International Technology Scanning Program

Reducing Congestion and Funding Transportation Using Road Pricing in Europe and Singapore

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16. Abstract Congestion pricing use has been limited in the United States because of political, institutional, and public acceptance concerns. The Federal Highway Administration, American Association of State Highway and Transportation Officials, and National Cooperative Highway Research Program sponsored a scanning study of Europe and Singapore to identify ideas and models for integrating road pricing approaches into U.S. practices. The scan team found that countries with clearly defined and well-understood policy goals were able to achieve targeted outcomes most effectively. The team also learned that a large-scale demonstration project is a good tool to build public acceptance of road pricing. Team recommendations for U.S. implementation include enhanced outreach and communication on road pricing use and research on public perception issues and implementation barriers. The team also recommended development of a road pricing toolkit to provide transportation professionals with a comprehensive decision analysis tool to assess the merits of road pricing options.			
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Reducing Congestion and Funding Transportation Using Road Pricing in Europe and Singapore

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International Technology Scanning Program

The International Technology Scanning Program, sponsored by the Federal Highway Administration (FHWA), the American Association of State Highway and Transportation Officials (AASHTO), and the National Cooperative Highway Research Program (NCHRP), evaluates innovative foreign technologies and practices that could significantly benefit U.S. highway transportation systems. This approach allows advanced technology to be adapted and put into practice much more efficiently without spending scarce research funds to re-create advances already developed by other countries.

FHWA and AASHTO, with recommendations from NCHRP, jointly determine priority topics for teams of U.S. experts to study. Teams in the specific areas being investigated are formed and sent to countries where significant advances and innovations have been made in technology, management practices, organizational structure, program delivery, and financing. Scan teams usually include representatives from FHWA, State departments of transportation, local governments, transportation trade and research groups, the private sector, and academia.

After a scan is completed, team members evaluate findings and develop comprehensive reports, including recommendations for further research and pilot projects to verify the value of adapting innovations for U.S. use. Scan reports, as well as the results of pilot programs and research, are circulated throughout the country to State and local transportation officials and the private sector. Since 1990, more than 80 international scans have been organized on topics such as pavements, bridge construction and maintenance, contracting, intermodal transport, organizational management, winter road maintenance, safety, intelligent transportation systems, planning, and policy.

The International Technology Scanning Program has resulted in significant improvements and savings in road program technologies and practices throughout the United States. In some cases, scan studies have facilitated joint research and technology-sharing projects with international counterparts, further conserving resources and advancing the state of the art. Scan studies have also exposed transportation professionals to remarkable advancements and inspired implementation of hundreds of innovations. The result: large savings of research dollars and time, as well as significant improvements in the Nation's transportation system.

Scan reports can be obtained through FHWA free of charge by e-mailing international@dot.gov. Scan reports are also available electronically and can be accessed on the FHWA Office of International Programs Web site at www.international.fhwa.dot.gov.

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Northumberland Strait Crossing Project (1996)

European Bridge Structures (1995)

All publications are available on the Internet at www.international.fhwa.dot.gov.

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Acronyms and Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
ANPR	automated number plate recognition
BAG	German toll enforcement vehicles
CBD	central business district
CO_2	carbon dioxide
COE	Certificate of Entitlement
CRD	Congestion Reduction Demonstration
CURACAO	Coordination of Urban Road-User Charging Organizational Issues
CZK	Czech koruna
DOT	department of transportation
DSRC	dedicated short-range communications
EETS	European Electronic Toll Service
ERP	Electronic Road Pricing
EU	European Union
EUR	euro
FHWA	Federal Highway Administration
GBP	U.K. pound
GmbH	German legal designation for company incorporation
GPS	Global Positioning System
GSM	Global System for Mobile Communications
HGV	heavy goods vehicle
HOT lane	high-occupancy toll lane
ITS	intelligent transportation systems
IU	in-vehicle unit
km/h	kilometers per hour
LTA	Land Transport Authority
OBU	onboard unit
PCU	passenger car unit
PPP	public-private partnership
SEK	Swedish krona
SGD	Singapore dollar
TfL	Transport for London
USD	U.S. dollar

Executive Summary

The evidence in the countries visited in this scan shows that road pricing can play a vital role in creating new funding for transportation, encouraging improved quality of life in the urban environment, advancing economic productivity for goods movement and business, increasing the use of public transit, and reducing congestion and emissions.

