make												
		Vehicle registrations (HOV, vanpool, hybrid)	X	X					X		X		Interviews	GreenPass registrations (SULEV and 45+ mpg)
		Home zip code												
		Demographics/socioeconomics				*								
	Trip Characteristics	Frequency of use												
		Time of day/departure time	X		X				X		X	Peak period congestion relief	Interviews; Published literature	Before & After: toll adjustment
		O-D/ travelshed determination	?											
		Toll spending/price paid (self-reported)	X				X		X		X		Interviews	
		Trip length												
		Trip purpose												

TABLE 9-1: PORT AUTHORITY OF NEW YORK AND NEW JERSEY CONGESTION PRICING PROGRAM SUMMARY MATRIX (CONTINUED)

	Performance Category	Performance Metrics	What Measures Are Used	When				Purpose		Importance		Goal/ Application/ Characterization	Source	Notes
				Ongoing	Before & After	Once	Irregular	Operations	Validation	Key	Secondary			
System Operations	*Finance*	Total transactions	X	X				X		X		Peak period congestion relief	Interviews	Proxy for vehicle demand
		Revenue (toll/charge)	X	X				X		X		Capital program funding	Interviews; Published literature	
		Average toll/ highest toll	X	X				X			X	Capital program funding	Interviews	
		Revenue (fee)												
		O&M Cost												
	Enforcement	Total traffic stops/ responses												
		Violations/citations/fines												
	Safety	Collisions/ accidents	X	X					X		X	Safety	Interviews	
		Incident response time/ duration												
		Speed differential												
	Customer Service	Inquiry activity (call, email)												
		Performance (quantitative measures)												
	System Function	Incidents												
		Facility availability												
		Equipment availability												
		Mean time to respond/ repair												
Environment	*Air Quality*	NAAQS criteria pollutants/VOCs												
		GHG/CO2												
	Noise	Noise levels												
	Fuel Consumption	Fuel consumption												
Transit	*Performance*	Travel time/on-time/excess wait												
		Average speed												
	Occupancy	Ridership/ boardings	X	X					X		X		Published literature	PATH system operated by PANYNJ
		Average vehicle occupancy												
	Finance	Farebox revenue												
		O&M Cost												
	Service	Quality/satisfaction/reliability												
Economics	*General*	Gross regional product/economic indices												
		Benefit-cost analysis												
	Business Impacts	Awareness/importance				*								
		General performance/openings/closings												
		Specific sectors/services/populations												
		On commercial trucking				*								Changes in shipment charges, routes, travel times, etc.
		Business costs and prices												
		Retail traffic & sales												
		Tourists/visitors												
	Property	Residential sales/rentals/values												
		Commercial sales/rentals/values												
Land Use	*Residential*	Housing decisions												
	Commercial	Business locations												

Metrics denoted with a * in the "When" column were collected as part of the FHWA-sponsored "Evaluation Study of PANYNJ's Time of Day Pricing Initiative" performed by RPI/Rutgers/NYU in 2005.
Other details of the metrics collected in that study are not provided because they are not neccesarily part of PANYNJ's current monitoring program.
Metrics that were collected in that study but are also part of PANYNJ's current monitoring are not duplicated with a *.
The focus of the study was the impacts and reactions to the introduction of time-of-day pricing in 2001.

Cordon and Area Pricing

10. Central London Congestion Charging

Greater London (or London) is a vast urban region comprising the City of London and 32 London boroughs. It has a population of about 7.5 million. Central London refers to the innermost part of London characterized by high density and land values, though with varying, unofficial boundaries that generally contain significant central government offices, primary financial and business services, and cultural institutions.

The Greater London Authority Act (GLA) passed by Parliament in 1999 sought to return central governorship to London's 33 boroughs, not had since the abolition of the Greater London Council in 1986. The GLA established the Greater London Authority, comprising the London Assembly and a Mayor of London. The London Assembly is an elected body that scrutinizes the Mayor's activities and has the power to amend the Mayor's budget. The GLA also established Transport for London (TfL), an executive agency under the Mayor's purview responsible for buses, the major road network, traffic control, the Docklands Light Rail, and later the London Underground. Finally, the GLA also authorized TfL to "…establish and operate schemes for imposing charges in respect of the keeping or use of motor vehicles on roads in its area" (Greater London Authority Act 1999, Part IV, Chapter XV).

Following the GLA's enactment, Ken Livingston became the first directly elected Mayor of London in May 2000. One of his campaign platforms was to improve congestion and the condition of the transportation system in London. At the same time, in preparation of the Mayoral elections, the Government Office for London established a working group—the ROad Charging Options for London (ROCOL) Working Group—to investigate how the newly granted road user charging powers might be applied in practice. They developed a plan for an "area licensing scheme" for central London controlled through the use of a camera-based number recognition system to monitor vehicle license plates. A congestion charge could then be assessed on vehicles that cross a set boundary. They felt the system could be in place by September 2003.

Mayor Livingston acted quickly on his campaign promise and the work of ROCOL, while also seeking to capitalize on the new revenue source the charging system would provide for reinvestment in an improved transportation system. He adopted the charging strategy in his official Transport Strategy in late 2000 and set in motion the steps taken to ultimately put the system in place in February 2003—in time to become a focal point of his reelection in 2004.

10.1 Overview of Central London Congestion Charging

Congestion charging was instituted in Central London in February 2003 for the 8-square-mile central business district inside the Inner Ring Road (a linked collection of major roads that surround the centermost part of London), containing the entire City of London, the financial district, and the West End. The flat rate, per-day charge is levied to enter the Congestion Charge Zone weekdays from 7 AM to 6 PM.[14] The rate was initially set at £5 and was increased to £8 in July 2005. Private vehicles entering the zone must pay the charge on the day of travel, or the next day for £10, online, through text message, on the phone, or at certain stores. Certain vehicles including taxis, London licensed private hire vehicles, motorcycles, and buses, are exempt from the charge. Other categories of vehicle users can register for

[14] The original hours of charging were from 7 AM to 6:30 PM. After the implementation of the Western Extension, the charging hours were changed to 7 AM to 6 PM, applied to both zones.

discounts, including a 90 percent discount for residents inside the zone and a 100 percent discount for eligible disabled persons and alternative fuel vehicles.

