



U.S. Department
of Transportation

**Federal Highway
Administration**

International Urban Road Pricing

Final Report

**Work Order 05-002:
Issues and Options for Increasing
the Use of Tolling and Pricing to
Finance Transportation
Improvements**

Prepared for:

**Office of Transportation
Policy Studies**

Prepared by

AECOM CONSULT
T E A M

June 9, 2006

June 9, 2006

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**RE: Final Report - International Urban Road Pricing
Task Order 05-002**

Dear Mr. March:

AECOM Consult, Inc. is pleased to present this final report of *International Urban Road Pricing* to the Federal Highway Administration (FHWA). This report is one of the deliverables under the task order: *Issues and Options for Increasing the Use of Tolling and Pricing to Finance Transportation Improvements*. The report presents a comprehensive summary of road pricing initiatives being developed and implemented in urban areas abroad to deal with growing traffic demand and transportation funding needs. A number of road pricing approaches and the issues and strategies for addressing them are described and illustrated through a series of brief cameos and more detailed case studies. The report is intended for those interested in the development and application of road pricing approaches to managing travel demand in urban areas.

We appreciate the opportunity to perform this timely study of international efforts to introduce tolling and/or road pricing in urban settings. It has been a distinct pleasure working on this assignment with you, other members of the Office of Policy staff, and members of the Congestion Pricing staff.

Very truly yours,



Daniel L. Dornan, P.E.
Senior Consulting Manager
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INTERNATIONAL URBAN ROAD PRICING – FINAL REPORT

ABSTRACT

Charging for the use of highway facilities through the collection of tolls has long been a means to generate the funds needed to develop and operate highway facilities when adequate public funding is unavailable. In recent years, the concept of directly charging users of highways has expanded to include various pricing schemes aimed at managing travel demand in and around densely populated urban areas. Many of the leading examples of road pricing to manage urban area congestion can be found outside of the United States, in major metropolitan areas characterized by high density urban cores, highly constrained roadway networks, significant transit capabilities and utilization, and limited public funding to pay for expanding transportation infrastructure.

While there may be differences in land use patterns, travel preferences, transportation funding sources, and cultural/institutional issues between urban areas in other countries and the United States, many of the challenges facing road pricing initiatives and strategies to address them are similar. Since there is a longer history of road pricing in urban areas outside the United States, lessons learned from these international examples may help sponsoring agencies of urban road pricing in this country avoid some of the pitfalls that have impeded earlier initiatives and learn from their successes.

This report explores the use of road pricing in various cities and countries outside the United States, with a focus on different road pricing schemes used to manage demand in urban areas. Also included are several distance-based heavy vehicle pricing schemes used in several European countries to address the growing post-European Union (EU) problems of foreign trucks traversing their highway system without purchasing fuel in those countries. As a result, these vehicles have avoided contributing to the cost of building, maintaining, and operation these facilities. The report summarizes the major kinds of road pricing schemes, the goals of these schemes, and the predominant locales where these approaches are being used. The report includes a series of case studies and cameos of actual road pricing initiatives, with case studies of successful projects and cameos of unsuccessful efforts. Through these case studies and cameos, the report provides insights and lessons learned regarding what to do and what not to do in developing and implementing urban area road pricing for demand management.

The report is aimed at transportation planners and policy-makers in the U.S. considering the application of pricing to urban highway networks in the U.S. It is intended to help agency staff in understanding both the challenges and opportunities of road pricing initiatives, to identify potential obstacles early in the planning process, and develop effective strategies to assure successful implementation.

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1. INTRODUCTION

This chapter presents the background of road pricing initiatives used abroad to manage travel demand in urban areas, the purpose and scope of the study, and the road pricing terminology used throughout the report. The chapter also provides an overview of the remaining chapters and appendices of the report.

BACKGROUND

The predominant mode of travel in the United States remains the automobile for persons and trucks for freight. This is reflected in the U.S. highway system and the urban form of many of the cities in the U.S. Demand for road space is increasing much faster than the increase in capacity, particularly in the fastest growing metropolitan areas. As cities in the U.S. have developed and grown, the ability to service the continued growth in travel is increasingly limited by strict approval processes, the scarcity of land and traditional sources of funding to build additional highway capacity. Unable to build their way out of congestion, urban planners and policy-makers in the U.S. are looking for alternative ways to provide for the mobility needs of the nation through new sources of funding and better utilization of highway facilities.

Until recently, road pricing in the U.S. has primarily been in the form of tolls used to finance through revenue bonds the construction and operation of selected roads, bridges, and tunnels that lacked available funding from motor fuel taxes. In recent years, decision-makers in the U.S. have begun to consider various road pricing strategies to achieve a range of objectives as well as generate additional program funding. These strategies include:

- Variable priced toll lanes which increase toll rates during peak travel periods and may reduce rates in the shoulder periods;
- Express lanes which charge users who choose to use the special purpose lanes;
- High Occupancy Toll (HOT) lanes which enable single occupant vehicles (SOV) access to high occupancy vehicle (HOV) lanes for a specified fee, that may vary by time of day or congestion level;
- Super HOT lanes which are like HOT lanes but limit free access to very high occupancy vehicles;
- Fair And Intertwined Regular (FAIR) lanes which provide off-setting tolls and credits for using tolled lanes and un-tolled lanes, respectively; and
- Truck-Only Toll (TOT) lanes; and
- Variable toll lanes.

Most of the urban road pricing initiatives in the U.S. have involved or are planning to involve the implementation of variable pricing schemes or the development of HOT or express lanes. These enable users to pay to travel on special-purpose lanes while still providing toll-free access to general-purpose lanes. This is reflected by the statistics which are displayed on the next page:

- Out of ten road pricing initiatives currently operating in the U.S., four involve variable pricing and four involve the conversion of HOV lanes to HOT lanes.
- Out of 16 road pricing initiatives proposed in the U.S., 11 involve HOT lane conversions.

HOT lanes are unique to the United States, a consequence of the institutional framework of the federal-aid highway program which prohibits placing tolls on federally-funded facilities except for HOV lanes which are able to apply tolls to vehicles carrying fewer occupants than required for HOV eligibility. Despite the significant investment in HOV lanes over the past 25 years by federal and state governments, there has been little impact on highway congestion levels due to the relatively poor utilization of these rationed lanes. Whereas HOV lanes were intended to increase effective highway capacity by adding additional highway lanes that required carpooling, they rarely achieved their capacity potential due to the reluctance of American drivers to rideshare.

HOT lanes compensate for the shortfalls of HOV lanes by allowing single occupant vehicles (SOV) to utilize the lanes for a prescribed toll, while still permitting free use by carpoolers. In some cases more fuel-efficient cars, such as hybrid vehicles, are also exempted from the toll even with one occupant. Whereas road rationing on the basis of occupancy has not met expectations in the U.S., the prospect for road pricing combined with occupancy-based road rationing provides a relatively low cost way to boost the effective capacity of use of available highway infrastructure while augmenting funding for transportation infrastructure.

The international experience with urban road pricing differs significantly from the comparable U.S. experience. In many cities abroad, urban road pricing has moved from being primarily a revenue generating tool for adding more roadway capacity to a broader tool to manage travel demand in urban areas, while still generating significant revenues for projects aimed at improving multiple modes, including roadways, transit, and rail. Given the land constraints and design of many international cities, some of these cities have concluded that congestion cannot be managed simply by adding more lane-miles. As a result, these international urban areas have sought innovative ways to manage demand by encouraging auto users to shift modes, travel times, routes, or destinations. The primary road pricing approaches being considered or used by cities abroad for managing roadway traffic include the following:

- Cordon tolling; and
- Value pricing.

Among the major cities overseas that developed or applied innovative strategies to manage traffic demand are the following:

- Bergen, Oslo, and Trondheim, Norway;
- Copenhagen, Denmark;
- Edinburgh, Scotland;
- Helsinki, Finland;
- London, Bristol, and Leeds, England;
- Rome and Genoa, Italy;
- Randstad region of the Netherlands;
- Stockholm and Gothenburg, Sweden;

- Hong Kong, China; and
- Singapore.

Since many of these cities were originally developed prior to the automobile age, their land use patterns and street networks are less able to accommodate automobiles and trucks. Despite having extensive public transit systems, these cities have experienced growing demand for both automobile and truck travel which cannot be handled efficiently by the available roadways. This has resulted from a number of related factors, including:

- Growing affluence of Europeans, which allows for more auto ownership, especially among the growing middle class;
- Rising demand for the increased independence and prestige perceived to be associated with auto travel within these countries; and
- Increasing mobility between countries since the creation of the EU.

As a result, city leaders and planners are more willing to institute road pricing strategies to manage the level of automobile and truck traffic, consistent with broader objectives (such as air quality, improved on-street bus operations, protection of heritage, and creation of pedestrian-friendly urban spaces). In cities such as Rome, road pricing strategies are being integrated with parking pricing strategies to better influence auto driver behavior and reduce downtown congestion.

Given their lead in instituting road pricing strategies, major cities overseas offer their U.S. counterparts valuable insights into road pricing approaches that may have merit in this country as physical and financial constraints curtail efforts to expand urban area road capacity. While there are major institutional, financial, economic, cultural, and land use differences between urban areas in the United States and abroad, the experiences of cities overseas demonstrate how road pricing concepts can be applied to manage travel demand in congested urban settings.

In addition to the congestion management strategies noted above, another innovative road pricing strategy being developed and applied in a number of European countries is distance-based pricing aimed at heavy vehicles (trucks). These approaches are not being applied because of congestion control but to recover costs of international travelers, trucks mainly, that are damaging the highways in one country but not paying for maintenance of these facilities through the gas tax programs in place. These gas tax rates are many times the rates applied in the U.S. and are used for a variety of transportation and non-transportation purposes.

With the creation of the European Union and the inclusion of many Eastern European countries, international truck travel has escalated quickly to serve the growing cross-border trade that has resulted (much like the effect of the North America Free Trade Agreement (NAFTA) between the U.S. and Mexico). However In Europe, where the nations are geographically smaller, goods are frequently moved from one country to another, passing through one or more intermediate countries along the way. When foreign registered trucks merely travel through an intermediate country without purchasing fuel in that country, the result is a significant loss of fuel tax revenues to that country. Several countries in Europe most impacted by this phenomenon include Austria, Germany, and Switzerland. Each of these countries has implemented a distance-based tolling program aimed at all heavy trucks using their major highways to address this problem. In this report, we provide case studies for two of these programs: Germany and Switzerland.

In considering the content of this report and the case studies that are presented, it is important to recognize the differences in political philosophy between the U.S. and countries overseas. Many of these countries are social democracies, while the U.S. places greater emphasis on the freedom of the individual. In the U.S., individual rights relating to personal travel, interstate travel, and property rights are greatly valued. Since the U.S. is a much more litigious nation, these issues are likely to be hotly contested when these initiatives are proposed for implementation in this country. Hence when considering cordon, congestion control, and distance pricing schemes like those implemented overseas for possible application in urban areas of the U.S., one must take into account how these various schemes might be viewed within the context of a nation very sensitive to the freedom and privacy of the individual. While there are differences in conditions and philosophies between urban areas within the U.S., the applicability of these strategies in the U.S. will meet with great resistance unless these issues and sensitivities are completely understood and addressed.

PURPOSE AND SCOPE

This report is directed at transportation policy-makers and planners in the United States who are considering the application of road pricing to urban highway networks. It is intended to assist agency staff in understanding both the challenges and opportunities of road pricing initiatives, to identify potential obstacles early in the planning process, and develop effective strategies to assure successful implementation.