Road Pricing

Road pricing has a long history in the form of tolled bridges, tunnels, and turnpikes designed to generate revenue to pay for the construction, operation, and maintenance of these facilities. In the last half century, road pricing has been viewed as an opportunity to leverage the principles of supply and demand to manage traffic with congestion pricing. This is achieved by charging drivers a user fee (i.e., a toll or other charge) that may vary by traffic demand, time of day, vehicle classification, or other factors. In practice, road pricing provides a tool for road operators to manage limited roadway capacity to reduce congestion and maintain free-flow traffic conditions on highways, as well as to generate revenues that help pay capital, operating, and maintenance costs.

The broad application of congestion pricing in the United States has been limited because of political, institutional, and public acceptance concerns. However, variable charges have been used successfully by many U.S. industries, including hospitality, air travel, utilities, and telecommunications.

Road pricing has been instituted on a broader basis in other countries, notably the Czech Republic, Germany, Singapore, Sweden, and the United Kingdom, and is in the midst of comprehensive planning in the Netherlands. The scan team traveled to Europe and Singapore to meet with transportation officials with expertise in road pricing programs to learn firsthand about their approaches and practices.

While a number of basic objectives may underlie a road pricing program, the scan team focused on two primary purposes of road pricing: to manage demand and to generate revenue. Figure 1 illustrates the fact that some programs emphasize one objective, and others seek to blend the two objectives in one harmonious program. The countries visited in this scan can be viewed through the lenses of revenue generation and demand management. London, Singapore, and Stockholm are in the demand management circle, while the Czech Republic and Germany fall solidly in the revenue generation circle. The aim of the Netherlands is to transition on a revenue-neutral basis to a more fair transportation funding system that charges users for vehicle use instead of vehicle ownership. A clear understanding of the primary policy objectives behind the implementation of road pricing and consistent decisionmaking aligned with the objectives were essential elements for all successful projects reviewed as part of this scan.

Both the U.S. Department of Transportation (U.S. DOT) and the American Association of State Highway and Transportation Officials (AASHTO) have made economic and environmental sustainability and community livability top priorities. The evidence in the countries visited in this scan shows that road pricing can play a vital role in creating new funding for

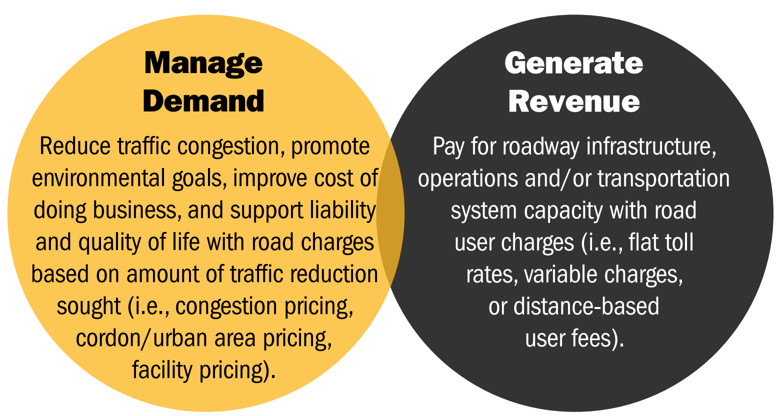


Figure 1. Purposes of road pricing.

transportation, encouraging improved quality of life in the urban environment, advancing economic productivity for goods movement and business, increasing the use of public transit, and reducing congestion and emissions.

Major Findings

Over a 12-day period, the scan team interacted with host country experts to develop an understanding of the political, institutional, and technical factors that contributed to the successful implementation of road pricing. Based on discussions and observations made during and after the scan, the team developed the following nine major findings:

1. Host countries and regions with **clearly defined and well-understood policy goals** were able to achieve their targeted outcomes most effectively.

2. A **large-scale demonstration** project is a powerful tool for building public acceptance, allowing people to experience the benefits of congestion pricing.

3. Thorough **planning and performance measurement** pay benefits in ensuring achievement of overall goals, managing the pricing program as an element of overall transportation system performance, and directing implementation and operations effectively.

4. **Linking the pricing structure to the benefits received** by the user contributes to public acceptance and helps avoid the potential negative impacts of traffic diversion.

5. **Public outreach and communications** were key components of the program at every stage: before making the implementation decision, during the program design process, and during the operational phase.

6. **Open-source system designs offer long-term advantages** by leveraging market competition to manage implementation and operations costs, ensure system flexibility and scalability, and establish a foundation for system interoperability.

7. **Interoperability** among states and countries is recognized as a critical issue that needs to be addressed at high levels.

8. **Equity and privacy** concerns are addressed by host countries through exemptions, revenue use, technology, and business rules.

9. The urban area pricing projects integrated **public transit investments and land use planning** to manage congestion.

These findings are complemented by more than 30 documented lessons learned that are characterized by seven functional categories and business disciplines. The lessons learned are intended to provide more indepth discussions of the findings from discussion with the host countries. They are organized to enable subject matter experts to examine the areas of greatest interest most effectively.