A system of cameras located along the cordon is equipped with Automatic Number Plate Recognition (ANPR) technology. License plate numbers are captured and compared with a database of payees. Some plates not recognized by the cameras require manual checking. Those that enter the zone without paying trigger a penalty notice to be sent to the vehicle's registered owner, identified from a Driver and Vehicle Licensing Agency database.

Due to the success of the original central zone, and again following though on a (re)election campaign promise to examine possible extensions of congestion charging, Mayor Livingstone acted on TfL studies indicating the greatest benefits of extending the zone would come from a western extension. Planning and infrastructure implementation took place throughout 2005 and 2006. The Western Extension charging commenced in February 2007, effectively doubling the charging zone to include Westminster and Kensington & Chelsea. An uncharged through-route bisects the two zones.

Overall the goals of the congestion charging program, as outlined in the Mayor's Transport Strategy, have been to:

- Reduce congestion;
- Make radical improvements to bus services;
- Improve journey time reliability for car users; and
- Make the distribution of goods and services more efficient.

In addition, a reduction in traffic was expected to lead to a reduction in emissions, and net revenue would be available for reinvestment in London's transportation network.

Revenue from the congestion charging program was approximately £268 in fiscal year 2007-08, with operational costs of about £131, resulting in net revenues of £137. Net revenues since inception through fiscal year 2007-08 have roughly totaled £440. By law, these revenues have been and continue to be reinvested in measures outlined in the Mayor's Transport Strategy. Since its implementation in 2003, this reinvestment has substantially comprised bus network improvements at roughly 80 percent of net revenues. Other investments have included road and bridge reconstruction, road safety projects, infrastructure improvements for pedestrians and bicyclists, and transportation technology to improve the environment.

Several proposed changes to the charging program have recently been proposed and are currently under evaluation. The primary proposal initiated by Mayor Boris Johnson, elected in 2008, is the review and removal of the Western Extension. Concerns exist over impacts to the local economy and the zone's residents, despite measureable reductions in traffic, increased use of alternative transportation modes, and improvements to the environment. Other proposed changes include a rate increase to £9 and the implementation of an automated payment system, whereby drivers can register with a debit or credit card and not have to actively remember to pay the charge on the day of travel. The rate to use the old method of payment would increase to £10, and payment on the day after travel would increase to £12.

10.2 What is Monitored?

The full spectrum of performance monitoring activities for London's congestion charging is provided in the accompanying Facility Performance Monitoring Summary Matrix. The matrix is a comprehensive record of all current, known metrics used to monitor performance on the facility, organized by evaluation category. Provided in the matrix for each metric used are: frequency of collection; purpose; a simple indication of importance; particular characterizations of the metric that relate back to government/facility goals or applications; sources of information; and other notes. The matrix is intended to be a visual overview of London's complete monitoring effort, easily comparable to other cordon or area priced facilities with similar matrix summaries.

A comprehensive five-year program monitoring program was put into place by TfL to assess the effects of the charging scheme. The five-year program resulted in the publication of six annual reports from 2003 to 2008, each progressively building on one another, with the fifth in 2007 introducing additional monitoring of the effects of the Western Extension, as well as a one-time benefit-cost analysis. The program was designed to assess key traffic, transport, business, economic, social, and environmental impacts of the scheme by consolidating information from over 100 specially designed surveys and studies, while making use of existing surveys and data sources. Sources included:

- Data generated from traffic management and scheme operation functions
- Moving car observer surveys
- The use of monitoring and enforcement cameras
- A wide range of traffic counts across a variety of areas, sites, screenlines and cordons
- Various counts of buses and bus passengers, plus data from other public transport providers
- Trip diaries, a wide range of travel surveys, as well as data from parking providers, the Public Carriage Office (taxi licensing), and the London Accident Analysis Unit (part of TfL)
- Business surveys, economic case study work, plus data on a range of key environmental indicators

The purpose of the five-year monitoring program was to provide much of the information that enabled the Mayor and other interested parties to assess the impacts and implications of congestion charging, and whether adjustments to the scheme should be considered. Baseline conditions were measured before the charging scheme was put into place. The work was managed by a team of permanent TfL staff, with independent contractors undertaking most of the main data collection elements.

The individual metrics and their specifics are provided in the Facility Performance Monitoring Summary Matrix, along with those that comprise the ongoing monitoring effort by TfL.

Since the official conclusion of the five-year program, TfL continues to monitor the congestion charging scheme and has published the results in its newly introduced *Travel in London* annual report on the city's transportation network. Report 2 published in 2010 states that during 2008 and 2009, TfL has "continued core elements of traffic and congestion monitoring in relation to the scheme."

10.3 Why Performance Evaluation Takes Place and How Performance Monitoring Data is Used

As stated previously, the main purpose of performance evaluation was to assess the effects of the scheme and make necessary changes to its operation. Several principles guided the performance monitoring program:

- Monitoring should robustly detect and characterize the main expected effects of congestion charging;
- Monitoring should enable unexpected or unanticipated effects to be determined;
- Monitoring should seek to understand as well as measure;
- Monitoring should aim to meet the legitimate needs of all stakeholders for information; and

- Monitoring should provide Best Value.

Changes to the congestion charge must be made to its Scheme Order, the legal framework behind the charge that contains the definitions of what the charge is, where it applies, details on discounts and exemptions from the scheme, penalty charges, refunds, etc. Scheme Orders are made under the powers established in the GLA. Changes to the Scheme Order occur through a procedure known as a Variation Order, of which many have been proposed and instituted since the charge's inception, altering and improving the scheme based on the results of monitoring, including those to operations, the payment structure, the charge itself (e.g. when increased from £5 to £8), the implementation of the Western Extension, and others. Each Variation Order is subject to public consultation before the Mayor considers TfL's response to the representations received and decides whether to confirm the change (with or without modifications) and make it part of the Scheme Order. Monitoring then continues to evaluate the effects of these changes after they are put into place.

Also stated earlier, TfL has continued the core elements of traffic and congestion monitoring in relation to the scheme in 2008 and 2009. New traffic level and congestion data have allowed TfL to study the relationships between traffic volumes and road network performance in Central London in detail, and derive fundamental relationships which provide a better understanding of the factors behind recent trends in Central London road network performance.

10.4 Other Data Gathering Activities

Beyond the comprehensive monitoring program and ongoing efforts of TfL, several other evaluations of the original congestion charge have taken place. However, as these were not part of the official monitoring of the program by its operating agency, TfL, they are not included in the Facility Performance Monitoring Summary Matrix.