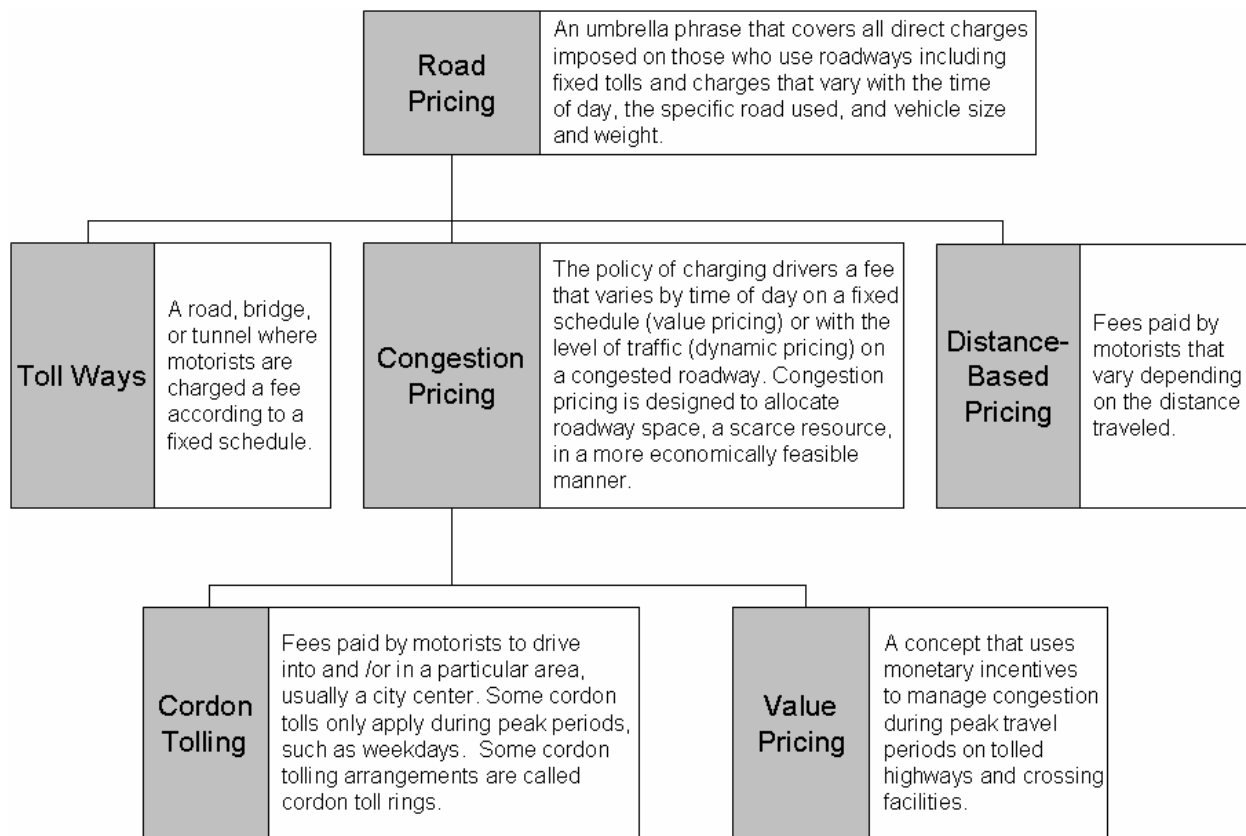
The report explores the use of road pricing in various cities and countries abroad, with a focus on different kinds of initiatives used to manage congestion in urban areas. It summarizes the major kinds of road pricing initiatives, the goals of these schemes, and the predominant locales where they are being applied. The report includes a series of case studies and cameos of actual road pricing initiatives, including both successful and unsuccessful projects. Through the case studies and cameos, the report provides insights and lessons learned regarding what to do and what not to do in developing and implementing urban area road pricing for travel demand management.

ROAD PRICING TERMINOLOGY

Road pricing is a general term used to describe any form of direct charging for road use, including tolls, managed lanes, or distance-based charging. Shadow tolls are not considered a road pricing scheme but are essentially a financing mechanism as part of a public-private partnership since the vehicle driver is not directly charged for use of the facility. Congestion pricing is used to describe those forms of road pricing specifically aimed at reducing and managing traffic demand (hence the term, managed lanes). This report focuses on the primary forms of road pricing used in urban areas abroad to manage congestion. Examples of distance-based pricing are included because of their growing prevalence in Europe for managing heavy truck charging and the emerging interest within the U.S. in some kind of distance-based approach to replace the motor fuel tax in the future. (Forkenbrock, 2006)

Exhibit 1 depicts the hierarchy of road pricing terminology used throughout this paper, defining the three primary road pricing strategies used abroad: cordon tolling, value pricing, and distance-based pricing.

Exhibit 1 Urban Road Pricing Terminology



Sources: FHWA; Texas A&M University; TDM Encyclopedia; TRB Conference Proceeding 34.

REPORT OVERVIEW

The remaining chapters and appendices of this report present the following information:

- **Chapter 2 – International Urban Road Pricing Overview.** This chapter provides a summary of international experience with urban road pricing, describing the major types of road pricing, the goals of these schemes, the major obstacles encountered, and key strategies for successful implementation. Included in this chapter are brief cameos that describe how road pricing initiatives were undermined by various issues or implementation problems.
- **Chapter 3 – Case Studies.** This chapter presents selected international urban congestion pricing case studies that have been implemented successfully. The case studies focus on the operational and legal issues encountered, obstacles addressed, and the resulting revenue and traffic impacts. These case studies include examples of cordon tolling, value pricing, and distance-based pricing schemes that are in use in England, France, Germany, Japan, Norway, Singapore, and Switzerland.

- **Chapter 4 – Conclusions.** This chapter synthesizes the lessons learned from the prior chapters, including key reasons that international urban road pricing schemes are not successfully implemented as well as strategies to promote successful development and implementation.
- **Appendix A – Glossary of Road Pricing Terms:** This appendix contains a list of road pricing terminology used in this report.
- **Appendix B – List of Acronyms.** This appendix contains definitions of each acronym used in this report.
- **Appendix C – Bibliography.** This appendix provides a listing of documentation on international urban road pricing initiatives, including various sources referenced throughout the report.

2. INTERNATIONAL URBAN ROAD PRICING OVERVIEW

In many countries abroad, the development of cities predated the era of the automobile. As a result, land use patterns and the design of their street systems are not compatible with the expansion of auto use now being witnessed in many urban centers. Due to the land constraints and designs of many cities abroad, some of these cities have concluded that traffic congestion cannot be managed simply by building more roads. As a result, their leaders and planners have been forced to look for innovative ways to manage congestion by encouraging auto users to shift modes, travel times, routes, or destinations. One of the most successful means of encouraging this shift in travel demand has been through the use of urban road pricing schemes.

This chapter summarizes the international experience with urban road pricing initiatives, particularly those that have been designed to manage congestion. It begins by defining the potential goals of urban road pricing schemes, which include but are not limited to congestion management. This is followed by a discussion of the major issues and obstacles encountered by international urban road pricing initiatives. The chapter concludes by describing key strategies to address or avoid these issues and obstacles.

URBAN ROAD PRICING GOALS

The primary objective of the international urban road pricing initiatives discussed in this report is reducing congestion levels during periods of peak travel demand. However, urban road pricing schemes may have additional goals such as generating revenue, reducing environmental impacts such as air and noise pollution, and encouraging transit use. These additional goals are not exclusive of congestion management and are frequently applied in combination. While an urban pricing initiative may have multiple goals, the objective considered most important usually determines the type of road pricing scheme selected for a region. (Eliasson and Lundberg, 2002)

Congestion Management

Congestion is a critical issue for urban areas throughout the world as economic development and auto/truck uses continue to grow. As a result, many urban areas are employing various travel demand management strategies to alleviate congestion, reduce travel times, and increase accessibility, particularly during peak travel periods. By using road pricing to charge a higher price to enter or travel within an urban area during peak travel periods, auto users are encouraged to reduce their number of trips, shift their travel to off-peak times or to different locations, or find alternative modes of travel. For many proponents of urban road pricing, congestion management is considered the primary objective. (Eliasson and Lundberg, 2002)

Revenue Generation

Revenue generation is also a goal for many urban road pricing initiatives, and at the very least it is an outcome. Some urban road pricing initiatives are intended to generate revenues to finance infrastructure needs, while congestion management is an additional benefit. Other initiatives seek to manage congestion, while the revenues generated are an additional benefit. The revenues from urban road pricing schemes are often used to fund infrastructure investments that may include roads, transit, or even other non-transportation related projects. In fact, how the revenues generated by the urban road pricing scheme are used is often the key to obtaining public acceptance for the scheme – even if the primary goal is congestion management.

Reduce Environmental Impacts

Another common objective for urban road pricing schemes is to reduce the air and noise pollution associated with high levels of traffic and congestion. When reducing air and noise pollution is a major component of road pricing, tolls generally will vary by the size or weight of the vehicle or the vehicle's emissions class. While environmental improvements are often a benefit experienced by urban areas using road pricing, they are not generally the primary goal of these measures. (Eliasson and Lundberg, 2002) Instead they are a side-benefit of more constrained and efficient automobile operations that result in fewer emissions.

Encourage Transit Use

Urban road pricing schemes also may be designed to encourage current auto users to shift to available transit services. In many cities overseas, transit is the predominant form of personal travel and any road pricing scheme that improves transit services gains broader public support.

Many auto users view transit as a less desirable mode of travel, in terms of comfort, convenience, or availability. When urban road pricing schemes are introduced, the costs associated with auto trips increase. If the increased costs are perceived to be a greater burden on auto users than the enhanced comfort and convenience typically associated with auto travel, auto users may shift to transit services. On the other hand, if the transit system does not provide adequate service between auto users' trip origins and destinations, particularly in the growing suburban communities outside the urban core areas, the shift to transit probably not occur.

When encouraging transit use is a goal of the urban road pricing scheme, improvements and expansion of the city's transit services typically are included as part of the scheme's implementation plan. By combining the road pricing fee with improvements in transit service, even more auto users may be willing and able to shift to transit, thereby further relieving the road network of excessive vehicles.

MAJOR OBSTACLES ENCOUNTERED

Even though urban road pricing initiatives are designed to generate socially desired benefits, all of the international road pricing initiatives examined for this study have faced some sort of opposition because at least one group perceived that their members would be made worse off because of the road pricing scheme. Failure to adequately address the concerns of such groups has impeded the implementation of a number of urban road pricing schemes, especially when the voices of opponents were louder than those of supporters. Therefore sponsors of urban road pricing initiatives should continuously evaluate and respond to the issues and obstacles that confront the project as it moves from planning to implementation to refinement.

While reviewing the experiences of several international urban road pricing initiatives that failed, it is apparent that the obstacles leading to failure are often similar. This chapter discusses the major obstacles that international urban road pricing initiatives encountered during the planning phase relating to public acceptance, equity, politics, economics, technology, and the design of the pricing scheme. Specific examples of how these issues contributed to the failure of urban congestion pricing initiatives are also presented as cameos so others may learn from these experiences.

Public Acceptance

Public acceptance is an essential ingredient for successful urban road pricing initiatives because without public buy-in it is difficult to gather the necessary political support to implement the road pricing scheme. In general, people do not like paying for public goods such as roads, especially when they have been using them without direct user charges. To make people more accepting of road pricing charges, the project sponsors should properly educate the public about the need for the proposed road pricing scheme and how they will benefit from it. If the public does not see a need for the road pricing initiative or does not think that they will benefit from it, the urban road pricing initiative will be difficult to implement. This is similar to the resistance expressed by the public in the U.S. to suggestions to place tolls in existing non-tolled highways, an important factor when considering the creation of cordon areas or rings.

Research studies and real world experience from abroad demonstrate that public acceptance of urban road pricing initiatives is based on many factors, and these factors vary in importance depending on the land use, demographic, and transportation characteristics of the region where road pricing is being considered. Research reveals that the most important factors influencing public acceptance of urban road pricing include:

- **Perception of the congestion problem.** People often view themselves as victims of congestion rather than part of the cause. (Eliasson and Lundberg, 2002) Until the public understands how congestion works and how the proposed urban road pricing scheme will alleviate congestion and reduce travel times, they likely will not view paying to drive on a road they currently drive for free as an acceptable solution.
- **Equity or fairness.** Road pricing is often perceived to only benefit the wealthy, or the people who can most afford to pay the charge without changing their travel patterns. Everyone else will have to adjust their current travel to a less optimal mode, destination, route, or time. The costs associated with the pricing schemes are readily apparent to users—the benefits frequently are not. Another dimension of equity is geographic proximity to the facility with road pricing. Those persons with relatively easy access to the facility are more likely to benefit from road pricing schemes that reduce congestion along their trip than persons whose total trip length includes only a small proportion of travel on the priced lanes. On the other hand, their out-of-pocket costs for tolls would be less.
- **Success of public outreach efforts.** If the public does not understand how an urban road pricing initiative will work or understand its benefits, they focus on the increased costs of the toll or user fee. The public outreach campaign should therefore explain:
 - The severity of the congestion problem and the costs associated with doing nothing,
 - What the road pricing initiative is and how it will work,
 - The goals of the initiative, and
 - How the revenue proceeds will be used.

Otherwise it will be difficult to find advocates who will support the urban road pricing initiative in a public referendum or re-elect politicians who support such a scheme.

- **Use of toll revenues.** The public typically wants to know how the road pricing revenues will be used and how this use will benefit them. For urban road pricing initiatives, this generally translates into the dedication of revenues to road and/or transit investments. If the perception is that the government can use toll revenues for non-transportation purposes, there is more likely to be public distrust of government and greater opposition to the urban road pricing initiative.