Implementation

Based on the key findings and lessons learned, the team recommends that additional resources and effort be focused on three strategic areas:

1. **Enhanced outreach and communications.** To advance the use of road pricing in the United States, it is paramount that transportation leaders, policymakers, key stakeholders, and a larger cross-section of the public understand the benefits and implications of broader road pricing.

2. **Additional research needs.** With the application of road pricing in the United States limited to high-occupancy toll lanes, there is a continued need for additional research to better comprehend issues related to public perception, implementation barriers, behavioral effect, and integration of road pricing with multimodal land use and transit options.

3. **Road pricing toolkit.** Transportation professionals lack a comprehensive decision analysis tool to assess the merits of various road pricing options to address specific problems. The toolkit would include a module to assist in making design decisions, a guidebook or primer to assist technical managers in developing financing and procurement strategies, comprehensive and synergistic transportation plans that incorporate road pricing concepts applicable in the U.S. context, and analytical tools to estimate performance and costs of alternative concepts in comparison with conventional tax-based approaches. The tools would culminate in a decision tree to help transportation leaders make informed decisions on the relevance and feasibility of a road pricing alternative.

Chapter 1 | Introduction

Transportation networks affect virtually every aspect of peoples' lives—where they live, where they work, where they shop, and how much they pay for goods and services. In many U.S. metropolitan areas, congestion is a significant and growing problem. Road pricing holds great promise as a strategy for reducing the absolute levels of congestion, while at the same time raising revenue for transportation, reducing environmental impacts of traffic, and allowing people to consider the full cost of transportation and land use decisions. The primary purposes of road pricing include congestion or value pricing to manage demand, environmental pricing to reduce environmental impacts, and tolling to generate revenues (see "Types of Road Pricing").

The scale of application of road pricing may also be used to categorize it into facility-based pricing, zone-based pricing, or distance-based pricing (see "Scale of Application").

At any scale of application, charging systems may have rates that vary by time of day, traffic volumes, vehicle classification, and other factors to garner the advantages of a congestion pricing approach or to address environmental impacts.

U.S. transportation agencies have a long history of facility-based tolling for revenue generation and have made great strides in managing demand on specific highway lanes using congestion pricing. However, broader scale applications of road pricing (i.e., zone-based or regionwide) have been limited because of political, institutional, and public acceptance issues. Zone-based pricing (e.g., in urban centers) and regionwide pricing of roadway systems have fallen short of implementation in the United States and have been evident only in research, demonstration pilots, and proposals that failed to get to implementation, such as the New York City cordon pricing proposal.

Variable charges have been used successfully to manage demand in many U.S. industries, including the pricing of hotels, airfare, electricity, and mobile phone services. Many economists view road pricing, or using pricing signals to manage demand, as the single most viable approach to reducing traffic congestion. Yet, the application of variable pricing in the United States has been limited primarily to a few toll facilities and high-occupancy toll (HOT) lanes in a handful of cities.

Both the U.S. Department of Transportation (U.S. DOT) and American Association of State Highway and Transportation Officials (AASHTO) address traffic congestion in their programs. U.S. DOT's Urban Partnership (UP) and Congestion Reduction Demonstration (CRD) programs have set the stage for adding several facilities to the list of U.S. examples of pricing. One of the UP/CRD cities, Seattle, WA, will price all lanes on an existing facility. In addition, U.S. DOT and the Federal Highway Administration (FHWA) provide technical

Types of Road Pricing (Based on Purpose)

- **Congestion or value pricing—**Fee charged by time of day or traffic volume to reduce traffic, manage traffic flow, and/or maintain target travel speeds.
- **Environmental pricing—**Fee charged to reduce the environmental impacts of traffic.
- **Tolling—**Generic fee paid to access a road, bridge, or tunnel to generate revenue to cover the costs of construction and/or operations.

Scale of Application of Road Pricing

- **Facility-based charges—**Charges for use of specific roadway facilities or dedicated lanes on these facilities.
- **Zone-based (area or cordon) charges—**Variable or fixed charges to drive within or into a congested urban area. Under a cordon system, such as in Stockholm and Singapore, users pay a fee every time they cross the cordon boundary. In an area-priced system, such as in London, users pay a fee to enter, leave, or travel within a defined area.
- **Regionwide or nationwide distance-based charges—**Per-mile charges on all roads within a prescribed region or country.

assistance and conduct research on road pricing as a demand-management and revenue-generation strategy. FHWA established an office to promote implementation of innovative program delivery strategies, such as road pricing and public-private partnerships (PPP).