Prior to the implementation of congestion charging, the London Assembly recommended eight criteria on which to judge London's congestion charge; it:

- Must deliver a real and sustained reduction in congestion
- Must not have an adverse impact on the areas outside the charging zone
- Must not disadvantage Londoners (particularly low-income groups)
- Must deliver a real improvement to bus journeys in London
- Should not have an adverse effect on London's economy or services
- Should not have an adverse effect on London's environment
- Should not penalize "innocent" drivers
- Should deliver net revenue to fund transport initiatives

A report published in February 2004 evaluated the extent to which each criterion had been met 10 months into the scheme's implementation through results from a focus group, TfL data, and various surveys. Through mostly qualitative discussions, the report summarized:

- Impacts on congestion within central London and outside the charging zone
- Impacts on Londoners, especially low-income groups
- Effects on public transportation, especially buses
- Impacts on the economy and the environment
- Remarks on customer service and enforcement

- Net revenue to fund transportation initiatives

The report concluded with a number of recommendations for further monitoring and policy considerations for TfL. Although the report makes multiple mentions of future monitoring by the London Assembly, no further reports specifically on the congestion charge monitoring were published.

A second monitoring effort was commissioned in 2002 by the Association of London Government (ALG)—renamed the London Councils in October 2006—and performed by Ove Arup & Partners. The London Councils is a local government association comprising representatives from the 32 London Boroughs and the City of London, as well as the police authority and fire brigade. This review by the London Councils was intended to act as an independent audit of the congestion charging scheme, as TfL's ability to carry out the scheme's primary performance monitoring was thought to potentially become influenced by its administration and collection of the charge.

Five study elements were selected as a focus of the monitoring program, and data was gathered and analyzed before and after the scheme's implementation in 2002 and 2003, respectively:

- An independent assessment of the impact of the congestion charging scheme on traffic levels inside and immediately outside the zone
- An independent assessment of any traffic diversion to parallel routes around the charging zone
- An examination of the impacts of the scheme on parking usage and revenue in and around the congestion charging zone
- An examination of the effect of the scheme on parking around stations in outer London
- An examination of bus occupancy levels following the introduction of the scheme

Evaluation measures and performance metrics incorporated in this effort included traffic levels measured in vehicle kilometers traveled inside and outside the zone, along the cordon, and diverted to parallel routes around the zone. Parking activity inside and outside the zone and on-street near rail stations as measured by counts, parking charge revenue, the number and cost of resident permits, and violation and enforcement data were also tracked. Finally, bus occupancy and measures of overcrowding were manually counted using videotape.

THIS PAGE LEFT BLANK INTENTIONALLY.

TABLE 10-1: CENTRAL LONDON CONGESTION CHARGING SUMMARY MATRIX

	Performance Category	Performance Metrics	What Measures Are Used	When				Purpose		Importance		Goal/ Application/ Characterization	Source	Notes
				Ongoing	*Before & After*	*Once*	*Irregular*	*Operations*	*Validation*	*Key*	*Secondary*			
Traffic	*Speed & Travel Time*	LOS												
		Speeds/ average speed	X	X	X				X			Reliability	Tfl Annual Impacts Monitoring, Travel in London	
		Speed differential (GP vs. HOT lanes)												
		Travel times	X		X				X			Reliability	Tfl Annual Impacts Monitoring	
		Travel time savings												
		Cost of delay/VOT												
	Volume	Vehicle volume (hourly/daily/weekly/monthly)	X	X	X				X	X		Reduce congestion	Tfl Annual Impacts Monitoring, Travel in London	Key for central charging zone/western extension
		Person volume (hourly/daily/weekly/monthly)	X	X	X				X				Tfl Annual Impacts Monitoring, Travel in London	Estimate from annual CAPC survey
		Tolled trips/ untolled trips												
	VMT/VKT	VMT/VKT	X	X	X				X	X		Reduce congestion	Tfl Annual Impacts Monitoring, Travel in London	Key for Inner Ring Road
	Congestion	Delay/wait times	X	X	X				X	X		Reduce congestion; Reliability	Tfl Annual Impacts Monitoring	Excess travel time (min/km)
		Congestion coefficient												
		Queue length												
	Mode Share	Mode share (SOV, HOV, transit)	X	X	X				X				Tfl Annual Impacts Monitoring, Travel in London	
	Occupancy	Avg. vehicle occupancy (auto)	X	X	X				X				Tfl Annual Impacts Monitoring, Travel in London	
	Bike/Ped	Bike/ped traffic counts	X	X	X				X				Tfl Annual Impacts Monitoring, Travel in London	
	Parking	Park-n-ride activity (lot counts)												
		Off-street parking activity (counts/occupancy)												
		On-street parking activity (counts/occupancy)												
		Cost of parking/parking revenue												
		# of resident permits/permit cost												
		Violations/revenue												
Public Perception	*Awareness*	Of the facility/general/how much?												
		Specific features												
		Toll adjustments												
		Future plans												
	Acceptance	General/fairness/equity												
		Specific questions												
	Satisfaction	General/perceived value/how well?												
		Traffic conditions/ reliability												
		Perceived time savings												
		Perceived safety												
		Signage												
		Agency performance/customer service												
		Enforcement												
	Effectiveness	Congestion reduction	X		X				X				Tfl Annual Impacts Monitoring	
	Social Impacts	Specific activities/populations	X		X				X				Tfl Annual Impacts Monitoring	
	Media Coverage	No. of articles/reports (positive or negative)												
	Marketing	Volume/success												
Users	*Transaction Method*	Transponder/video/by-mail/cash												
	Accounts	Total, open/closed												
		No. of transponders issued												
	User Characteristics	Vehicle classification	X		X				X				Tfl Annual Impacts Monitoring	
		Vehicle make												
		Vehicle registrations (HOV, vanpool, hybrid)												
		Home zip code												
		Demographics/socioeconomics												
	Trip Characteristics	Frequency of use												
		Time of day/departure time												
		O-D/ travelshed determination	X		X				X				Tfl Annual Impacts Monitoring	
		Toll spending/price paid (self-reported)												
		Trip length	X		X				X				Tfl Annual Impacts Monitoring	
		Trip purpose	X		X				X				Tfl Annual Impacts Monitoring	

TABLE 10-1: CENTRAL LONDON CONGESTION CHARGING SUMMARY MATRIX (CONTINUED)