Netherlands Congestion Pricing Initiatives

The cities of the Randstad region of the Netherlands have considered the implementation of several congestion pricing initiatives since the mid 1990s. These initiatives included cordons and a per-kilometer charge to reduce congestion and raise revenues for transportation infrastructure. However, these congestion pricing initiatives failed to gather enough public support to be implemented. After the failure of these initiatives, surveys were conducted to measure the level of public acceptance for the congestion pricing proposals and to determine the major areas of public concern. The surveys revealed that there was little public support for road pricing due to the general distrust of government, a lack of understanding on how the tolling fees would be determined, and concerns about how the revenues would be used. (TRB, 2005) In addition, the surveys showed that the public did not perceive traffic volume as a major problem; rather, they viewed poor driving habits and the resulting incidents as the major cause of congestion. (TRB, 2005) By failing to demonstrate a need for the congestion pricing schemes as tools to manage congestion rather than as revenue generating mechanisms, the urban areas in the Netherlands have not been able to successfully implement a congestion pricing scheme.

Equity

The equity concerns surrounding urban road pricing initiatives are twofold: social and geographic. Social equity centers on how road pricing schemes impact different socio-economic groups in terms of costs and benefits. Geographic equity, on the other hand, relates to the location of road pricing schemes and how the boundaries impact different groups, particularly in cordon tolling schemes. For both social and geographic equity concerns, the primary issue is that road pricing does not impact all users equally.

Typically the social equity concerns involve the belief that urban road pricing costs and benefits favor the wealthy, or those who can afford to pay the congestion fee without altering their travel patterns. However, research has shown that the social equity arguments can be offered from the perspective of both the poor and the wealthy. (Eliasson, 2002) Some of the conflicting social equity arguments that have been made include the following:

- **The wealthy experience greater costs than the poor.** Since wealthy people are more likely to own and drive cars than the poor, they pay more under road pricing schemes.
- **The poor experience greater costs than the wealthy.** Since the poor have lower discretionary incomes than wealthy people, a disproportionate share of their income is required to pay road pricing fees. In addition, the poor are more likely to be subject to road pricing fees than the wealthy since they are less able to alter their driving times to avoid peak period travel since their work schedules are less flexible.

- **The wealthy experience greater benefits than the poor.** The wealthy have a higher value of time and are more willing to pay a road pricing fee if it reduces their travel time.
- **The poor experience greater benefits than the wealthy.** The poor are more likely to use public transit; and therefore, the poor are not as affected by the cost of road pricing. Additionally, the poor are more likely to experience benefits if the revenues from congestion pricing are used to improve transit services

Geographic equity relates to how the boundary of the urban road pricing scheme impacts the costs and benefits associated with groups located within and outside the pricing area, particularly with cordon tolling schemes. In small cordon areas, those living within the cordon zone are often perceived as paying the most because they are more likely to have to cross the cordon boundary for work or personal reasons. In large cordon areas, those living outside the cordon zone often experience the largest costs because they are more likely to have to cross the cordon boundary for work or personal reasons. (TRB, 2005)

Edinburgh, Scotland Congestion Pricing Initiative

In 2004, Scotland's capital city of Edinburgh proposed an urban congestion pricing scheme involving two cordons. The outer cordon was to be located just inside the city's bypass in an attempt to control the increasing congestion on the edges of the city; while the inner cordon was designed to protect the World Heritage Site located in the inner city. The Scottish Executive's guidance required that fair treatment be a high policy goal; however, the City Council included an exemption from the outer cordon charge for city residents who live outside the outer cordon. (Saunders, Cancun 2005) During the formal public review process the issue of geographic equity was raised and a recommendation was made to remove the outer cordon exemption for city residents living outside the outer cordon in order to achieve fair treatment. (Saunders, Cancun 2005) While the City Council agreed to many of the public's recommendations, they did not remove this particular exemption. The referendum went to the public in February 2005 with the exemption still included, and the referendum failed. While the inclusion of the exemption for outer city residents was not the only reason for the cordon pricing initiative's failure, it did exacerbate public concerns about the equity of the scheme.

Political Support

Political opposition to urban road pricing initiatives is closely linked to the public acceptance and equity concerns discussed above. Most urban road pricing schemes abroad require the passage of legislation or public referendums in order to be implemented. Without public acceptance, few politicians or political groups are willing to risk their political careers by supporting a controversial road pricing scheme the public opposes.

Urban road pricing schemes are politically difficult to implement because inevitably some people believe they will be made worse off as a result of the scheme. (Small and Gomez-Ibanez, 1998) When urban road pricing schemes are implemented, some people may have to select a less optimal travel route, time, or mode—or face increased travel costs. If opposition groups are vocal and well organized and support groups are less organized or unable to address their concerns, political support will be limited and may eventually evaporate.

An additional political issue associated with urban road pricing initiatives may be the public's distrust of the sponsoring government agency. The public frequently is skeptical about the agency's intentions for the use of road pricing revenues and is hesitant to give the agency access to a new revenue source. (Eliasson and Lundberg, 2002) Despite successes in reducing congestion, urban road pricing schemes frequently are viewed as solely revenue generating mechanisms rather than congestion management tools. A further concern is that the road pricing revenues generated will be an incentive for the state or federal government to reduce revenues allocated to the city or region, since the region is generating additional road program revenues.

Netherlands Distance-Based Pricing Initiative

The Netherlands proposed that distance-based user fees replace a portion of the excise taxes levied on vehicles. The goal of this pricing scheme was to shift the costs from individuals owning a car to drivers using the car. Initially distance-based pricing schemes could not easily vary the fee by time of day, but the advent of newer technology allows differentiation to be added at a later date. In the 2002 election, a new political majority that did not approve of the distance-based pricing scheme was elected. The policy of the new political majority was that the distance-based pricing scheme could not be introduced until better travel alternatives (both road and transit) were made available. As a result, the distance-based pricing initiative was deferred. (Eliasson and Lundberg, 2002)

Economic Consequences

The economic impacts of urban road pricing include the creation, loss, and/or relocation of jobs and incomes. Critics often argue that urban road pricing will force many businesses, particularly retail, to leave city centers for more suburban areas because people will not want to pay the road pricing charges associated with center city travel. As the costs of auto travel increase, people will look to reduce their auto travel between work, home, and other recreational destinations such as shopping. This reduction in auto travel could impact business locations through the movement of businesses to more suburban locations or the movement of people to more urban locations, both of which may be unintended consequences of the initiative.

The nature and extent of economic impacts resulting from road pricing are highly dependent on the structure of the scheme, the city, and its surrounding areas. If the road pricing area is small, businesses could be encouraged to move outside this area; however, if the road pricing area is large, it is less likely that businesses will look to move as people will be more likely to have to enter or travel within the road pricing area. Additionally, the availability of public transportation or time differentiated charges impacts how people and businesses respond to the urban pricing. With time differentiated charges and an extensive transit network, it is likely that the number of trips to the road pricing area may not change, only the timing or mode of travel.

Studies have been performed to measure the size of the potential economic impacts of urban road pricing schemes. These studies generally agree that the relocation effects of urban road pricing schemes are relatively small. A simulation study performed by Eliasson and Mattson in 2001 estimated that congestion pricing would result in redistribution of approximately two percent of households and a slightly higher redistribution for businesses in a typical European city. (Eliasson and Lundberg, 2002) However, more research in this area is needed to determine the relocation impacts of urban road pricing schemes after they have been implemented and operated

over reasonably long period of time to allow the actual economic effects to occur and be measured instead of merely simulated. These studies will need to consider other contributing factors which may have an even more significant impact on housing and business locations, such as housing costs, land costs, fuel costs, and vehicle tax rates.

Technology

When urban road pricing schemes were first introduced, the primary technology concerns were the delays associated with paying the charges and enforcing collection. Now that technology is available to efficiently collect and enforce differentiating urban pricing schemes electronically, the largest technology concerns today involve making the public and politicians comfortable with the electronic toll collection (ETC) system. (TRB, 2005) These technology-related concerns include:

- **Implementation costs.** Politicians' initial concerns regarding road pricing initiatives focus on the capital costs associated with ETC systems and whether these costs will be sufficiently offset by lower operating costs. Users, on the other hand, do not want to pay for the on-board vehicle units (transponders) and often argue that the costs associated with implementing the ETC systems will be greater than the revenues or benefits received.
- **Reliability.** Users worry that the equipment will fail and result in lost charges, incorrect fines, or cheating. Additionally, users believe that the person driving the car should be responsible for the charge, not the owner. Currently, on-board transponders make the owner responsible for the toll. Portable transponders can help address this concern. As the technology continues to advance and is used successfully in other cities, these concerns are diminishing.
- **Privacy.** One of the major concerns with ETC systems is the potential for loss of personal privacy. People are concerned that the administering agency could track their movements and potentially provide or sell their travel data to other agencies or organizations. Privacy concerns have been great enough to prevent the implementation of urban pricing schemes in several large cities. Increasingly sponsoring agencies are realizing that privacy concerns should be proactively addressed to gain and sustain public and political support for proposed road pricing schemes.

Hong Kong Congestion Pricing Initiative

In the 1980s, the City of Hong Kong considered the introduction of an electronic congestion pricing scheme. The initiative studied between 1983 and 1985 included three zones and differentiated charges by time of the day. The public response was unfavorable because there were significant privacy concerns about the ability of the government to track users' movements and identities. Privacy was a major concern to Hong Kong's residents due to the planned reunification with China and the potential access of the Chinese government to this travel data. As a result, public opinion of the congestion pricing scheme was very negative and the initiative failed. (Eliasson and Lundberg, 2002)

Design of Road Pricing Initiative

The design of urban road pricing schemes is critical to their successful implementation and should adequately reflect all goals of the initiative – such as managing congestion, improving the environment, encouraging transit usage, and raising revenue. If the proposed scheme does not clearly demonstrate how the initiative will address its goals and what performance improvements will result, the scheme likely will fail to obtain the political and public support necessary for successful implementation.

The implementation and design of an urban road pricing scheme may result in one or more groups being made worse off in terms of increased travel costs or being forced to choose a less optimal travel mode, time, route, or destination when compared to the status quo. Inevitably someone will be worse off as a result of congestion pricing or there would be no reason to implement it since the concept is to change road usage patterns. For negatively-impacted groups, the only effective communication strategy is to help them to understand why the project is necessary. If these impacts are not addressed, public and political opposition is likely to grow and threaten the viability of the scheme. Efforts should be undertaken to mitigate these impacts and demonstrate that such impacts will be even worse if nothing is done.

Fairness concerns should be anticipated and addressed through the design of road pricing schemes where this is a major issue. Potential mitigation measures include:

- Providing exemptions to particularly impacted groups;
- Varying pricing levels by time of day;
- Improving competing services (e.g., public transit);
- Explaining specifically how the revenues generated will be used; and
- Simplifying the charging scheme, method of collection, and method of enforcement.

Care should be taken to ensure that such refinements do not make the pricing scheme overly complex and jeopardize the initiative. Highly complex urban road pricing schemes are harder to explain to the public and often experience greater difficulty in gathering the public support needed for successful implementation.

Cambridge, England Congestion Pricing Initiative

In the early 1990s, Cambridge, England considered a congestion pricing scheme that included a cordon toll ring with a fee that varied in real time according to the level of congestion experienced within the cordon toll ring. The idea behind the structure was to charge a toll that best matched the external costs vehicles impose on others. The scheme's proposed technology included an on-board unit connected to a clock and the vehicle's odometer that would generate a charge based on the number of kilometers traveled below free-flow speed or under stop-and-go driving conditions. The proposal was unable to gain the public and political support necessary due to the unpredictability and complex nature of the charges. (Small and Gomez-Ibanez, 1998)

KEY STRATEGIES FOR SUCCESS

The experiences of international urban road pricing initiatives have revealed several key strategies to address the obstacles discussed in the previous section. These strategies are based on the lessons learned from both successful and unsuccessful urban road pricing initiatives. The key strategies identified and discussed in this section include the following:

- Determine what congestion problems the road pricing scheme is intended to address that underlay the reasons for implementing the project;
- Identify how the project will address these congestion problems as well as the estimated consequences of inaction;
- Introduce the road pricing scheme as part of a larger congestion relief initiative that includes both capital and operational elements;
- Identify both the benefits and costs of the road pricing scheme relative to the status quo;
- Implement a continuous public outreach and communication program;
- Anticipate through public and business outreach the major challenges that will face the project and their severity throughout the planning process; and
- Demonstrate how equity and privacy concerns will be addressed and mitigated.

These implementation strategies are discussed below.

Identify Congestion Problems and Their Severity

The first step in overcoming the obstacles facing urban road pricing initiatives is to clearly and publicly identify the problems that the road pricing initiative is attempting to solve. For urban areas considering road pricing initiatives, congestion is typically the primary problem; however, the initiatives also may be addressing funding needs, environmental degradation, safety, or a combination of these issues. It should be clearly explained to the public what the primary goals of the road pricing initiative are. Otherwise, the initiative may be misconstrued to be solely a revenue generating mechanism for the sponsoring agency.