One of AASHTO's key objectives under its strategic goal to reestablish transportation as a national priority recognizes the need to increase mobility by encouraging multimodal and intermodal solutions, policies, and technologies. AASHTO's goal to "provide world-class technical services" includes facilitating the use of emerging technologies, processes, and programs and advancing innovative practices. Road pricing is an innovative strategy that can help achieve these goals.

The results of this international road pricing scan will inform the U.S. road pricing research agenda, but, more important, it will identify best practices from international experience to assist U.S. practitioners in considering and implementing broader road pricing strategies.

Purpose of Road Pricing Scan

The purpose of the scan was to identify new ideas and practical, workable models for integrating road pricing approaches into State, local, and regional policies, programs, and practices. This scan reviewed urban and nationwide road pricing approaches in Europe and Singapore so that the U.S. participants could develop an understanding of the political, institutional, and technical factors that contributed to their successful implementation and, in some cases, their rejection. These insights have helped the scan participants recognize the conditions and objectives in which road pricing can play a productive and meaningful role. Their perspectives will be communicated to a broad U.S. audience of policy- and decisionmakers. The best practices from the places visited will be used to develop and apply new strategies for implementing broader forms of road pricing in the United States and help focus attention on the potential for road pricing as an effective part of 21st century transportation operations and financing policies, programs, and practices.

Panel Scope, Sponsorship, and Composition

The U.S. panel met with officials from Berlin, Germany; the Czech Republic; London, United Kingdom; Singapore; Stockholm, Sweden; and The Hague, Netherlands, from Dec. 7 to 18, 2009. The face-to-face visits enabled participants to gain a deeper understanding of each host country's history and context, the goals and objectives that were established, how road pricing was designed to address transportation and policy objectives, and the hurdles that were faced and how they were overcome. The exchanges provided an opportunity to gain indepth understanding of program goals and methods, implementation costs, benefits, transportation impacts, revenue generation and use, operating and technical practices and their costs, financing approaches, effects on safety and the environment, and public acceptance.

The panel was cosponsored by AASHTO, FHWA, and the National Cooperative Highway Research Program (NHCRP). The 10 members of the multidisciplinary team included transportation professionals from four State departments of transportation (DOT), one regional transportation agency, FHWA, the Federal Trade Administration (FTA), and private industry. Bob Arnold of FHWA and Vance Smith of the Georgia DOT were the cochairs, Patrick DeCorla-Souza of FHWA served as the Implementation Team chair, and John Doan of SRF Consulting Group was the report facilitator. Other team members were Rodney Barry of FHWA, Jayme Blakesley of FTA, Mark Muriello of the Port Authority of New York and New Jersey, Gummada Murthy of the Virginia DOT, Patty Rubstello of the Washington State DOT, and Nick Thompson of the Minnesota DOT. Contact information and biographies for each team member are in Appendix A. Details on the scan preparation and itinerary are in Appendix B.

Panel Topics of Interest

Major topics of interest included the following:

- Urban and nationwide pricing
- Strategies for addressing political, regulatory, and legal barriers, particularly those related to public acceptance
- Institutional arrangements and interagency collaboration to enable effective applications of pricing techniques
- Implementation strategies and costs
- Experience with quantifying projected and actual benefits (e.g., congestion reduction, safety, and environmental) and developing performance metrics
- Relationship between road pricing as a revenue stream and operational strategy to reduce congestion, improve safety, or enhance the environment

Figure 2. Scan team members in Singapore (left to right): Patrick DeCorla-Souza, Rodney Barry, Nick Thompson, Patty Rubstello, Jayme Blakesley, John Doan, Mark Muriello, Bob Arnold, Gummada Murthy, and Vance Smith.

- Equity concerns, particularly redistribution issues and strategies related to toll revenues
- Relevance and importance of including supporting strategies such as transit enhancements, system operations strategies and technologies, and travel demand management

Specific questions on the panel's interests in these topics are in Appendix C. These amplifying questions were sent to country hosts before the U.S. visits to help them determine whom to invite to the meetings with the U.S. contingent and to ensure that presentations addressed the interests and needs of the scan team.

Host Delegations

During the scanning study, the team members met with representatives from more than a dozen organizations that represented a broad range of road pricing practitioners, executives, and key stakeholders. The majority of the organizations represented one of the following perspectives: road agency (city, regional, or national), infrastructure financing agency, trade group, or research organization. In addition, the scan team had informal conversations with residents of the locations visited, including taxi drivers, hotel staff, tour guides, and others, to better understand the local context.