	Performance Category	Performance Metrics	What Measures Are Used	When				Purpose		Importance		Goal/ Application/ Characterization	Source	Notes
				Ongoing	*Before & After*	*Once*	*Irregular*	*Operations*	*Validation*	*Key*	*Secondary*			
System Operations	*Finance*	Total transactions												
		Revenue (toll/charge)	X	X					X				Tfl Annual Impacts Monitoring	
		Average toll/ highest toll												
		Revenue (fee)												
		O&M Cost	X	X					X				Tfl Annual Impacts Monitoring	
	Enforcement	Total traffic stops/ responses												
		Violations/citations/fines	X	X					X				Tfl Annual Impacts Monitoring	
	Safety	Collisions/ accidents	X	*	X				X				Tfl Annual Impacts Monitoring	
		Incident response time/ duration												
		Speed differential												
	Customer Service	Inquiry activity (call, email)	X	X					X				Tfl Annual Impacts Monitoring	
		Performance (quantitative measures)	X	X					X				Tfl Annual Impacts Monitoring	
	System Function	Incidents												
		Facility availability												
		Equipment availability												
		Mean time to respond/ repair												
Environment	*Air Quality*	NAAQS criteria pollutants/VOCs	X		X				X				Tfl Annual Impacts Monitoring	
		GHG/CO2	X	*	X				X				Tfl Annual Impacts Monitoring	
	Noise	Noise levels												
	Fuel Consumption	Fuel consumption												
Transit	*Performance*	Travel time/on-time/excess wait	X		X				X				Tfl Annual Impacts Monitoring	
		Average speed	X		X				X				Tfl Annual Impacts Monitoring	
	Occupancy	Ridership/ boardings	X		X				X				Tfl Annual Impacts Monitoring	
		Average vehicle occupancy	X		X				X				Tfl Annual Impacts Monitoring	
	Finance	Farebox revenue												
		O&M Cost												
	Service	Quality/satisfaction/reliability												
Economics	*General*	Gross regional product/economic indices												
		Benefit-cost analysis	X			X			X				Tfl Annual Impacts Monitoring	5th Annual Report only (2007)
	Business Impacts	Awareness/importance												
		General performance/openings/closings	X		X				X				Tfl Annual Impacts Monitoring	
		Specific sectors/services/populations												
		On commercial trucking												
		Business costs and prices												
		Retail traffic & sales	X		X				X				Tfl Annual Impacts Monitoring	
		Tourists/visitors	X		X				X				Tfl Annual Impacts Monitoring	
	Property	Residential sales/rentals/values	X		X				X				Tfl Annual Impacts Monitoring	
		Commercial sales/rentals/values	X		X				X				Tfl Annual Impacts Monitoring	
Land Use	*Residential*	Housing decisions												
	Commercial	Business locations												

Metrics denoted with a * in the "When" column continue to be monitored and reported in the annual *Travel in London* reports.
However, they are not explicitly reported in connection to the Central London Charging scheme, as the report broadly covers transportation in London, not just the congestion charge.
TfL's five-year monitoring of the charging scheme conlcuded at the end of 2007 but the core elements remain as part of the broad monitoring program detailed in the *Travel in London* reports published since 2008.

11. Singapore Electronic Road Pricing

Singapore's Land Transport Authority (LTA) is a statutory board under the Ministry of Transport with responsibility over the country's roads and public transportation systems, including heavy and light rail, buses, and taxis. LTA was formed in 1995, consolidating four prior public sector entities: the Registry of Vehicles; the Mass Rapid Transit Corporation; the Roads & Transportation Division of the Public Works Department; and the Land Transport Division of the then Ministry of Communications.

Singapore itself is a city state of approximately 4.7 million people living in an area of 269 square miles—roughly 3.5 times the size of Washington DC—making it the second most densely populated country in the world. Historically, roadway traffic congestion has been a significant issue for the country, especially on routes to and within the CBD located along the middle of its southern coast.

Today, LTA's stated objectives are:

- To deliver a land transport network that is integrated, efficient, cost-effective and sustainable to meet the nation's needs
- To plan, develop and manage Singapore's land transport system to support a quality environment while making optimal use of our transport measures and safeguarding the well-being of the traveling public
- To develop and implement policies to encourage commuters to choose the most appropriate transportation mode

This last objective characterizes LTA's management of the road network, as it seeks to optimize use of its relatively finite road capacity while establishing policies that strongly encourage consideration of public transportation. Ambitiously, LTA has set a target of making 70 percent of all morning peak hour trips on public transport by 2020. Examples of policies that aggressively manage automobile use and allow for at least equal consideration of alternative modes include a vehicle quota system, significant ownership and registration fees, and a hybrid congestion pricing scheme—the Electronic Road Pricing (ERP) system.

11.1 Overview of Singapore's Congestion Pricing

Singapore's Electronic Road Pricing system is a combination of area and cordon pricing that controls access into Singapore's CBD and along major access routes. The genesis of ERP dates back to 1975 with the introduction of a manual area (radial cordon) pricing scheme for the CBD called the Area Licensing System (ALS). To enter the CBD's established Restricted Zone (RZ), an area license (coupon) had to be purchased and displayed, which was manually verified at check points. The original RZ for the ALS was determined through manual observation. In the mid-1990s, cordons along three major expressways leading into the RZ—the Road Pricing System (RPS)—were progressively introduced to complement the ALS.

In September 1998, the manual ALS and RPS were replaced by the current Electronic Road Pricing system, retaining each system's cordons. ERP utilizes overhead gantries and antennae to communicate with devices installed in users' vehicles (In-vehicle Units) that use reusable credit card-like stored-value smart cards to deduct an appropriate ERP charge. The ERP charge is generally levied for entry into the RZ weekdays between 7:30 AM and 8:00 PM. Also, inside a major shopping district in the RZ, the charge is levied on weekdays and Saturdays from noon to 8:00 PM. Along major expressways and arterials approaching the RZ, the charge is generally levied weekdays from 7:30 to 9:30 AM. Overall, the charge varies by vehicle type (passenger car/taxi, motorcycle, heavy and very heavy goods vehicles), by gantry, and per ½-hour on a fixed schedule with adjustments possible every three months to maintain smooth traffic flow. The "85th percentile" criterion is applied in making this adjustment, whereby 85 percent of roadway users perceive improved conditions (LOS/speed) following the adjustment.