Once the issues have been identified, the public should understand that the problems are severe enough to warrant the urban road pricing scheme. In other words, in the eyes of the public, the road pricing initiative should be seen as the least burdensome and most cost-effective way to address the failure or insufficiency of other congestion relief efforts and/or the lack of funding for needed road and transit infrastructure. The general public should understand that the city cannot build itself out of the congestion problem solely through road infrastructure improvements. If the public believes that other measures could have the same or greater impacts on congestion levels, it will be difficult to implement a road pricing scheme. The current problems created by congestion need to be shown as greater than those that may result from the proposed congestion pricing project.

Identify How the Urban Road Pricing Scheme will Achieve its Goals

The next step is to clearly identify how the urban road pricing scheme will reduce congestion in the urban area, generate revenue, and/or reduce environmental problems. It is essential that the public understand how the road pricing initiative will work to reduce these problems to gain public support. The potential results of a proposed road pricing scheme may be demonstrated in the public outreach campaign by presenting analysis results that show the traffic, revenue, and environmental impacts of the initiative; and by describing how similar strategies have been successfully deployed in other cities. Lessons learned from other projects include simplifying both the rate structure and the collection and enforcement processes.

Since urban road pricing initiatives generally represent a relatively new approach to congestion management for cities, there also are institutional issues to address with the public. Rarely are the required legislation and/or referenda in place to implement the initiative without further approval from some governing body or the public. While addressing how the road pricing scheme will help solve the congestion problem, it is also essential to map out the required steps for successful implementation. The public should understand not only how the road pricing initiative will work but also how it will be implemented, the major hurdles that must be cleared, and how long implementation will take. This will either solidify or diminish political support for the project, depending on how these issues and their resolution are handled – an essential ingredient for project success.

Introduce Urban Road Pricing as Part of a Larger Congestion Relief Proposal

The introduction of the urban road pricing initiative as part of a larger package of congestion relief measures is advised because it demonstrates to the public an understanding that road pricing alone will not solve urban congestion problems. The revenues generated by the road pricing initiative should be used to fund a package of congestion relief measures, which could include:

- Road and transit infrastructure;
- Transit service enhancement;
- Intelligent transportation systems (ITS); and
- Bicycle/pedestrian projects.

People should feel that they are not losing too much by paying road charges or altering their travel time, route, destination, or mode.

Without a strong political champion, the initiative may struggle to gain the support of the public and other political leaders. A political champion provides an important opportunity for someone who is respected in the community to openly discuss the road pricing initiative and to emphasize the benefits that it will provide not only to auto and truck users but to non-users as well. (TRB, 2005) A larger package of congestion relief improvements makes it more attractive for a politician to champion an urban road pricing initiative because it provides a greater opportunity to demonstrate to the public how they will benefit from the initiative. By introducing the road pricing initiative as part of a larger package of improvements, the political champion will be able to demonstrate a strong commitment to solving the congestion problem as well as a pledge to generate benefits for as many groups of stakeholders as possible.

Include Dialogue as Part of a Continuous Public Outreach and Communication Program

The strategy that is fundamental to all of the strategies discussed above is a continuous and multi-faceted public outreach and communication program that clearly explains:

- The problems and how the road pricing scheme will solve these problems;
- Other measures being taking to deal with the problems;
- The benefits associated with the road pricing initiative;
- How equity concerns are addressed by the initiative; and
- The projected performance results for all impacted groups.

The results of the road pricing scheme should be tracked relative to pre-initiative baseline conditions and projected performance targets and reported to stakeholders on a regular basis.

While the outreach program should be informative, it should not be perceived in such a way that public feedback is not desired or considered. Discussion with these groups will give project sponsors and political champions the opportunity to openly discuss the issues and benefits with interested parties and gain insight into their concerns as well as their ideas for changes or improvements. By being open to discussion, directly addressing public concerns, and being willing to compromise, the road pricing initiative's sponsors and political champion will be better able to gain the trust and support of the public—a key ingredient for successful implementation.

Efforts should be undertaken to maintain on-going dialogue with the public, businesses, and other stakeholders impacted by the road pricing scheme following implementation to gauge reactions and results, without being intrusive or a nuisance.

Identify the Benefits and Costs for All Groups

In order to gain public acceptance, public stakeholder groups should understand exactly how they will benefit from the urban road pricing initiative. The public is quick to recognize how they will be negatively impacted by road pricing since it involves a potential direct impact on their out-of-pocket costs. However, they often do not understand the full extent of the benefits for themselves or the region as a whole. Therefore, project sponsors and political champions should identify the major stakeholder groups and their interests, determine how they will be affected or perceive to be affected, clearly explain the benefits of the road pricing initiative for both users and non-users, and include measures into the scheme that will alleviate their concerns.

This strategy is closely tied to introducing the urban road pricing initiative as part of a larger package of congestion relief measures because the benefits can be demonstrated through the ability of the road pricing initiative to fund the other multi-modal projects needed by the city. Some groups may not benefit directly from reduced congestion on the roads—but they may benefit greatly from improved or expanded transit services. If the public feels that they are not losing too much as a result of the road pricing initiative but the region is benefiting, they are more likely to off be supportive. For example, if the affected group can not be exempted from the congestion pricing charges, there may be other benefits added for that group, such as improving public transit services or creating dedicated bicycle lanes.

Another approach to demonstrate an urban road pricing initiative's benefits to the public is to discuss the consequences associated with doing nothing. If no action is taken to manage

congestion, the city's congestion levels may continue to worsen, and the social costs associated with travel times, pollution, and accidents may continue to increase.

Many cities have reached the point where the further expansion of road capacity is limited and the only solution to improving congestion is to moderate travel demand and to encourage greater use of public transit. However, road and transit service investments are often required to encourage this shift in travel mode or route, and the money available from existing revenues for these improvements is often limited. By implementing road pricing in some form, scarce resources (i.e., roadway infrastructure) can be rationed while new revenues are generated to advance the construction of needed road and transit improvements.

Address Equity and Privacy Concerns

In order to adequately address the equity and privacy concerns associated with the introduction of urban road pricing initiatives, the stakeholder groups most sensitive to these issues should be identified early in the planning process. By identifying impacted groups, social equity, geographic equity, and privacy concerns can be better understood and addressed by the project sponsors. (TRB, 2005)

Once the specific equity and privacy concerns are known, they can be addressed through the following measures:

- **Identify how road pricing revenues will be used.** The use of revenues is an important component to addressing both social and geographic equity concerns. While the charges associated with the road pricing initiative may cost one income or geographic group more than others, how the revenues are used can be an important method for ensuring that these groups receive proportional benefits. For example, the revenues generated by road pricing initiatives can be used to improve transit services, which results in better transit alternatives for both existing transit users as well as auto users who shift to transit as a result of the road pricing initiative. The revenues may also be distributed in such a manner that the geographic regions paying a larger portion of the charges receive a proportional share of the proceeds through increased road and transit improvement funding. There should be a plan for ensuring that the revenues are indeed used for the purpose originally described. Also, since it is difficult to precisely predict the revenue that might be generated for many reasons, care must be taken not to over promise revenue results.
- **Provide appropriate exemptions and discounts.** Including exemptions from the road pricing charge for certain groups also may counter some of the equity concerns associated with the urban road pricing initiatives. Typically these exemptions or discounts include transit vehicles, emergency vehicles, taxis, motorcycles, hybrid vehicles, carpool vehicles, or reduced charges during off-peak periods. Several initiatives have attempted without success to include more extensive exemptions to appease local residents or businesses, such as city residents residing outside the outer cordon zone (Edinburgh, Scotland) or commercial trucks (Singapore, later repealed). These adjustments need to be tracked in terms of their impacts on total revenue collected and the ability to deliver on the infrastructure or service improvements promised.

If equity issues are known and understood, appropriate exemptions or discounts may be implemented to offset some of the concerns. However, care should be taken to avoid overly complicated systems. Research has shown that too many exemptions or pricing

levels make pricing systems appear to be random, unfair, and difficult to use. (Eliasson and Lundberg, 2002) Satisfying one group may dissatisfy another. Perhaps focus groups might be used to determine sensitivity to various issues and alternative adjustments to address these issues among different interest groups.

- **Reduce other vehicle taxes.** Equity also may be addressed through reductions in other taxes, such as vehicle excise taxes or other vehicle ownership taxes. This allows the cost burden to be shifted from vehicle ownership to vehicle usage in congested areas or during peak hours, which may be perceived to be more equitable. (Eliasson and Lundberg, 2002) Vehicle ownership is not necessarily tied to increased social costs such as congestion, pollution, and accidents. However, vehicle usage is linked to these social costs, particularly in congested urban areas.
- **Mitigate Privacy Concerns.** The perceived threat to personal privacy implied by ETC systems that can track a patron's movements can be readily addressed by segregating travel data from owner information in the system's database. In this way, privacy concerns relating to the application of ETC systems in road pricing initiatives can be mitigated. Unless this issue is addressed early in the project development process, it can become a fatal flaw in the design and undermine the political and public support for the road pricing scheme.

3. CASE STUDIES

This chapter describes the specific characteristics and issues encountered for a number of successful international urban road pricing initiatives. These case studies summarize real world experiences with implementation issues, overcoming these issues, and revenue and traffic impacts. The format of the case studies provides the general background, operational issues, legal issues, obstacles and strategies, and revenue and traffic impacts for each initiative. Case studies are included for each of the urban road pricing types used abroad, including:

- Cordon tolling;
- Value pricing; and
- Distance-based pricing.

CORDON TOLLING

Cordon tolling charges a fee to enter or drive within a particular area, usually a city center. In certain instances such as Singapore, the toll is applied to any trip within the cordon area, even if the cordon border is not crossed. The first urban road pricing scheme implemented in the world was an area pricing scheme introduced in Singapore in 1975, and the most recent implementation occurred in Stockholm in early 2006. Singapore is discussed below. The Stockholm cordon tolling initiative is so recent insufficient results are available to develop a full case study.

Singapore

Background. Singapore introduced the first urban road pricing scheme in 1975 in an attempt to control traffic levels within the city. The initial manual scheme required that auto drivers purchase an area license for S\$3 (about \$1.85) to drive within the restricted area of the city during the morning peak period. This fee rose to S\$5 (about \$3) in 1980. In 1989, many of the exemptions to paying the fee were removed and travel restrictions were extended to the afternoon peak period. With many more vehicles included in the scheme over a longer period of time, the daily fee was reset to S\$3 (about \$1.85).

In 1994, the restrictions were further extended to charge drivers S\$2 (about \$1.25) per day to travel during the period between the morning and afternoon peaks. In 1995, the system was extended to certain expressways and local roads in an attempt to mitigate the adverse impacts experienced on local roads. By 1998, the system was fully automated with in-vehicle units, payment by smart card, and enforcement through cameras and license plate reading equipment. In 1998, the fee structure changed to a per trip charge of from S\$0.50 to S\$2.50 (about 31¢ to \$1.55), depending on the time of day.

In early 2006, weekday rates for autos range from S\$0.50 to S\$3.50 (about 31¢ to \$2.15), depending on the time of day and the highway or arterial used.

Operational Issues. The current system is designed to control congestion based on a desired travel speed on the designated roads and expressways. The current fees vary by type of vehicle, location, day of the week, and time of day. Every three months the fees are revised upward or downward based on whether the travel speeds are above or below the desired speed. The changes in fees are advertised through electronic signs at each collection point.

Over the years, the system has evolved as needed to maintain the desired level of traffic in the restricted area. Initially, there were exemptions for motorcycles, transit vehicles, trucks, cars with four or more passengers, and taxis. By 1989, exemptions for all vehicles except transit vehicles were eliminated. However, in 2001 the project sponsors introduced an environmental component to the scheme by charging a reduced fee for electric or hybrid cars.

Legal Issues. The legal issues have been limited for the Singapore area licensing and road pricing scheme because the city government is also the national government. Singapore has a highly centralized governmental authority, with significant control over individual and commercial mobility. The political environment in Singapore is stable, and the government has a long history of controlling auto ownership and usage through high vehicle registration taxes and a vehicle quota system that limits the number of new car purchases in a month. As a result, public opposition to the area pricing scheme was limited.

Obstacles and Strategies. The major obstacles faced by the Singapore road pricing scheme are keeping the system flexible enough to evolve as traffic conditions and technology change and providing sufficient alternatives for travel into and within the city. The scheme has undergone multiple revisions to limit the number of cars traveling in the city and to keep the traffic moving at desired speeds. Since the government's goal has been to reduce auto usage, it has used proceeds from the road pricing program to help fund the development of transit systems serving the city. These include the Mass Rapid Transit heavy rail system (opened in 1988) and a light rail network (introduced in 1999).