Chapter 2 | General Observations

Road pricing projects have been implemented on five continents (Asia, Australia, Europe, and North and South America) and include notable facilities in Canada, Chile, Germany, Singapore, Sweden, and the United Kingdom. Bhatt et al. provided a concise overview in *Lessons Learned from International Experience in Congestion Pricing* (2008):

> Over the past 30 years, congestion pricing concepts have received considerable attention outside of the U.S. Compared to the U.S., Britain, Europe, and countries in Asia and the Pacific region have a longer history of interest in exploring the potential of pricing approaches to address congestion, environmental and transportation funding problems. Individual countries, as well as the European Union (EU), have established road pricing initiatives aimed at studying, implementing and evaluating a wide range of congestion pricing demonstrations and operational programs.

These projects have demonstrated that road pricing can be an effective means of managing demand and generating revenue and can also be politically and publicly acceptable. Pricing programs have reduced congestion on facilities and in priced areas, improved use of existing road capacity, created new travel options to driving adopted by travelers, and achieved the goals of demand management, emission reductions, and revenue generation. Revenues from pricing have been used to provide funding for multimodal transportation improvements.

Much like the U.S. experience, overseas road pricing projects have been met with considerable resistance and political and public debate. Models of new roadway capacity, propelled by the toll financing that is more prevalent overseas, are being met with less resistance and often allow for private sector participation in construction, finance, and operation of newly built priced roads. While models involving distance-based highway charges for commercial vehicles and urban zone-based congestion pricing have encountered far greater scrutiny and debate, they have tended to achieve more targeted transportation goals. They also have achieved broader objectives aimed at addressing the environmental, livability, and quality of life impacts of transportation in urban areas. Many international examples indicate that public acceptance and approval of pricing programs improves significantly after project implementation, when the benefits and impacts can be weighed in tangible terms based on the context of its application.

Many international road pricing programs are breaking new ground and providing important lessons for those interested in exploring the use of market-based approaches to address traffic congestion. Projects implemented to date have proven that travelers are willing to pay for road use provided there are demonstrable improvements to travel conditions coupled with other enhancements to the transport system. Pricing signals have had measureable effects on the traveling public's transportation decisions, evident in more efficient use of existing roadways and other transportation facilities, such as transit services. Although road pricing is operational in multiple locations abroad, it is still a new and innovative concept in the United States—one that requires careful planning, coalition building, public education and participation, and sufficient time and resources to develop well-designed and locally acceptable project plans.

Table 1 (see next page) summarizes the characteristics of the road pricing projects the team visited during the scan. Based on similar purposes and characteristics, London, Singapore, and Stockholm use urban congestion pricing concepts that aim to reduce urban congestion by **managing demand** through zone-based (i.e., area or cordon) or facility-based (as on Singapore expressways) pricing. The Czech Republic and Germany have distance-based charging systems for heavy commercial vehicles on selected highways with the primary goal of **generating revenue.** The Netherlands is unique among the sites visited because it is in the planning and implementation stages for a nationwide road pricing system that may charge all vehicles based on distance traveled, time of day, and vehicle type for the **combined purposes** of managing demand and generating revenue to shift to a more user pays basis.

Table 1. Summary of pricing projects.

	Countries Visited	Purpose/ Objective	Type of Pricing	Milestone Dates	Technology	Measured Impacts	Annual Revenues and Cost (in USD)*	Distribution of Net Revenues
Demand Management	**Stockholm, Sweden:** Congestion Tax	Manage congestion (primary) Promote transit and protect environment (secondary)	Cordon pricing in city center by time of day at SEK10 to SEK20 (about US$1.50 to US$3) per crossing of cordon line into and out of city center	Trial: January–July 2006 Referendum: September 2006 Permanently reinstated: August 2007	Automated number plate recognition (ANPR) to assess tax to vehicle owner	20% reduction in traffic congestion in the city center 10–14% decrease in emissions	Gross revenues (2009): SEK850 million (US$118.5 million) Net revenues (2009): SEK530 million (US$74 million) Overhead costs: SEK320 million (US$44.5 million), about 37% of revenues	Collected by national government and transferred to the city of Stockholm Net revenues used to invest in transit and new roads Net revenues used to invest in transit and new roads
	London, United Kingdom: Congestion Charge	Manage congestion (primary) Promote transit and protect environment (secondary)	Area pricing in central London and its western extension Flat daily rate of £8 (US$13)	Started in central London: February 2003 Price increased from £5 to £8 (60% increase) in July 2005 Western extension: February 2007 Repeal of western extension: planned in 2010	ANPR to track compulsory payment compliance and identify violators	Initial traffic reductions of 25% and 19% (central London and western extension, respectively)	Gross revenues (2008): £268 million (US$435 million) Net revenues: £137 million (US$222 million) Overhead costs: £131 million (US$212 million), about 50% of revenues Capital costs for central London zone: £130 million (US$211 million)	Net revenues used for transit (80%) and other transport (20%) improvements within greater London
	Singapore: Electronic Road Pricing (ERP)	Manage congestion (primary) Promote transit (secondary)	Cordon and expressway pricing by time of day and vehicle class	Cordon pricing via manually enforced paper permit system in 1975 Transition to ERP in 1998, followed by expressway pricing	Dedicated short-range communications (DSRC) in-vehicle units with removable stored-value smart card for payment ANPR for enforcement	Achieves free-flow road speed targets of 45–65 km/h on expressways and 20–30 km/h on arterials.	Gross revenues (2008): SG$125 million (US$90 million) Net revenues: SG$100 million (US$72 million) Overhead costs: SG$25 million (US$18 million), 20% of gross revenues	Net revenues returned to vehicle owners through tax rebates—heavy investment from general fund in transit and highway systems