The authority explained publicly prior to the introduction of ERP system that they would attempt to maintain revenue neutrality with the ERP charge. As evidence, annual revenues have remained relatively flat since the introduction of ERP in 1998. Revenue from ERP, itself, is not directly reinvested into the transportation system. It is remitted to the Ministry of Finance and placed in the country's general coffer for subsequent disbursement among all government services according to need. It is noted that the public is accustomed to the pricing scheme and does not require direct evidence of reinvestment into transportation for continued acceptance.

11.2 What is Monitored?

The ERP program is administered by the Land Transport Authority. Performance monitoring documentation from the authority is not publicly available, but the performance monitoring criteria are communicated publicly. The full spectrum of LTA's performance evaluation is summarized in the accompanying Facility Performance Monitoring Summary Matrix. The matrix is a comprehensive record of all current, known metrics used to monitor performance on the facility, organized by evaluation category. Provided in the matrix for each metric used are: frequency of collection; purpose; a simple indication of importance; particular characterizations of the metric that relate back to government/facility goals or applications; sources of information; and other notes. The matrix is intended to be a visual overview of LTA's complete monitoring effort, easily comparable to other cordon- or area-priced facilities with similar matrix summaries. A more qualitative discussion of how these metrics are applied in practice and which ones are the most significant is provided below. Not all metrics noted in the matrix are discussed here.

The underlying performance characteristics of ERP that are measured and tracked carefully by LTA include an array of standard traffic theory and traffic engineering metrics/techniques specifically focused on the speed of traffic. For example, speed-flow analyses are performed for all travel routes (expressways, major arterials, and minor arterials) to examine congestion levels relative to target LOS.

Performance measurement data is taken from five sources. An integrated data processing platform handles each of the inputs and allows for data collation and storage for analysis.

8. A fleet of roughly 7,000 taxis, equipped with GPS, and acting as floating cars—proxies—for the speeds of all roadway users
9. ERP gantries capable of measuring point speeds
10. Expressway traffic cameras (currently under expansion to arterials) located on average 500 meters apart that collectively can compute mean-space speeds
11. Loop detectors
12. On-site origin-destination surveys

Aside from traffic theory applications and critical speed-flow and mean-space speed calculations, other higher-level metrics are monitored and tracked for use by senior management within LTA and the Ministry of Transport. These include time to travel from benchmark locations throughout Singapore (this applies to public transport as well as roadways), system availability, and the quantification of delay into economic loss. Environmental effects and safety are not directly monitored, as these aspects are thought to correlate positively with the successful application of the ERP program and congestion reduction. Finally, when communicating system performance and policy decisions with the public, traffic speed is used as a simple, easy-to-comprehend metric with which to characterize system operation, rather than presenting the full detail of traffic theory computations.

11.3 Other Essential Data Gathering Activities

Customer input is solicited from periodic survey work and taken into account during ERP's pricing policy review. LTA staff report that public acceptance is moderate—the benefits of having the system in place generally outweigh the negative reaction to paying the charge. It was noted that the most challenging public policy issue with pricing is public acceptability, i.e., to pay for something that was previously "free", which continues to occur with the periodic expansion of cordons. Hence, numerous public communications programs are necessary to keep the motoring public informed.

11.4 Why Performance Evaluation Takes Place and How Performance Monitoring Data is Used

The primary function of performance evaluation is to maintain uncongested conditions within the RZ and the routes feeding into it by continually monitoring collected traffic data. Formerly, an optimal range of speeds was assigned to specific road types, and if monitored performance below this set speed envelope was observed, a pricing policy correction could be initiated. However, it was found that not all roadway users perceived these speed ranges as correlative with satisfactory service for the price paid. Consequently in 2008, the criterion was changed to the "85th percentile" measurement as described previously.

Currently, ERP's pricing policy is reviewed on a three-month cycle taking into account the wealth of collected data and computed traffic engineering metrics based on speeds. This review duration is considered optimal to allow enough time for traffic patterns to readjust—passing through a transient period and accounting for altered driver behavior. A formal process is followed to make an adjustment to the ERP charge schedule. Approvals are required from the Minister of Transport, and the new rates are formalized through appropriate legal documents or law.

In addition to adjustments to the ERP rate schedule, outward expansion of the area cordons defining the RZ and the cordons along major expressways and arterials may be deemed necessary, requiring additional gantries. Travel demand modeling identifies future potential cordon locations, which are monitored closely for expansion consideration. The process for cordon expansion is more involved than ERP rate adjustments and can potentially necessitate a parliamentary-level decision. Early communication to the public is used to make it aware of potential future gantry installations, but their implementation occurs only when deemed absolutely necessary. Overall, the number of gantries has roughly doubled since the introduction of ERP in 1998 as vehicle population increases over the last 12 years.

THIS PAGE LEFT BLANK INTENTIONALLY.

TABLE 11-1: SINGAPORE ELECTRONIC ROAD PRICING SUMMARY MATRIX

	Performance Category	Performance Metrics	What Measures Are Used	When				Purpose		Importance		Goal/ Application/ Characterization	Source	Notes
				Ongoing	*Before & After*	*Once*	*Irregular*	*Operations*	*Validation*	*Key*	*Secondary*			
Traffic	*Speed & Travel Time*	LOS	X	X				X		X		Minimize congestion, 85th percetile criterion	Interviews	
		Speeds/ average speed	X	X				X		X		Minimize congestion, 85th percetile criterion	Interviews	
		Speed differential (GP vs. HOT lanes)												
		Travel times	X	X					X		X	Meet state-established benchmarks	Interviews	Tracked by senior management, applied multimodally
		Travel time savings												
		Cost of delay/VOT	X	X					X		X	Meet state-established benchmarks	Interviews	Tracked by senior management, applied multimodally
	Volume	Vehicle volume (hourly/daily/weekly/monthly)												
		Person volume (hourly/daily/weekly/monthly)												
		Tolled trips/ untolled trips												
	VMT/VKT	VMT/VKT												
	Congestion	Delay/wait times												
		Congestion coefficient												
		Queue length												
	Mode Share	Mode share (SOV, HOV, transit)												
	Occupancy	Avg. vehicle occupancy (auto)												
	Bike/Ped	Bike/ped traffic counts												
	Parking	Park-n-ride activity (lot counts)												
		Off-street parking activity (counts/occupancy)												
		On-street parking activity (counts/occupancy)												
		Cost of parking/parking revenue												
		# of resident permits/permit cost												
		Violations/revenue												
Public Perception	*Awareness*	Of the facility/general/how much?												
		Specific features												
		Toll adjustments												
		Future plans												
	Acceptance	General/fairness/equity												
		Specific questions												
	Satisfaction	General/perceived value/how well?												
		Traffic conditions/ reliability												
		Perceived time savings												
		Perceived safety												
		Signage												
		Agency performance/customer service												
		Enforcement												
	Effectiveness	Congestion reduction												
	Social Impacts	Specific activities/populations												
	Media Coverage	No. of articles/reports (positive or negative)												
	Marketing	Volume/success												
Users	*Transaction Method*	Transponder/video/by-mail/cash												
	Accounts	Total, open/closed												
		No. of transponders issued												
	User Characteristics	Vehicle classification												
		Vehicle make												
		Vehicle registrations (HOV, vanpool, hybrid)												
		Home zip code												
		Demographics/socioeconomics												
	Trip Characteristics	Frequency of use												
		Time of day/departure time												
		O-D/ travelshed determination	X	X				X			X		Interviews	
		Toll spending/price paid (self-reported)												
		Trip length												
		Trip purpose												