Revenue and Traffic Impacts. The traffic impacts of the Singapore road pricing scheme have been significant. After the pricing scheme was introduced in 1975, the share of commuters using carpools or buses increased from 41 percent to 62 percent, and the number of all vehicles entering the zone during restricted hours declined by 44 percent. However, afternoon traffic failed to experience any significant decreases until the afternoon restrictions were added in 1989. (Small and Gomez-Ibanez, 1998)

After the ETC system was introduced in 1998, the traffic volume on heavily congested roads decreased by 17 percent, and traffic in the central city declined by 10 to 15 percent. (TRB, 2005) The annual revenues collected by the ETC system are approximately S\$80 million (about \$ 49 million), which is less than the revenues collected under the earlier manual area licensing and road pricing schemes. This is due in part to the reduction in vehicles paying the cordon area fee caused by commuters switching from automobiles to the various public transportation service options now available. The operating costs of the electronic road pricing system are approximately S\$16 million (about \$10 million), or 20 percent of the annual revenues. (TRB, 2005)

London, United Kingdom

Background. London implemented a central area congestion pricing scheme in February 2003 that required the payment of a daily £5 (about \$9) fee to travel within central London between 7:00 am and 6:30 pm, Monday through Friday. The daily rate was increased to £8 (about \$14) per vehicle in July 2005. The fee is enforced through the use of cameras at entry points to the central city which record the license plate numbers of every vehicle entering the central city and match the license plate numbers to payments made. Payments can be either pre-paid or paid the day of travel in the cordon area via phone, mail, internet, retail outlets, or service stations. Failure to pay the toll results in a fine of £100 (about \$175), that is reduced to £50 (about \$88) if paid within 14 days, and increased to £175 (about \$306) if not paid within 28 days.

The Mayor of London has proposed to extend the cordon zone further west in February 2007 to capture more of the congested areas of London, including Kensington, Chelsea, and Westminster. This recommendation has been made despite receiving support from only 24 percent of those surveyed in the affected area. If accepted, this extension will increase the Central London cordon zone by over five square miles (for about a 70 percent increase in size). It is expected that traffic volumes in the extended cordon zone will be reduced by 15 to 22 percent, compared to 18 percent for the original cordon zone. Once the western extension is operational, the finish time for charging within the overall charging zone will be 6.00 pm, Monday to Friday (rather than 6.30pm as at present), with no charge on public holidays or between Christmas Day and New Year's Day. A further western extension of the cordon zone is currently in the preliminary planning stage. (Livingstone, 2005)

Operational Issues. The largest operational issues encountered were associated with the charge levied and the technology selected to administer and enforce the pricing scheme. Initially the daily charge was intended to be £5 (about \$9) for autos and £15 (about \$27) for trucks. However, freight industries opposed the charge because there were no viable alternatives for freight vehicles. While private auto users could switch to transit, freight vehicles with destinations in central London had no choice but to pay the fee. As a result, the daily charge for trucks was reduced to £5 (about \$9), but the request for exemption was denied. (Crane, Cancun 2005)

The technology selected to administer and enforce the congestion charging scheme is a video-based license plate recognition system. This system requires the installation of cameras at entry points and software to accurately read license plate numbers as they enter the zone at speed and link those license plate numbers to a payment. The major advantage of this system is that it did not require the installation of on-board vehicle units. It also addressed concerns about how to collect payment from motorists who are only occasional travelers into central London.

The primary disadvantage of the system is that it charges the same fee regardless of the amount of travel made by a vehicle in the city center on a given week day. Thus while the scheme discourages people from making their first trip in the cordon zone, it does not discourage further travel in the city center once the vehicle makes its first trip in the cordon zone. Another system drawback is the inability to catch more than 80 percent of the violators due to issues with the cameras or the license plate reading software. (Eliasson and Lundberg, 2002) While this reduces the revenue generation and congestion management potential of the scheme when compared to an electronic system with on-board units, it made implementation much easier.

Legal Issues. Over the last 40 years, London has considered various road pricing schemes to help reduce congestion in the city. However, until 2003, these efforts had failed due to concerns about equity and potential negative economic impacts to businesses within the pricing area. Due to these concerns, political groups lacked the desired acceptance level to push these initiatives into the implementation stage. However, in 1998, important legislation was passed that sparked renewed interest in congestion pricing. The incoming Labor Party provided local governments with the authority to implement congestion pricing schemes, as well as taxes on private parking, and to use the net revenues generated from these charges on local transportation projects. (TRB, 2005)

While seven other cities in the United Kingdom have expressed interest in congestion pricing schemes, so far only London has successfully implemented a pricing scheme. London benefited by having a strong, committed champion in Mayor Ken Livingstone. He made congestion pricing a part of his election campaign and remained strongly committed to the project by supporting and defending the pricing scheme in public. The mayor benefited from the 1998 legislation and from the fact that as Mayor of London he had the authority as a local government to implement the pricing scheme with limited assistance from the central government or approvals from other agencies. (Crane, Cancun 2005)

Obstacles and Strategies. With a general public consensus that something needed to be done to reduce congestion in central London, the largest obstacles that faced the congestion pricing scheme were:

- Informing the public on the details of how the scheme would work; and
- Gaining public support for this measure.

Even though the mayor had the power to implement the pricing scheme, as an elected official he still needed public acceptance in order to make the scheme successful. Public acceptance of the pricing scheme resulted from the mayor's commitment to reduce congestion in central London and to address equity concerns raised by the public during the implementation process. These concerns related to the potential for the scheme to primarily impact lower income or disabled persons, who would be less able to afford the daily fee.

The equity concerns associated with the London congestion pricing scheme were primarily addressed by the addition of programs to help reduce traffic and its impacts within central London. These included improving and expanding public transit services, retiming traffic signals to improve traffic flow, and repairing roadway infrastructure to improve capacity, using the revenues generated by the area pricing scheme. Through these additional programs, viable travel alternatives, particularly transit, were provided to users who were unwilling or unable to pay the daily congestion fee. In addition to providing transit service improvements, the London congestion pricing scheme provided discounts and exemptions for certain groups to help offset some of the equity concerns associated with the scheme. For instance, residents within the charging area were able to register for a 90 percent discount. Exemptions were also offered to buses, coaches, taxis, motorcycles, emergency vehicles, disabled people, and reduced emissions vehicles. (Crane, Cancun 2005)

Revenue and Traffic Impacts. The Central London congestion pricing scheme has been particularly in reducing congestion within the charging area and but less successful in generating revenues for transportation improvements. Studies have estimated that auto movements have

decreased by 60,000 vehicles daily since the congestion pricing scheme was implemented in February 2003. (TRB, 2005)

After the first year of the initiative, the amount of traffic entering the cordon zone declined by 18 percent while the extent of traffic jams (congestion) within the cordon zone declined by 30 percent. In comparison, there was a 30 percent rise in taxi use and a 20 percent increase in bus movements in the zone, both modes being exempt from paying the congestion charge. Buses experienced a decrease of 60 percent in the disruption to their schedules due to traffic congestion, with 29,000 additional riders in the morning peak period. With more buses and lower traffic volumes in central London, bus waiting times in the zone have decreased by 33 percent. While project sponsors claim that 50,000 fewer cars entered the City each day a year after project initiation, the drop in persons entering the center of London amounted to only 4,000 people. (Monaghan, 2004)

While measures of congestion suggest that traffic management goals were achieved, the amount of revenue generated by the Central London Congestion Charging Scheme has been below expectations. When the scheme was in the early planning stages, estimated annual gross revenue was as high as £200. When the scheme began in February 2003, it was expected to generate approximately £120 million (about \$212 million) in gross revenue in 2003-2004, and £130 million (about \$230 million) in subsequent years. Net revenues were estimated to be approximately £68 million (about \$120 million) for 2003-04, and were expected to increase to £80 to £100 million (about \$140-\$175 million) in future years. Despite a 60 percent increase in fees in July 2005, net revenues have continued to fall well below expectations. The primary reasons for net revenues underperforming expectations include the following:

- The decline in traffic volume in response to the scheme has been greater than expected;
- The system can only account for only 80 percent of the violators of the scheme; and
- The number of exempt and discounted vehicles has been higher than anticipated. (TRB, 2005)

Bergen, Norway

Norway has been a leader in the establishment of urban road pricing schemes involving cordon tolling (which they designate as “cordon toll rings”). The three case studies discussed below include the Norwegian cities of Bergen (population 213,000), Oslo (population 533,000), and Trondheim (population 150,000).

Background. In 1986, Bergen was the first Norwegian city to implement a cordon toll ring. At the time the toll ring was implemented, traffic levels were increasing and the amount of government funding for transportation projects was declining. In order to make the necessary road investments, a new funding source was needed. As a result, the toll ring was primarily intended to reduce congestion by raising the revenues necessary to construct new road infrastructure in the city.

The initial cordon toll ring included seven manual toll stations (later increased to nine). These toll stations included a subscribers’ lane that allowed those with pre-paid tickets and subscription permits to travel through the toll stations without stopping. The tolls were in place 6:00 am to 10:00 pm Monday through Friday for all vehicles, excluding transit buses. The initial charge per crossing was NOK (Norwegian Krone) 5 (about 75¢) for cars and NOK 10 (about \$1.50) for trucks. This charge was doubled in 2000, and further increased in 2004 to NOK 15 (about \$2.25)

for cars and NOK 30 (about \$4.50) for trucks. Pre-paid tickets and unlimited passes are also available for a discount.

Operational Issues. The initial cordon toll ring system included manned toll plazas and was enforced through cameras. The manual system was in place until February 2004 when it was replaced with an ETC system that uses on-board transponders and toll station cameras that record the front license plates of vehicles at speed up to 150 kilometers per hour (about 90 miles per hour). (Waersted, Cancun 2005) The electronic system, AutoPass, is owned by the Norwegian state and was developed in 1999 as the nationwide standard for toll collection. By February of 2004, AutoPass transponders could be used on any toll road or system in Norway.

The Bergen ETC system is the same system that has been in place in Oslo and Trondheim since 1991, with one important difference: the ETC system in Bergen is composed of fully automated free flow stations with no option for cash payment. The enforcement cameras record license plates of all vehicles and those vehicles without a transponder can pay the toll at a local gas station or the vehicle owners will receive a bill in the mail. As a result of the fully automated system, the operational costs for the Bergen cordon toll ring have declined by 40 to 50 percent, which provided more funding for transportation improvements. (Skulstad, 2005)

Legal Issues. Legislation passed in 1963 allows tolls on public roads provided that the revenues are used on specific and agreed upon investments. As a result, tolls on individual facilities, particularly bridges and tunnels, are common in Norway. The Director of the local office of the National Public Roads Administration in Bergen used this legislation to develop the idea of the toll ring as a means to fund needed local road infrastructure projects. The concept of the toll ring was presented to three of the local political parties at an informal meeting, and after negotiation an agreement was reached to support the implementation of the Bergen cordon toll ring. The negotiation was facilitated by the fact that congestion was viewed as a major problem for the city where there is a long tradition of tolls on both bridges and tunnels. As required by law, the Bergen City Council accepted the plan, and then central government approved the plan in June 1985. (Bekken and Osland, Cancun 2005)

The initial cordon toll ring was scheduled to end in 2001, fifteen years after it opened. However, a new transportation and city development program was developed and approved by the City Council, which extended the cordon toll ring program to fund these improvements. The new program of transportation projects includes both road and transit initiatives, including a city tram. In 2001, legislation was passed permitting the use of variable road pricing to influence travel demand by charging more when the roads are more congested. Despite this new capability, the extended program kept the same fixed price structure as the initial program rather than initiate variable pricing to help regulate traffic. This was due to the following reasons:

- Opposition of one member of the initial three-party coalition to any kind of variable road pricing;
- Lack of public support for expanding the program; and
- Desire of the City Council to gain public support for extending the program beyond its promised end date. (Bekkan and Osland, Cancun 2005)

Obstacles and Strategies. The major obstacle faced by the Bergen cordon toll ring programs has been balancing the legal capabilities of the city with public acceptance of road pricing, as discussed above. In 2001, the public was not comfortable with both extending the program and expanding it by adding the variable pricing element. As a result, the City Council decided to

focus on merely extending the program so as not to jeopardize the effort by adding the variable pricing element.

The Bergen cordon toll ring has been successful in generating revenues for road infrastructure, and there has been public support for using portions of program revenues to improve transit services in the city. However, the public is less comfortable with using road pricing to manage congestion.