Revenue Generation	**Germany:** Heavy Goods Vehicle (HGV) Charging on Highways	Generate revenue and promote user-pays principle (primary) Protect environment and encourage mode shift to rail and water (secondary)	Truck tolls for HGVs greater than12 metric tons on the autobahn and limited portions of other national highways based on distance traveled, number of axles, and emissions class	Opened in January 2005	Global Positioning System (GPS) for vehicle location Global System for Mobile Communica-tions (GSM) for data transmission DSRC and ANPR for enforcement Manual booking system via kiosk terminals and Internet for those without onboard units	Violations less than 2% Empty truck trips declined by 7% 58% shift from dirtier truck models (Euro class 1, 2, 3) to cleaner trucks (Euro class 4, 5)	Gross revenue (2008): €3.5 billion (US$5 billion) Overhead costs: 15–20% of gross revenues Average toll rate: €0.163 per km (US$0.378 per mi)	Net revenues for roads (50%), rail (38%), and waterways (12%) €560 million (US$815 million) per year for trucker "harmonization" program
	Czech Republic: Truck Charging on Highways	Generate revenue and promote user-pays principle (primary) Advance environmen-tal objectives (secondary)	Truck charges on selected national highways based on distance traveled, number of axles, and emissions class	Opening: January 2007 Originally for HGVs >12 metric tons Expansion to include trucks >3.5 metric tons in January 2010	Transponder-based DSRC system with gantries on mainline highways ANPR for enforcement	Average toll rate of US$0.35 per mi on freeways	Gross revenue (2008): CZK6 billion (US$340 million) Overhead costs: 30% of gross revenues Average toll rate: CZK4.05 per km (US$0.36 per mi) for highways; CZK1.90 per km (US$0.17 per mi) for first-class roads	Net revenues for roads and highways, railway lines, and inland transport routes
Planned	**The Netherlands:** National Distance-Based Tax	Planned to manage congestion, replace vehicle tax revenue, and promote user-pays principle (primary) Promote transit and protect environment (secondary)	National distance-based road pricing of all vehicles (commer-cial trucks and private cars) on all roadways	Phased implementa-tion originally planned to begin in 2011, with all trucks covered by 2012 and all vehicles by 2018 Implementation on hold because of parliamentary elections in June 2010	Under development, likely GPS for vehicle location, GSM-based data communication, and DSRC interroga-tion with ANPR for enforcement	2020 forecasted results: 10–5% reduction in vehicle-miles traveled 40–60% reduction in delays 10% reduction in CO_2 6% increase in public transit use	Gross revenues (2019 forecasted): €9 billion (US$13.1 billion) Overhead costs: to be determined (capped in law at 5% of gross revenues) Capital costs (estimated): €5.7 billion (US$8.3 billion)	Revenues intended to replace existing vehicle ownership taxes

*See Appendix F for currency exchange rates

Each host country has unique geographic, cultural, and political contexts that drive the decisionmaking and public involvement process. All of the countries have parliamentary democracy forms of governance, in which the executive power lies in a cabinet led by a prime minister and supported by parliamentarians who lead the ministry of transport. In addition, the urban pricing regions visited (London, Singapore, and Stockholm) have high-density development, making certain types of road pricing more applicable and the provision of multimodal services such as transit, biking, and walking more feasible and effective.

DEMAND MANAGEMENT: Stockholm's Congestion Tax

The purpose of the Stockholm road pricing project is to reduce traffic congestion and vehicle emissions in the inner-city area. It was initially introduced by the Green Party and Social Democrats as a full-scale trial with the objectives of reducing congestion, improving access and mobility, promoting transit, and promoting environmental sustainability.