TABLE 11-1: SINGAPORE ELECTRONIC ROAD PRICING SUMMARY MATRIX (CONTINUED)

	Performance Category	Performance Metrics	What Measures Are Used	When				Purpose		Importance		Goal/ Application/ Characterization	Source	Notes
				Ongoing	*Before & After*	*Once*	*Irregular*	*Operations*	*Validation*	*Key*	*Secondary*			
System Operations	*Finance*	Total transactions												
		Revenue (toll/charge)												
		Average toll/ highest toll												
		Revenue (fee)												
		O&M Cost												
	Enforcement	Total traffic stops/ responses												
		Violations/citations/fines												
	Safety	Collisions/ accidents												
		Incident response time/ duration												
		Speed differential												
	Customer Service	Inquiry activity (call, email)												
		Performance (quantitative measures)												
	System Function	Incidents												
		Facility availability	X	X					X		X	Meet state-established benchmarks	Interviews	Tracked by senior management, applied multimodally
		Equipment availability												
		Mean time to respond/ repair												
Environment	*Air Quality*	NAAQS criteria pollutants/VOCs												
		GHG/CO2												
	Noise	Noise levels												
	Fuel Consumption	Fuel consumption												
Transit	*Performance*	Travel time/on-time/excess wait												
		Average speed												
	Occupancy	Ridership/ boardings												
		Average vehicle occupancy												
	Finance	Farebox revenue												
		O&M Cost												
	Service	Quality/satisfaction/reliability												
Economics	*General*	Gross regional product/economic indices												
		Benefit-cost analysis												
	Business Impacts	Awareness/importance												
		General performance/openings/closings												
		Specific sectors/services/populations												
		On commercial trucking												
		Business costs and prices												
		Retail traffic & sales												
		Tourists/visitors												
	Property	Residential sales/rentals/values												
		Commercial sales/rentals/values												
Land Use	*Residential*	Housing decisions												
	Commercial	Business locations												

12. Stockholm Congestion Tax

The City of Stockholm (or Stockholm Municipality) is one of 26 municipalities in the County of Stockholm. The county is home to about 2 million of Sweden's 9.3 million inhabitants and is also referred to as Greater Stockholm—the city's overall metropolitan region. The municipality itself has a population of about 830,000. Including the urbanized, surrounding 10 municipalities, the population is about 1.25 million.

To reduce congestion in Stockholm and improve the urban and natural environment, a congestion tax (*Trängselskatt*) is levied for vehicular travel into the city center. Administration and collection of the tax is the responsibility of the Traffic Registry Department within the newly-formed Swedish Transport Agency, which oversees the country's rail, air, sea, and road transportation systems. Until January 2009, it was operated by the Swedish Road Administration when that agency was dissolved into the Swedish Transport Agency. The City of Stockholm Traffic Administration and County Council-owned Greater Stockholm Public Transport (SL) contribute to the congestion tax's ongoing monitoring and evaluation.

12.1 Overview of Stockholm's Congestion Tax

Stockholm's permanent congestion tax went into effect on August 1, 2007. A variable charge is levied to enter the 13.8-square-mile city center on weekdays between 6:30 AM and 6:30 PM. A charge of 10, 15, or 20 kroner varies on a fixed schedule with peak and shoulder periods costing more. There is also a maximum daily charge of 60 kroner. Some vehicle exemptions apply and no charge is levied on public holidays or during the month of July.

Control points along the city center cordon utilize a system of cameras, laser detectors, and antennae to automatically record vehicle license plates as they pass below gantries. A monthly bill is generated and sent to the registered owner. The charges are tax deductable for private individuals traveling between home and work and for all business users.

Prior to the permanent implementation of the congestion tax, a trial period was held from January 3 to July 31, 2006 (The Stockholm Trial). The decision to implement the trial dates back to action by the Stockholm City Council in June 2003. This was followed by passage of a law by the Swedish Parliament, the *Riksdag*, enabling a congestion tax/environmental charge to be levied in Stockholm until July 31, 2006 (Swedish Code of Statutes SFS 2004:629). The decision to begin the trial period on January 3, 2006 was set in April of the previous year.

Along with implementing the congestion tax on a trial basis, the Stockholm Trial expanded public transit service and park-n-ride sites within the city and county. Specific goals of the trial included:

- A 10–15 percent reduction in the number of vehicles that entered the central city during morning and afternoon rush hours
- Improved access on the busiest roads in Stockholm
- Reduced emissions of CO_2, NO_x, and particles in central city air
- Better street-level environment as perceived by people in the central city

During the Stockholm Trial, the Swedish government commissioned a Congestion Charge Secretariat to plan, coordinate, communicate, and evaluate the trial. The Congestion Charge Secretariat prepared and executed a comprehensive evaluation program to assess the extent of goal achievement and the effects of the Stockholm Trial. Contributions to creating the evaluation program came from the former Swedish Road Administration, the County Office of Regional Planning and Urban Transportation, SL, and various research institutes, private consultants, and city administrations (the City of Stockholm Traffic

Administration, the Stockholm Office of Research and Statistics, and the Environment and Health Administration).

The end of the trial period was followed in September 2006 by referenda held in 15 Stockholm County municipalities (those in the urban region as well as four others) in which they voted on whether to implement the charge permanently. Only the City of Stockholm voted in favor of the permanent charge, but the reigning national government prior to the September election date (Social Democrats) had stated that they would act only on the results of the City of Stockholm's referendum. The opposition party (Alliance for Sweden) had stated that they would consider the referenda of other municipalities as well if they came to power. The Alliance for Sweden won a majority in that election, but prior to the formation of a government, party leaders announced on October 1 that the congestion tax would be implemented permanently. The tax was approved by Parliament in June 2007 and reintroduced on August 1.