Revenue and Traffic Impacts. The primary goal of the Bergen cordon toll ring was to address the growing traffic congestion problem in the city by raising revenues to expand the city's road infrastructure. As a result the traffic impacts of the toll ring have been modest with only a six to seven percent decrease in Bergen traffic levels. (TRB, 2005) The charges were designed to raise NOK 35 million (about \$5 million); however, revenues have been significantly higher, totaling NOK 70 million (about \$10 million) by 2000. The operating costs for the Bergen cordon toll ring under the manual collection system were approximately 20 percent of total revenues, due largely to the use of manned toll stations until the introduction of the ETC system in 2004. (Jeromoachou, Potter and Warren, Cancun 2005) With the ETC system, the collection costs have been reduced to approximately ten percent of total revenues. (TRB, 2005)

Oslo, Norway

Background. After the success of the Bergen cordon toll ring, Oslo introduced a cordon toll ring in 1990. It is the largest cordon toll ring in Norway and includes 19 tolling stations. The tolls are in place 24 hours a day, seven days a week. The charge for crossing the toll ring is NOK 12 (about \$1.80) for light vehicles and NOK 24 (about \$3.60) for heavy vehicles; however, a discounted rate of NOK 8 (about \$1.20) is offered to frequent users. The area encompassed by the Oslo cordon toll ring is significantly larger than the Bergen cordon toll ring and contains approximately 50 percent of the Oslo population. (Tretvik, 2003)

Operational Issues. The selection of the Oslo tolling stations was based on a compromise between sites that offered the highest revenues and a small number of collection stations located in areas where the land could be acquired for a reasonable price. (TRB, 2005) Eleven of the tolling stations are relatively small with one lane for electronic collection from subscribers (no stop required) and one manned lane; while, the remaining stations also include coin operated lanes to assist with the manual collection of tolls.

ETC lanes in place are for subscribers who have an on-board transponder that allows the vehicle to travel through toll stations without stopping. Transponders can be purchased with a pre-paid balance from the operating agency either for an unlimited number of trips in a defined time period or a specified number of trips over any time period. As the vehicle passes through the station, the subscription balance is automatically deducted. If the subscription balance is not sufficient for the toll, the license plate is photographed and a ticket is sent to the car owner. The vehicle owner also has the option of paying the toll for a small fee at local gas stations within three days, which will avoid a larger NOK 300 (about \$44) fee charged if the ticket is mailed to the owner. (Eliasson and Lundberg, 2002) The ETC system also has access to Swedish registrations so that tickets can be issued to Swedish residents as well as Norwegian.

Legal Issues. Initially the Oslo cordon toll ring was to be an ordinary toll road to fund the construction of tunnels below the city center that would ease congestion by providing an alternate route for through traffic. However, to get the cordon toll ring initiative passed, the City of Oslo and Akershus County entered into an agreement to use the revenues to fund other

transportation projects as well as the tunnels, including dedicating 20 percent of the revenues for transit projects. A second package of projects to be funded by the cordon toll ring was introduced in 2001 along with a NOK 2 (about 30¢) increase in the charge to cross the toll ring. In this second package, all of the net toll revenues are to be used for transit investments.

Obstacles and Strategies. Public opposition was a major obstacle for the Oslo cordon toll ring as opinion polls revealed that 70 percent of respondents were opposed to the toll ring when it was first proposed. (TRB, 2005) Despite this lack of initial public support, the Oslo cordon toll ring gathered enough political support to be implemented in February 1990. Some of the key reasons that have been identified for the passage of the Oslo cordon toll ring include:

- Effective public communication and outreach program;
- Severity of congestion in Oslo;
- Success of the Bergen cordon toll ring;
- Collection period limited to 15 years;
- Use of the revenues for both road and transit investments; and
- Agreement of major political parties to support the initiative. (TRB, 2005)

Revenue and Traffic Impacts. The primary goal of the Oslo cordon toll ring was to generate the revenues necessary to construct road and transit projects that would add capacity to relieve congestion in the city. As a result, the traffic impacts of the toll ring itself have been minimal, with only a three to four percent reduction in traffic. (TRB, 2005) There are approximately 250,000 daily crossings of the Oslo cordon toll ring that generate annual revenues of approximately NOK 1 billion (about \$148 million). (TRB, 2005) The annual operating costs account for approximately ten percent of these revenues, while the remainder is used to support road and transit investment. (TRB, 2005)

Trondheim, Norway

Background. The Trondheim cordon toll ring was implemented in October 1991 with 12 toll stations. The ETC system in place in Oslo was also used in Trondheim; however, only two of the 12 toll stations have manned lanes for manual payment, while the remaining stations offer coin toll collection machines. The toll is in effect at all times other than weekday nights after 6:00 pm and weekends. The toll for light vehicles is NOK 12, with a discounted rate of NOK 5 to NOK 7 (75¢ to \$1.00) for frequent users, while heavy vehicles pay NOK 24 (about \$1.75).

In 1998, the area within the toll ring was subdivided into zones so that residents living within the toll ring could share the fiscal responsibilities for congestion relief with their more suburban counterparts. This change was designed to improve equity and increase revenue by charging for crossing zone boundaries within the toll ring. The new scheme increased the number of toll stations to 22 and increased the toll rates for entering the ring by approximately NOK 1 (about 15¢). In 2003, five more toll stations were added.

Operational Issues. The initial toll rate schedule introduced by the Trondheim cordon toll ring in 1991 was more complex than the rate schedules for either Bergen or Oslo. The Trondheim cordon toll ring was able to approximate congestion pricing more than the Bergen and Oslo toll structures by offering discounts to ETC subscribers for off-peak travel and placing caps on charges per hour or per month. (Small and Gomez-Ibanez, 1998)

Approximately 30 percent of the Trondheim residents lived within the toll ring, and under the initial pricing structure these residents never paid the toll but received benefits from the road infrastructure investments made within the cordon toll ring area. In response to lower than anticipated revenues and equity concerns resulting from this disparity, the city instituted a new pricing structure in 1998 that added an additional toll for crossing zone boundaries within the toll ring. This created a combination cordon ring and zone pricing scheme. The toll rates for crossing the zonal boundaries within the toll ring were kept significantly lower than the tolls to enter the cordon ring. Proceeds from the additional zone-based tolls increased annual program revenues by approximately 50 percent. (Small and Gomez-Ibanez, 1998)

Legal Issues. Like other Norwegian cordon toll rings, the Trondheim cordon toll ring was introduced as a means to fund transportation infrastructure projects in the city at a faster rate than possible if only using state funds. The introduction of the cordon toll ring benefited significantly from the success of the Bergen and Oslo cordon toll rings because the city felt that it had to keep pace with the infrastructure improvements being made in other large cities in Norway. (Bekkan and Osland, Cancun 2005) As a result, the local office of the National Public Roads Administration and the major political parties worked together to support an infrastructure investment package that included road, transit, and bicycle/pedestrian projects to be funded in part by proceeds from the toll ring. When the package was assembled during the late 1980s, environmental concerns were a major issue. As a result, the toll ring included requirements that 20 percent of the revenues generated be dedicated to transit and safety investments. (Bekkan and Osland, Cancun 2005)

Obstacles and Strategies. Like other Norwegian cordon toll rings, initial public acceptance of the Trondheim cordon toll ring was very limited. Studies showed that positive public opinion towards the proposed cordon toll ring was only nine percent prior to fully developing the concept (Tretvik, 2003). As a result, the planning stage of the Trondheim cordon toll ring included extensive public outreach efforts to demonstrate why the toll ring was necessary and to specify how the revenues would be used. During these public outreach efforts there were opportunities for public feedback, and this feedback was reflected in the final toll rate structure which included the following accommodations for electronic subscribers:

- No more than one charge per hour;
- Limit on the total number of charges per month;
- Transponder provided at no cost;
- Discounted charge for off-peak travel; and
- Ability to make payments directly from bank accounts. (Waersted, Cancun 2005)

The Trondheim cordon toll ring is scheduled to expire in 2007. Efforts to extend the program beyond its promised expiration date appear in jeopardy since a large road project in the toll ring program recently failed to gain the support of the City Council. Without this promised road project, the likelihood of gathering political support for a new cordon toll ring is not likely, and there is even discussion of ending the current program early. (Waersted, Cancun 2005)

Revenue and Traffic Impacts. After the first year of operation, the Trondheim cordon toll ring resulted in a ten percent decline in inbound traffic and a seven percent increase in bus travel during toll hours. (TRB, 2005) The infrastructure investments funded by the toll ring have contributed to reduced congestion compared to before the toll ring. Annual revenues generated by the toll ring are approximately NOK 150 million (about \$22 million). (TRB, 2005) Ninety-

five percent of the toll revenues are collected by the ETC system, and as a result, the annual operating costs of the Trondheim cordon toll ring are about ten percent of total revenues, a rate comparable to the Oslo cordon toll ring. (TRB, 2005)

Stockholm, Sweden

The most recent cordon tolling program was introduced in Stockholm, Sweden on January 3, 2006 as a seven-month experiment set up by the national government. Like the London and Singapore initiatives, the Stockholm cordon tolling initiative relies on the improvement and expansion of competitive public transit services to promote public acceptance and address equity concerns. A public referendum will be held in September 2006 to determine if the initiative should be reinstated.

VALUE PRICING

Value pricing schemes utilize varying toll rates on tolled highways and crossing facilities to encourage a shift in travel from peak periods to less congested off-peak periods. In value pricing schemes, toll rates may vary by time of day, itinerary, emissions classification of the vehicle, or some combination of these. The case studies presented below include value pricing in place on Autoroute A1 in France and a value pricing experiment undertaken in Japan. These case studies only use value pricing to manage congestion; however, value pricing is frequently used in combination with other cordon or area pricing schemes as was demonstrated in the Singapore and Trondheim case studies.

Autoroute A1, Northern France

Background. Autoroute A1 is a 132-mile tolled expressway between Paris and Lille, located in northern France. It is operated by Sanef, one of the largest motorway concessionaires in Europe. Historically, Autoroute A1 experienced heavy traffic as cars returned to Paris on Sunday afternoons and evenings. In 1992 Sanef introduced a Sunday varying toll structure that charged 25 to 56 percent higher tolls for vehicles traveling between 4:30 pm and 8:30 pm to discourage travel during this period. To further encourage non-peak travel, toll rates were reduced by 25 to 56 percent for the period two hours before and after the peak travel period. Exhibit 2 shows the variable auto toll rates on the A-1 Expressway in 1992, in term of French Francs. In 1992, the normal toll for the longest trip from Paris to Lille to the north was 52 Francs (about \$10). Currently, the normal toll from Paris to Lille is €13.1 (about \$15.5).

Operational Issues. The primary operational issues for Autoroute A1 are the implementation and enforcement of different toll rates on Sundays, depending on the time of day. When the variable tolls were initially implemented, Sanef used a manual payment process that involved having patrons pick up a ticket when entering the facility and return the ticket with the required payment at a toll booth upon exiting the facility. In recent years, Sanef has begun to upgrade the toll collection equipment to include more automated toll booths and electronic collection. As a result, the new ETC system should have the capability to apply and enforce the variable toll structure of Autoroute A1 and maintain compatibility with other toll facilities operated by Sanef.

Legal Issues. France has over 50 years experience using toll roads to fund the construction, maintenance, and operation of road infrastructure. However, only more recently have the French begun to explore the use of variable tolls as a means to manage congestion on their toll roads and to recover the external costs associated with vehicle use (environmental, time delays, etc.).

Exhibit 2 Sample Sunday Auto Tolls - Southbound A-1 Expressway, France

	Shortest trip (Senelis – Paris)	Longest trip (Lille – Paris)
Normal Toll (In Francs) (Sundays before 2:30pm and after 11:30pm and all other days)	9	52
Peak Toll (In Francs) (Sundays 4:30-8:30pm)	14	65
Shoulder Toll (In Francs) (Sundays 2:30-4:30pm and 8:30-11:30pm)	4	39

Source: Gómez-Ibáñez and Small (1994).

Note: 1992 exchange rate is 1 Franc = US\$0.19

The French government supports variable tolls as long as they include certain provisions such as:

- Vehicles using the same facility pay the same tolls unless there is a significant difference in the situation on the road, such as level of congestion; and
- Variable tolls are essentially designed to reduce congestion, not to increase revenues (i.e. if toll rates increase during peak hours, the toll should decline during selected off-peak hours). (TRB, 2005)

Obstacles and Strategies. Due to the extent of public involvement and the well publicized goal of the variable tolls to not increase revenues, public acceptance was favorable. By offering a reduced toll rate for the periods immediately prior to and following the toll increase during the Sunday peak period, users of Autoroute A1 could easily avoid the increased toll and even had an opportunity to reduce their toll expense.

Revenue and Traffic Impacts. The variable tolls introduced on Autoroute A1 were designed to spread the large number of vehicles using the road during the Sunday afternoon and evening peak period to non-peak periods, not to increase revenues. As a result, the most significant impacts have been on the timing of travel due to shifting of traffic from the peak periods when tolls are increased to the shoulder periods when tolls are reduced. While total Sunday traffic increased by 1.3 percent after the variable toll was implemented, there was a decrease of four to eight percent during the Sunday afternoon and evening peak period and an increase of close to seven percent during the reduced toll periods. (Gomez-Ibanez and Small, 1994 and Small and Gomez-Ibanez, 1998) More recent data from the Sanef 2004 Annual Report indicates that the variable tolls have impacted the travel times of more than 12 percent of the auto traffic during the Sunday afternoon and evening peak period on Autoroute A1.