Stockholm's Congestion Tax (Trängselskatt i Stockholm)

Purpose: Manage congestion (primary), promote transit and reduce emissions (secondary)

Application: Urban cordon pricing

Fee structure: Time-of-day pricing

Use of revenues: Fund transportation and transit improvements in the city of Stockholm

Technology: Automated number plate recognition (ANPR)

Milestones: January 2006 (trial began), July 2006 (trial ended), September 2006 (referendum), August 2007 (reopened)

Managing authority: Swedish Transport Administration

Other highlights: Coupled with significant transit investment in equipment, facilities, and operations; exempts through traffic (30 percent of vehicles from Lidingö Island and on Essingeleden bypass); 7-month preimplementation demonstration

Results: 20 percent reduction in traffic, 10 to 14 percent decrease in emissions, 2 to 10 percent improvement in air quality

The concept involves charging a variable tax for crossing a cordon drawn around the Stockholm city center. Vehicles registered in Sweden are charged when they pass one of 18 control points while entering or exiting the congestion zone in the city's center on weekdays between 6:30 a.m. and 6:30 p.m. (figure 3). The rates vary from 10 Swedish kroner (SEK), or about US$1.50, during offpeak hours to SEK15 (about US$2.25) during the shoulders of the peak periods and SEK20 (about US$3) during the peak periods (7:30 to 8:30 a.m. and 4 to 5:30 p.m.). Vehicles are charged each time they cross a control point, up to a maximum of SEK60 (about US$9) per day (figure 4).

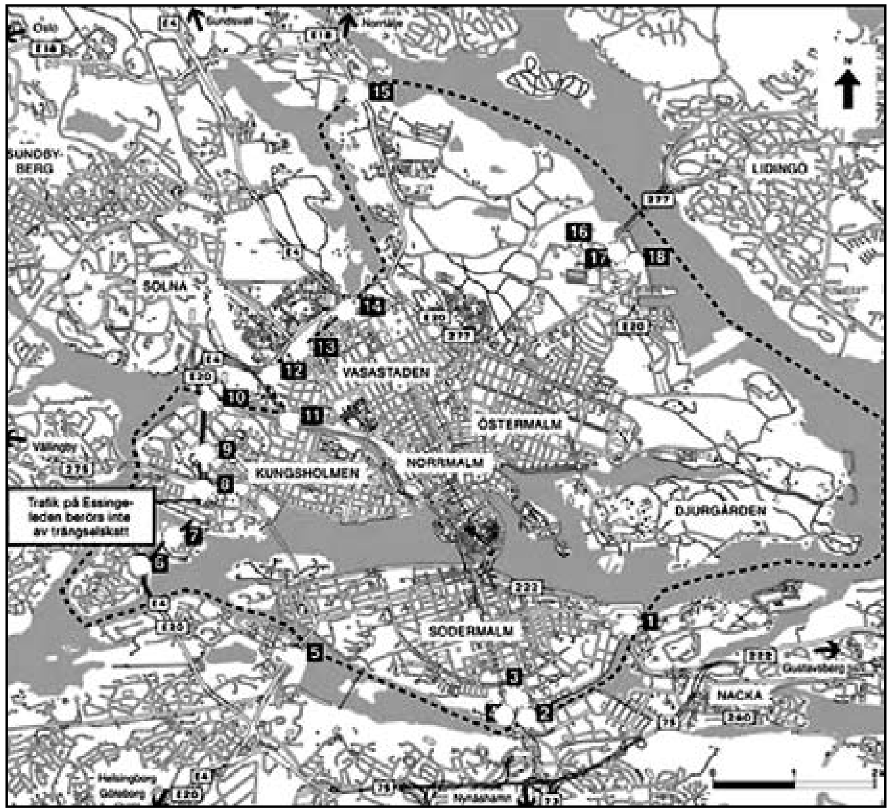
Because the congestion charge is managed as a tax by the national government, any change in the fee schedule requires parliamentary action. It has not yet been determined how this provision for price adjustments will impact the effectiveness of maintaining roadway conditions at uncongested levels. No price change has been contemplated since the system was permanently adopted in August 2007.

The plan was originally developed in spring 2003. The options for the charging zone were carefully analyzed using traffic simulation tools that defined the details of the system. The traffic analysis was a critical element of proper planning, ensuring that there would be no unintended impacts elsewhere in the network as a consequence of the congestion charge. The planners originally contemplated more complicated charging schemes, but the program's schedule constraints did not allow these to be pursued. The final system was simple and easy to understand, which contributed to successful operation and public acceptance.