In 2008, revenue from the congestion tax was approximately 850 million kroner, including from the tax, administrative and late payment fees, and enforcement revenues. Operational costs amounted to about 393 million kroner, although this included several one-time charges. Estimated operational costs in 2010 and beyond are approximately 250 million kroner. Net revenues from the permanent charge (estimated to be 600 million kroner per year starting in 2010) have been reinvested in the Stockholm region's road network, unlike during the trial period when net revenues were invested in improved public transportation.

12.2 What is Monitored?

The full spectrum of performance monitoring activities for Stockholm's congestion tax is provided in the accompanying Facility Performance Monitoring Summary Matrix. The matrix is a comprehensive record of all current, known metrics used to monitor performance on the facility, organized by evaluation category. Provided in the matrix for each metric used are: frequency of collection; purpose; a simple indication of importance; particular characterizations of the metric that relate back to government/facility goals or applications; sources of information; and other notes. The matrix is intended to be a visual overview of Stockholm's complete monitoring effort, easily comparable to other cordon or area priced facilities with similar matrix summaries.

During its seven-month duration, a comprehensive monitoring program for the Stockholm Trial was carried out by the Congestion Charge Secretariat. A significant number of performance metrics were selected for a before-and-after evaluation with respect to the trial's stated goals—congestion reduction, improved natural environment, and improved perceived city environment. The accompanying matrix indicates the full extent of these metrics. Those metrics that were monitored as part of the Stockholm Trial are indicated with an "X" in the box labeled "Before & After" under the "When" column, and "Stockholm Trials 12/06" is indicated in the "Source" column, referring to the final report on the trial's monitoring published five months after its conclusion.

Significant measures of traffic to determine the trial's effect on congestion levels included vehicle volumes entering the central city through the priced cordon, travel times, and delays along major routes into the city center. Estimations of reductions in CO_2, NO_x, and particulates were important indicators of improved air quality and the natural environment. Finally, comprehensive surveys helped inform the qualitative (and generally difficult to measure) perceived improvement on the urban environment. Questions asked in these surveys generally focused on quality-of-life impacts such as mode-specific transportation access, traffic conditions, air quality, and safety and security. Additional metrics tracked throughout the trial period included: total vehicle kilometers traveled (inside the cordon and along approach roads); mode share; bicycle and pedestrian counts; transit ridership and service; road safety; and various indicators of public perception.

Since the implementation of the permanent congestion tax in August 2007, the City of Stockholm Traffic Administration has published periodic reports on performance monitoring, representing the most current performance evaluation of the congestion charge. However, the reporting itself and the metrics monitored have been uneven and not as focused as the formal program in place for the seven-month trial period in 2006. Initial reports published shortly after the implementation of the permanent charge largely tracked the same metrics as those during the trial and concluded that permanent charge's effects on congestion had been very similar.

Current monitoring of the permanent congestion tax includes metrics indicated in the matrix with an "X" in the box labeled "Ongoing" under the "When" column. The most current report from the Traffic Administration (September 2009) summarizes the collection of ongoing metrics and an overview of the congestion tax from 2005-2008. Traffic volumes, travel times, and delay continue to be tracked, indicating a reduction in traffic slightly less than during the trial, but still to be considered significant. The report notes a significant increase in the number of exempt vehicles entering the charge zone (28 percent of the total), especially because of alternative fuel vehicles, although this exemption expires in 2012. Air quality and emissions, including CO_2 continue to be tracked and indicate improvements in the city's natural environment. Public transportation ridership and service performance is monitored and continues to show improvement with the permanent charge in place than without. Public perceptions and business impacts are also tracked and are generally favorable. Finally, revenue, as described previously, is reported.

12.3 Why Performance Evaluation Takes Place and How Performance Monitoring Data is Used

The comprehensive monitoring program during the seven-month trial period was critical to validating the success of the congestion charge and communicating its effects and benefits to stakeholders and the public. Instituting the congestion charge on a temporary basis and putting in place a rigorous program that made it possible to understand what worked well and what could be improved was a tactical decision that met with great success. Overall, the final report on the trial period concluded the congestion tax's goals were met, with an even greater-than-expected reduction in congestion, improved levels of CO_2 and particulates, and an improved city environment, at least with respect to those changes that could be measured and quantified.

Measurable and documented improvements that were apparent to the public contributed to the success of the referendum in the City of Stockholm, which in turn convinced the Swedish Parliament to institute the congestion tax on a permanent basis.

Currently, the City of Stockholm Traffic Administration reporting on traffic and the congestion tax notes that, "it is becoming increasingly difficult to isolate the effects of the congestion tax both from other permanent and temporary changes in the traffic system, and from external factors." This view helps explain the comparatively uneven monitoring and reporting since the inception of the permanent charge. The report goes on to state that long-term monitoring of the city's entire transportation system is essential to optimizing its use and minimizing impacts on the climate in the face of rising population and demand for travel. However, the report also states that, "in this context the continued monitoring of the congestion tax as a distinct element of the traffic system is increasingly less relevant" and that future monitoring should occur cooperatively at the regional level, accurately taking into account secondary effects and the intertwined nature of a multimodal transportation system.