Japan

Background. Since the 1950s, road construction in Japan has been significantly accelerated through toll financing. Indeed, almost all of the intercity highways and some fringe urban highways in Japan are tolled, most of which is part of the 5,109-mile toll system of the Japan Highway Public Corporation (JHPC or Nihon Doro Kodan). The JHPC toll system is the largest in the world, accounting for almost five million transactions per day and \$20 billion in annual

revenues. (Japan, 2004) In addition, there are three other publicly-owned toll authorities in Japan operating additional toll highways in Tokyo and the Hanshin region and bridges linking Honshu to Shikoku. (Samuel, 2005)

Toll rates in Japan are set to recover the full costs of facility construction, operation, and maintenance. Early toll highways in Japan were very profitable. However, since 1972, less profitable highways have been allowed to be added to the system that require cross-subsidization by the more profitable toll highways. This has placed a financial strain on the public toll authorities, such as JHPC, leading to high levels of borrowing to finance less cost beneficial roads and bridges.

With the economic slowdown and increased efforts by the trucking industry to control costs in the late 1990s, there was a significant diversion of traffic from toll roads in Japan to non-tolled alternative routes. As a result, the more expensive toll roads became underutilized while the non-tolled local roads became significantly more congested. This exacerbated the financial challenges facing the toll authorities in Japan.

In 2003 the Japanese toll authorities began experimenting with offering discounts of up to 50 percent for travel during off-peak periods and for long distance travel in order to shift traffic from congested non-tolled roads to less congested parallel toll roads. In the Japanese situation, variable pricing was used to better balance traffic on competing roadway systems by encouraging travelers to shift from one type of facility (non-tolled roads) to another type of facility (tolled roads), instead of merely shifting travel demand on the same facility from peak to off-peak periods.

Operational Issues. Currently, ETC users account for only 11 percent of traffic volume on the tolled roads in Japan. (TRB, 2005) While there are multiple public toll road operators in Japan, the ETC systems they use are compatible. These systems use on-board vehicle units (transponders) with an integrated circuit card.

The success of the move to variable pricing on Japan's tolled highways will in part depend on the extent to which toll road operators are able to convert their users to electronic toll collection. More widespread patron use of ETC would facilitate the implementation of variable tolls to mitigate congestion on Japan's roadways. Using ETC would enable drivers to quickly pay the current toll without having to fumble for the correct cash to pay the toll.

Legal Issues. The use of auto and fuel tax revenues for road construction and maintenance was not sufficient to fund road infrastructure needs in Japan. As a result, the government passed a law in the 1950s that allowed toll roads to be constructed for national expressways and highways, regional roads, and municipal roads. The guidelines for the toll rates required that they recover the capital, operating, and maintenance expenses for the collection period and that they are fair.

Due to the lack of toll road utilization and the higher levels of congestion on non-tolled roads, the Council for Infrastructure recommended in 2002 that more flexible tolling on toll roads be implemented. As a result, in 2003, the Road Bureau of the Ministry of Land, Infrastructure, and Transport introduced several flexible tolling demonstration projects. Based on the level of success of these demonstration projects, the use of variable tolls may be extended on the Japanese toll road system.

Obstacles and Strategies. The major obstacle to implementing variable tolls in Japan is the potential loss of revenues by the public toll road operators. The tolls are set at a level to recoup

the costs associated with the road, and if the tolls are reduced, there is the potential that the toll revenues will not be sufficient to recover these costs. If the revenues are not sufficient, it will be necessary to determine whether the public benefits from the variable tolls (reduced congestion, noise, and pollution) are greater than the loss in revenue.

Revenue and Traffic Impacts. The variable pricing experiment in Japan demonstrated that travel demand on roads with traffic volumes exceeding 1,000 vehicles per day would increase by a range of 0.4 percent to 1.0 percent for each percentage decrease in tolls. (Fukasawa and Muto, Cancun 2005) These results suggested that a decline in toll rates would likely result in a loss of total revenue. However, there were several examples where variable tolls caused a large enough increase in traffic to offset most, if not all of the revenues lost due decreased toll rates. In Aganogawa, a 50 percent reduction in tolls increased average traffic volumes 173 percent for weekends and 195 percent for holidays. (Fukasawa and Muto, Cancun 2005)

Another consideration was the potential for social benefits to outweigh the loss in toll revenues. In Hitachi, a 50 percent discount in tolls resulted in a travel time savings of ¥15 million (about \$125,000) per day, compared to a toll revenue loss of ¥600,000 (about \$ 5,000) per day.

DISTANCE-BASED PRICING

Distance-based road pricing schemes impose fees based on the number of miles or kilometers traveled in a designated area in an attempt to discourage the use of vehicles. Currently, most distance-based road pricing schemes used overseas are imposed on interurban heavy vehicle traffic. These include systems in Austria, Germany, and Switzerland. However, there have been discussions about applying distance-based pricing schemes to a broader spectrum of road users in these countries (as well as England), including smaller trucks and cars in urban as well as rural areas. (TRB, 2005)

While these road pricing programs are intended to manage interurban heavy vehicle traffic, a major reason for their implementation has been to recover vehicle user fees from trucks not registered in the host nation. With the fairly recent establishment of the European Union and the dropping of traditional trade barriers between member nations, the extent of cross-border trade and hence truck traffic has increased significantly. Distance-based electronic tolling of interurban truck travel on major highways is seen as a way to better control the volume of international freight moving on European highways while capturing user fees from all heavy vehicles, regardless of country of origin or destination, to support the development and upkeep of these highways.

The case studies discussed below include distance-based heavy vehicle fees in place in Switzerland and Germany. Many of the issues discussed in these case studies may be applicable to distance-based road pricing schemes applied to all traffic in urban areas.

Switzerland

Background. Switzerland has a higher share of heavy vehicle traffic than most European counties due to its central location and roadway crossings through the Alps. In 2003, 19 percent of all vehicles crossing the Alps occurred in Switzerland, while 66 percent of all trucks crossing the Alps used its roadways. (Stewart-Ladewig, Cancun 2005) The extent of heavy vehicle traffic on Swiss roadways generates significant negative impacts on the condition of the roads, the environment, and the quality of life for the people living near these roadways. As a result, in 2001, the distance-based Swiss Heavy Vehicle Fee (LSVA) was introduced for heavy vehicles of

3.5 tons or more traveling on all Swiss roadways. The current fee for a vehicle with a maximum weight of 40 tons ranges from .0215 to 0.288 Swiss Francs (about 2¢ to 22¢) per ton-kilometer, depending on the emissions class. (BAV – Bundesamt für Verkehr, 2005)

Operational Issues. The Swiss Customs Administration is responsible for the implementation of the heavy vehicle fee collection system and its continued operation. The fee is based on the kilometers traveled on Swiss roads, the maximum allowable weight of the vehicle, and the emissions category of the vehicle. The ETC system, which is mandatory for all Swiss heavy vehicles, includes an on-board unit that tracks the mileage on Swiss roads through the tachograph (which measures speed, distance traveled, stops, and time spent idling), a GPS component, and a movement signal that ensures the tachograph is not altered. Beginning in 2004, the Swiss on-board unit is compatible with the Austrian heavy vehicle fee ETC system. Additionally, a manual payment option is available to foreign heavy vehicles who do not wish to have the on-board unit installed. The manual system requires the heavy vehicle to stop at the Swiss border to receive a chip card and a manual inspection of the tachometer. Upon leaving Switzerland, the heavy vehicle must stop again to calculate and pay the fee.

Legal Issues. The legislative approval to initiate a distance-based heavy vehicle fee was passed by the Swiss federal assembly and the member states comprising the Swiss confederation in 1994. However, it was not until 1998 that the legislation to implement the distance-based fee was accepted by a public referendum. To gain public support for the referendum, it included a provision requiring that two-thirds of the revenues generated be dedicated to fund major rail infrastructure projects and the remaining third dedicated to the cantons for road infrastructure projects. Based on the outcome of the public referendum, the goals of the heavy vehicle distance-based fee were expanded to include the following:

- Pay for additional rail and road infrastructure;
- Pass some of the additional costs of road maintenance associated with heavy vehicle traffic back to the trucks; and
- Encourage a shift in freight traffic from roadways to rail, particularly for through traffic.

Obstacles and Strategies. The largest obstacles that confronted the Swiss heavy vehicle distance-based fee were obtaining acceptance from the trucking industry and the public. In order to gain the acceptance of the trucking industry, the Swiss heavy vehicle fee included an increase in the allowable vehicle weight from 28 tons to 34 tons. The weight restriction was further increased from 34 tons to 40 tons in 2005 along with the introduction of another fee increase. In addition, the heavy vehicle fee gained public acceptance by requiring the allocation of two-thirds of the revenues generated to rail infrastructure investments, including two new tunnels through the Alps. (Rapp and Balmer, 2003) This requirement demonstrated to the public the government's desire to shift more of Switzerland's through freight traffic from roadways to rail.

Revenue and Traffic Impacts. Until the distance-based heavy vehicle fee was introduced in 2001, freight traveling on Swiss roads was increasing by approximately seven percent per year, and this growth had been expected to continue. (Rapp and Balmer, 2003) Following the introduction of the heavy vehicle fee, truck traffic declined by approximately five percent on Swiss roadways in 200. (Rapp and Balmer, 2003) In addition, the fee led to reductions in heavy vehicle emissions as the trucking industry turned to less polluting vehicles to take advantage of lower fees for vehicles with lower emissions. (Stewart-Ladewig, Cancun 2005)

The revenues generated by the heavy vehicle fee were approximately 800 million Swiss Francs (about \$610 million) in 2002. (Stewart-Ladewig, Cancun 2005) Cumulative program revenues are expected to reach 16 billion Swiss Francs (about \$12 billion) by 2020. (BAV, 2005) The collection costs associated with the fee are estimated to be about five to seven percent of the revenues collected. (Rapp and Balmer, 2003)

Germany

Background. The distance-based German heavy goods vehicle fee, called the LKW Maut, was scheduled to begin in 2003. However, after several delays due to technical difficulties, the fee was implemented in January 2005 on all foreign and domestic trucks weighing 12 tons or more. The fee structure ranges from 10 to 17 eurocents (about 12¢ to 20¢) per kilometer, depending on the emissions category and number of axles of the vehicle. Both electronic and manual collection systems are available.

Operational Issues. The Federal Office for Goods Transport supervises the heavy goods vehicle fee operations, while a private consortium, Toll Collect, built and operates the system. The unique ETC system uses an on-board unit that contains a GPS receiver, digital map, and a mobile phone that provides communication with the payment center. The unit recognizes when the vehicle is traveling on a road that requires payment and transmits the relevant data to the payment center. The ETC system is not currently compatible with heavy vehicle collection systems used by other European countries. A manual collection system is also available that requires registration of the vehicle and intended route prior to the trip.

Legal Issues. In 1999 the German government decided to move forward with the implementation of a distance-based fee for heavy goods vehicles traveling on federal motorways. The distance-based fee was designed to:

- Recover the costs associated with heavy vehicles (wear on roads, pollution, noise, and safety), particularly from foreign registered trucks merely passing through Germany;
- Improve the competitiveness of the German trucking industry by imposing a fair price on those trucks registered in other countries not previously charged for using German highways.
- Provide financing for transportation infrastructure; and
- Encourage freight to move from the roadways to railways or waterways. (TRB, 2005)

By September 2002, the German government selected Toll Collect as the operator and decided that 50 percent of the net toll revenues would be dedicated to rail and inland waterway infrastructure investments in order to further encourage the shift in freight movements from the roads to the railways and waterways.

Obstacles and Strategies. The largest obstacles that the German distance-based heavy goods vehicle fee faced were technological rather than public acceptability. In fact, the fee was supported by domestic trucking organizations because they felt that they were at a competitive disadvantage with foreign carriers. Germany has higher fuel taxes than other European countries. Therefore, domestic trucking organizations argued that foreign truckers were able to benefit from lower fuel expenses in their own countries and could avoid refueling in Germany. As a result, the timely development, distribution, and operation of an entirely new type of ETC system posed the greatest threat to the implementation of the German heavy goods vehicle fee.

This is a challenge for any initiative that proposes to develop and use its own proprietary vehicle classification and toll collection technology instead of applying off-the-shelf technology.

The implementation of this road pricing initiative faced a series of delays due to technical problems associated with the new ETC system. The use of technology that was not compatible with the heavy vehicle fees used in other European countries resulted in the need for longer testing periods and created some resistance by foreign carriers. Part of this resistance was also caused when only one German-based company was allowed to install the OBUs in both domestic and foreign trucks, giving German truck companies an advantage in the installation of the OBUs. The resistance of foreign carriers was offset to a certain extent by providing the on-board units, estimated to cost €500 (about \$600), without charge if €500 worth of tolls were pre-paid. (Commission Expert Group on Transport and Environment, 2003) In the end, the electronic and manual collection systems used for the German heavy vehicle fee were successfully introduced in January 2005— two years later than initially planned.