TABLE 12-1: STOCKHOLM CONGESTION TAX SUMMARY MATRIX

	Performance Category	Performance Metrics	What Measures Are Used	When				Purpose		Importance		Goal/ Application/ Characterization	Source	Notes
				Ongoing	Before & After	Once	Irregular	Operations	Validation	Key	Secondary			
Traffic	*Speed & Travel Time*	LOS												
		Speeds/ average speed												
		Speed differential (GP vs. HOT lanes)												
		Travel times	X	X	X				X	X		Reduce traffic/improve access	Stockholm Trials (12/06); City of Stockholm Traffic Administration	
		Travel time savings	X		X				X		X	Reduce traffic/improve access	Stockholm Trials (12/06)	
		Cost of delay/VOT												
	Volume	Vehicle volume (hourly/daily/weekly/monthly)	X	X	X				X	X		Reduce traffic/improve access	Stockholm Trials (12/06); City of Stockholm Traffic Administration	
		Person volume (hourly/daily/weekly/monthly)												
		Tolled trips/ untolled trips												
	VMT/VKT	VMT/VKT	X		X				X		X	Reduce traffic/improve access	Stockholm Trials (12/06)	
	Congestion	Delay/wait times	X	X	X				X	X		Reduce traffic/improve access	Stockholm Trials (12/06); City of Stockholm Traffic Administration	
		Congestion coefficient	X		X				X		X	Reduce traffic/improve access	Stockholm Trials (12/06)	
		Queue length												
	Mode Share	Mode share (SOV, HOV, transit)	X		X				X		X	Reduce traffic/improve access	Stockholm Trials (12/06)	
	Occupancy	Avg. vehicle occupancy (auto)												
	Bike/Ped	Bike/ped traffic counts	X	X	X				X		X	Reduce traffic/improve access	Stockholm Trials (12/06); City of Stockholm Traffic Administration	
	Parking	Park-n-ride activity (lot counts)	X	X	X				X		X	Reduce traffic/improve access	Stockholm Trials (12/06); City of Stockholm Traffic Administration	
		Off-street parking activity (counts/occupancy)	X		X				X		X	Reduce traffic/improve access	Stockholm Trials (12/06)	
		On-street parking activity (counts/occupancy)		X					X		X		City of Stockholm Traffic Administration	
		Cost of parking/parking revenue												
		# of resident permits/permit cost												
		Violations/revenue												
Public Perception	*Awareness*	Of the facility/general/how much?	X		X				X		X		Stockholm Trials (12/06)	
		Specific features												
		Toll adjustments												
		Future plans												
	Acceptance	General/fairness/equity	X		X				X		X	Improve city environment	Stockholm Trials (12/06); City of Stockholm Traffic Administration	
		Specific questions												
	Satisfaction	General/perceived value/how well?												
		Traffic conditions/ reliability												
		Perceived time savings												
		Perceived safety												
		Signage												
		Agency performance/customer service												
		Enforcement												
	Effectiveness	Congestion reduction												
	Social Impacts	Specific activities/populations	X		X				X		X	Improve city environment	Stockholm Trials (12/06)	
	Media Coverage	No. of articles/reports (positive or negative)												
	Marketing	Volume/success												
Users	*Transaction Method*	Transponder/video/by-mail/cash												
	Accounts	Total, open/closed												
		No. of transponders issued												
	User Characteristics	Vehicle classification	X	X	X				X		X		Stockholm Trials (12/06); City of Stockholm Traffic Administration	
		Vehicle make												
		Vehicle registrations (HOV, vanpool, hybrid)												
		Home zip code												
		Demographics/socioeconomics												
	Trip Characteristics	Frequency of use												
		Time of day/departure time												
		O-D/ travelshed determination	X	X	X				X		X		Stockholm Trials (12/06); City of Stockholm Traffic Administration	City destination vs. through traffic
		Toll spending/price paid (self-reported)												
		Trip length												
		Trip purpose	X		X				X		X		Stockholm Trials (12/06)	

TABLE 12-1: STOCKHOLM CONGESTION TAX SUMMARY MATRIX (CONTINUED)

	Performance Category	Performance Metrics	What Measures Are Used	When				Purpose		Importance		Goal/ Application/ Characterization	Source	Notes
				Ongoing	Before & After	Once	Irregular	Operations	Validation	Key	Secondary			
System Operations	*Finance*	Total transactions	X	X					X		X		City of Stockholm Traffic Administration	
		Revenue (toll/charge)	X	X					X		X		City of Stockholm Traffic Administration	
		Average toll/ highest toll	X	X					X		X		City of Stockholm Traffic Administration	
		Revenue (fee)	X	X					X		X		City of Stockholm Traffic Administration	
		O&M Cost	X	X					X		X		City of Stockholm Traffic Administration	
	Enforcement	Total traffic stops/ responses												
		Violations/citations/fines												
	Safety	Collisions/ accidents	X	X	X				X		X		Stockholm Trials (12/06); City of Stockholm Traffic Administration	
		Incident response time/ duration												
		Speed differential												
	Customer Service	Inquiry activity (call, email)												
		Performance (quantitative measures)												
	System Function	Incidents												
		Facility availability												
		Equipment availability	X	X					X		X		City of Stockholm Traffic Administration	
		Mean time to respond/ repair												
Environment	*Air Quality*	NAAQS criteria pollutants/VOCs	X	X	X				X	X		Improve natural environment	Stockholm Trials (12/06); City of Stockholm Traffic Administration	
		GHG/CO2	X	X	X				X	X		Improve natural environment	Stockholm Trials (12/06); City of Stockholm Traffic Administration	
	Noise	Noise levels	X		X				X		X	Improve natural environment	Stockholm Trials (12/06)	
	Fuel Consumption	Fuel consumption												
Transit	*Performance*	Travel time/on-time/excess wait	X	X	X				X		X	Reduce traffic/improve access	Stockholm Trials (12/06); City of Stockholm Traffic Administration	
		Average speed	X		X				X		X	Reduce traffic/improve access	Stockholm Trials (12/06)	
	Occupancy	Ridership/ boardings	X	X	X				X		X	Reduce traffic/improve access	Stockholm Trials (12/06); City of Stockholm Traffic Administration	
		Average vehicle occupancy												
	Finance	Farebox revenue	X		X				X		X		Stockholm Trials (12/06)	
		O&M Cost												
	Service	Quality/satisfaction/reliability	X		X				X		X	Reduce traffic/improve access	Stockholm Trials (12/06)	
Economics	*General*	Gross regional product/economic indices	X		X				X		X		Stockholm Trials (12/06)	
		Benefit-cost analysis	X			X			X		X		Stockholm Trials (12/06)	
	Business Impacts	Awareness/importance												
		General performance/openings/closings	X	X					X		X		City of Stockholm Traffic Administration	
		Specific sectors/services/populations	X		X				X	X		Improve city environment	Stockholm Trials (12/06)	
		On commercial trucking												
		Business costs and prices												
		Retail traffic & sales	X		X				X		X	Improve city environment	Stockholm Trials (12/06)	
		Tourists/visitors												
	Property	Residential sales/rentals/values												
		Commercial sales/rentals/values												
Land Use	*Residential*	Housing decisions	X		X				X		X	Improve city environment	Stockholm Trials (12/06)	
	Commercial	Business locations	X		X				X		X	Improve city environment	Stockholm Trials (12/06)	