Despite the lack of opposition from the domestic trucking industry, there were a number of concerns voiced by the public. These included increased truck traffic on local roads as a result of trucks diverting from federal motorways to avoid paying the fee, and the potential for the fee to be extended to all vehicles. The first issue was readily addressed by allocating the revenues to road, rail, and waterway infrastructure projects that would help expand auto and freight capacity throughout Germany. The latter concern was addressed when the Federal Office for Goods Transport withdrew a proposal to expand the program to other vehicles using federal highways, following public outcries and threats to move national elections earlier than originally scheduled.

Revenue and Traffic Impacts. The German heavy goods vehicle fee is expected to generate €2.5 billion (about \$3 billion) per year, which will be reinvested in highway, rail, and waterway infrastructure. (Hessler, 2005) It is expected that the fee will also increase transportation costs by about seven to nine percent and consumer prices by about 0.15 percent. (LogisticsToday, 2005) The traffic impacts associated with the German heavy goods vehicle fee are currently being studied, including:

- The shift in traffic from the federal motorways to local roads;
- The shift of freight from roads to rail and waterways; and
- The composition of the trucking fleet traveling through Germany.

These impacts will help determine how successful the fee has been in reducing roadway traffic and improving the emissions standards in the trucking fleet using German highways. If there is a significant shift to local roads, the fee may be extended to parallel local roads in order to encourage the use of the federal motorways.

4. CONCLUSIONS

The information presented in this report highlights the variety of purposes and levels of success achieved by cities in different parts of the world that apply road pricing to manage urban area congestion and/or generate transportation revenues. This chapter summarizes the major lessons learned from the sample of urban road pricing initiatives discussed in the prior chapter, including key reasons why some initiatives failed while others succeeded.

LESSONS LEARNED

The major lessons learned from the cameos and case studies presented in this report are summarized below:

- Road pricing has gained momentum in a number of major metropolitan areas around the world, particularly where the primary employment and retail activities are concentrated in a central business district (CBD), and where high downtown development density precludes adding significant capacity to the existing roadway network.
- A wide variety of road pricing schemes are being developed and applied abroad to raise additional funds for transportation infrastructure and services, and to better manage congestion, many focused on the cores of urban areas. The predominant road pricing schemes used overseas include the following:
 - Cordon tolling (including cordon toll rings);
 - Variable pricing (peak period higher than off-peak); and
 - Distance-based pricing (primarily for heavy trucks on major highways).

Interest in this third road pricing approach can also be attributed to the EU transport plan to encourage freight shippers to use rail, waterborne, and other means of transport rather than congested highway systems.

- In a number of older, densely-developed cities, such as London, Stockholm, and Rome, **cordon tolling** is primarily used to reduce travel demand by auto drivers, not as a means to develop additional revenues to build more roadway capacity. In these cities, the program revenues are used to pay for the cost of operating the program and to provide additional public transit facilities, vehicles, and services within the cordon area. These programs work best where the predominant mode of travel is already public transit. The cordon toll rings in Norway are primarily intended to generate sufficient revenues over a prescribed time period to build more highway and/or transit capacity. In certain cases, these programs have been extended to enable more highway and transit infrastructure to be developed.
- In countries like Germany, Switzerland, and Austria, expanding international trade following the establishment of the European Union created road funding inequities between domestic and foreign motor carriers. Foreign truckers used highways in these countries without contributing to their costs by not buying fuel taxed by these countries. These nations implemented **distance-based pricing** to equitably charge all heavy trucks for using their highways in lieu of paying the traditional motor fuel taxes.

In addition, by charging heavy trucks based on distance traveled in the host nation and the level of emissions produced by the truck, motor carriers have been encouraged to reduce the

extent of empty return hauls and to use trucks that pollute less. The EU also supports this approach to encourage freight to move on alternative modes to the highway, thereby freeing up more available highway capacity for automobiles.

- In Switzerland, two-thirds of the revenues generated by the heavy truck distance-based tolling scheme fund major rail infrastructure improvements to encourage shippers to route more of their goods moving through Switzerland by rail. The remaining third goes to highway infrastructure improvements.
- In other parts of the world, including France and Japan, **variable road pricing** on existing tolled highways is used to shift peak period traffic to the shoulder periods of the day, thereby reducing gridlock in the peak period. These road pricing schemes are intended to reduce congestion, not raise revenues.
- Success in road pricing in one jurisdiction does not necessarily mean the same scheme will be successful in another jurisdiction, even within the same country. The apparent success of the Central London cordon area pricing scheme is in sharp contrast to the lack of success of seven other jurisdictions in Great Britain which have proposed various kinds of urban area congestion pricing.
- The use of road pricing as a congestion management tool for urban areas abroad shows mixed results in terms of successful implementation and renewal. There are notable examples where road pricing schemes have been successfully implemented and revised, such as:
 - Singapore cordon area pricing program;
 - Central London congestion pricing program; and
 - German distance-based heavy goods vehicle fee program.

However, there are many examples of proposed schemes that failed to generate sufficient public support to even get to the implementation stage of development.

The following lists the key reasons why road pricing initiatives have failed to be implemented abroad:

- Inadequately describing the rationale for the program (i.e., how will the program make things better) and the consequences of inaction.
- Failing to anticipate, understand, or address public opposition to the initiative, particularly where opponents are more effectively mobilized and able to discourage or defeat the scheme's political champions (especially those groups who fail to understand how the scheme could benefit them and perceive they will only be disadvantaged by the scheme).
- Trying to please every interest group by making exceptions and discounts that defeat the intent of the program or make it overly complex.
- Over-emphasizing revenue generation as the principle reason for road pricing.
- Not clearly stating how the proceeds from the road pricing scheme will be used.
- Public distrust of the agency responsible for program implementation and administration.

- The specific details of road pricing schemes for managing urban congestion vary widely between jurisdictions. This results from differences in culture, geography, demographics, modal split, political sponsorship, and public acceptance.

The following lists the most common features of successful road pricing initiatives:

- Having strong political champion(s) with the determination and longevity to see the program developed, implemented, and refined. Where the scheme is authorized by the national government, as in Singapore, Stockholm, and Japan, there is greater potential for the scheme to reach the implementation stage. However, this does not guarantee success, especially if the political party supporting the scheme is voted out of office.
- Clearly defining the goals of the road pricing initiative and the benefits expected to be received by the traveling public in terms of:
 - § Congestion relief (i.e., shorter commute times, more reliable travel times, reduced vehicle operating costs, improved safety);
 - § Reduced air pollution;
 - § Improved alternative transport services; and
 - § Expedited projects to expand existing transport network capacity.
- Dedicating at least a portion of the net revenues from the scheme to improve public transit infrastructure and/or services, especially in those urban areas where public transit is much more heavily used by the public.
- Continuously monitoring and adjusting the road pricing scheme over time as the conditions and requirements for congestion relief and the need for revenues to support infrastructure development change.
- Using interoperable transponders for multiple jurisdictions implementing road pricing schemes within the same country (or the same national or cross-European ETC system).

CLOSING

The experience of the international community in developing and implementing road pricing schemes is focused on densely populated cities where historical patterns of land development and the evolution of transport modes has led to gridlock conditions. Whereas highway tolling is commonplace in many nations overseas, particularly in Europe, Asia, and South America where the proportion of tolled highways often exceeds that of the United States, road pricing for congestion relief generally is a much more recent phenomenon. The advent of electronic toll collection, vehicle classification and tracking, and telecommunications technologies has provided a significant boost to proponents of road pricing worldwide. As more highway infrastructure becomes tolled and as more drivers use transponder technology, there will be greater opportunities to price the use of scarce highway capacity, especially where they are most scarce—the dense urban cores of major metropolitan areas.

The lessons learned from both the successful and unsuccessful attempts to implement road pricing abroad are valuable for proponents of road pricing schemes in the United States. Despite differences in culture, land use, transport systems, and modal split between urban areas in the U.S. and overseas, it is clear that continuous public outreach and communication, clear program goals, and well-defined uses of proceeds are vital to the successful implementation of road pricing schemes wherever they are proposed.

APPENDIX A – GLOSSARY OF ROAD PRICING TERMS

Congestion Pricing. The policy of charging drivers a fee that varies by time of day on a fixed schedule (value pricing) or with the level of traffic (dynamic pricing) on a congested roadway. Congestion pricing is designed to allocate roadway space, a scarce resource, in a more economically feasible manner.

Cordon Tolling. Cordon tolls are fees paid by motorists who cross a cordon line (often called a toll ring) or drive in a particular cordon area, usually a city center. Some cordon tolls only apply during peak periods, such as weekdays.

FAIR Lanes.* "Fast and Intertwined Regular Lanes" involve separating freeway lanes, typically using plastic pylons and striping, into two sections: "fast" lanes and "regular" lanes. The fast lanes would be electronically tolled express lanes where tolls may change dynamically to manage demand. In the regular lanes, constricted flow would continue, but drivers with transponders would be compensated with credits. Credits could be used as toll payments on days when they choose to use the fast lanes, or as payment for transit, paratransit or parking at commuter park-and-ride lots in the corridor.

HOT Lanes.* "HOT" is the acronym for "High Occupancy/Toll." On HOT lanes, low occupancy vehicles are charged a toll, while High-Occupancy Vehicles (HOVs) are allowed to use the lanes free or at a discounted toll rate. HOT lanes create an additional category of eligibility for people wanting to use HOV lanes. People can either meet the minimum vehicle passenger requirement, or they can choose to pay a toll to gain access to the HOV lane.

Managed Lanes. A lane or lanes designed and operated to achieve stated goals by managing access via user group, pricing, or other criteria. The term refers to HOV lanes, HOT lanes, or other types of restricted or special lanes such as truck-only toll lanes.

Express Lanes.* Involves tolls on added lanes that vary by time-of-day and are collected at highway speeds using electronic toll collection technology. Tolls may be on a fixed schedule or allowed to vary based on the level of traffic to keep the lanes free flowing, even during peak travel periods. Express lanes are usually physically separated from the general-purpose lanes provided within major roadway corridors. Express lane access is managed by limiting the number of entrance and exit points to the facility.

Road Pricing. Covers all direct charges imposed on those who use roadways including fixed tolls and charges that vary with the time of day, the specific road used, and vehicle size and weight.

Toll Ways. A road, bridge, or tunnel where motorists are charged a fee to use the facility according to a fixed schedule.

Truck Toll Ways or Truck-Only Toll (TOT) Lanes. One or more lanes in each direction for sole use by trucks, separated from existing lanes by concrete barriers, and generally equipped with their own ingress and egress ramps.

* From FHWA Office of Transportation Policy Studies, Value Pricing Website:
<http://www.fhwa.dot.gov/policy/otps/terminology.htm>

Value Lanes.* Describe a concept that includes both HOV lanes and HOT lanes.

Value Pricing. Monetary incentives used to manage congestion during peak travel periods. Tolls may be set "dynamically," i.e., they may be increased or decreased every few minutes to manage demand so as to ensure that the express lanes are fully utilized, yet remain uncongested.

Variable Tolls.* Involves tolls on congested toll facilities that are varied by time of day with the intention of encouraging some travelers to use the roadway during less congested periods, to shift to another mode of transportation, or to change routes. With less people traveling during congested periods, the remaining peak period travelers will have decreased delays. To be eligible for the variable toll programs, vehicles must be equipped with transponders, which are read by overhead antennas.

* From FHWA Office of Transportation Policy Studies, Value Pricing Website:
<http://www.fhwa.dot.gov/policy/otps/terminology.htm>

APPENDIX B – LIST OF ACRONYMS

BAV - Bundesamt fur Verkehr (Switzerland Federal Office of Transport)
CBD – central business district
CSCMP – Council of Supply Chain Management Professionals
USDOT – United States Department of Transportation
ETC – electronic toll collection
EU – European Union
FAIR – Fast And Intertwined Regular lanes or Fast freeways And Intertwined Regular roads
FHWA – Federal Highway Administration
FMCSA – Federal Motor Carrier Safety Administration
GPS – Global Positioning System
HGV – heavy goods vehicle
HOT – high-occupancy toll lanes
HOV – high-occupancy vehicle or high-occupancy vehicle lanes
ITS – intelligent transportation systems
JHPC - Japan Highway Public Corporation
LKW Maut – German distance-based heavy vehicle tax named “Toll Collect”
LSVA - Swiss Distance Related Heavy Vehicle Fee
NAFTA - North America Free Trade Agreement
NOK – Norwegian Krone currency
SOV – single occupant vehicle
T&E – European Federation for Transport & Environment
TOT – truck-only toll lanes
TRB – Transportation Research Board
URL – uniform resource locator (web address)
U.S. – United States
VKM - vehicle kilometers
VMT – vehicle miles traveled

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