The road pricing project in Stockholm was unique in that it was introduced with a 7-month demonstration period, after which the system was turned off and subjected to a public referendum by Stockholm residents to inform a final decision by policymakers on its continuation as a permanent system. In June 2003 the Stockholm City Council voted to conduct a trial implementation of congestion pricing in its central business district (CBD). The project became operational in January 2006 and was shut down as scheduled at the end of July 2006. Six weeks later, on Sept. 17, 2006, Stockholm residents voted on whether to reactivate or terminate the road pricing system.

Before the demonstration, public support for the pricing program was at 25 percent. After the demonstration, public support from Stockholm residents voting in the referendum was more than 50 percent in favor of reinstating the congestion tax. The referendum counted only Stockholm residents who realized the most tangible benefits of congestion pricing coupled with significant investments in transit. Optional votes taken in some of the surrounding suburbs at the same time as the city referendum showed less than 50 percent support from those communities. These votes were not mandated by Parliament, but were requested by localities that questioned the wisdom of the scheme. Recent opinion polls show that 65 percent of the public would vote in favor of the system in its current form, 17 percent would like to see the price raised, and 25 percent would like to see the price decreased (figure 5, see next page).

The overall implementation included a SEK1.3 billion (US$180 million) investment for the tolling system plus SEK2 billion (US$280 million) in related public transit improvements. The transit investment funded a 10 percent expansion of the Stockholm public transport system, which included 200 articulated buses (equivalent of 10,000 new seats), 2,400 new park-and-ride spaces, bus priority at traffic signals, improved rail service, new dedicated bus lanes, and 12 new express bus routes (figure 6, see next page).



SOURCE: Gunnar Soderholm Presentation, City of Stockholm, Dec. 8, 2009

Figure 3. Eighteen congestion charging control points create the Stockholm cordon.

Originally, the transit and tolling systems were scheduled to be launched in tandem. However, the transit service enhancements went into operation 5 months before the congestion charging system because of tolling system procurement delays. Transit usage and traffic congestion levels in the city center did not change with the introduction of the new transit service. It was only after the congestion tax was implemented that transit use grew significantly and a 20 percent reduction in traffic was realized. Half of the operation and maintenance cost associated with the new bus services was covered by fares and half by taxes.

Congestion charges and times

Peak Periods		
7.30–8.30 a.m., 4–5.30 p.m.	SEK20	€2
Semipeak Periods		
7–7.30 a.m., 8.30–9 a.m. 3.30–4 p.m., 5.30–6 p.m.	SEK15	€1,5
Medium-Volume Periods		
6.30– a.m., 9 a.m.–3.30 p.m. 6–6.30 p.m.	SEK10	€1
Maximum Charge:	SEK60/day	€6
Evenings, Saturdays, Sundays, holidays: **No Charge**		

Figure 4. Congestion charge fee schedule.

Vehicles exempt from paying fees include public buses, taxis, certain alternative-fuel vehicles, emergency vehicles, motorcycles, vehicles with handicap plates, and foreign-registered vehicles. An exemption is also provided to residents of the Island of Lidingö, who can access the rest of Sweden only by traversing the CBD. Vehicles driving between the island and the bridge control points have 30 minutes to make a through trip without being charged. However, if they remain in the CBD for more than 30 minutes, charges are applied. The capital cost to institute the Lidingö Rule was estimated at more than

SOURCE: Gunnar Soderholm Presentation, City of Stockholm, Dec. 8, 2009

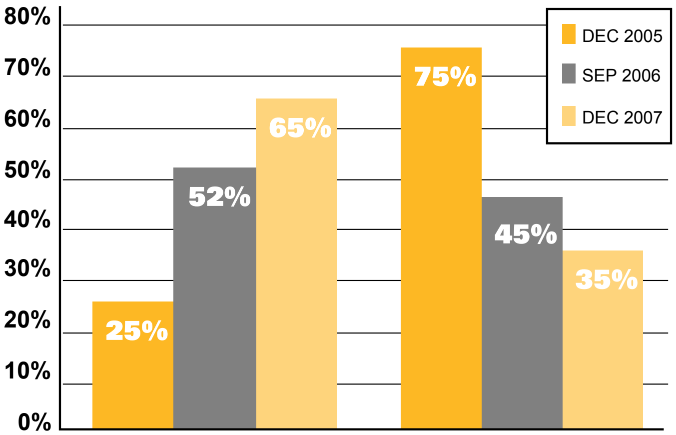


Figure 5. Public support for Stockholm congestion tax (2005–2007).

SOURCE: Bhatt, et al. "Lessons Learned from International Experience in Congestion Pricing"

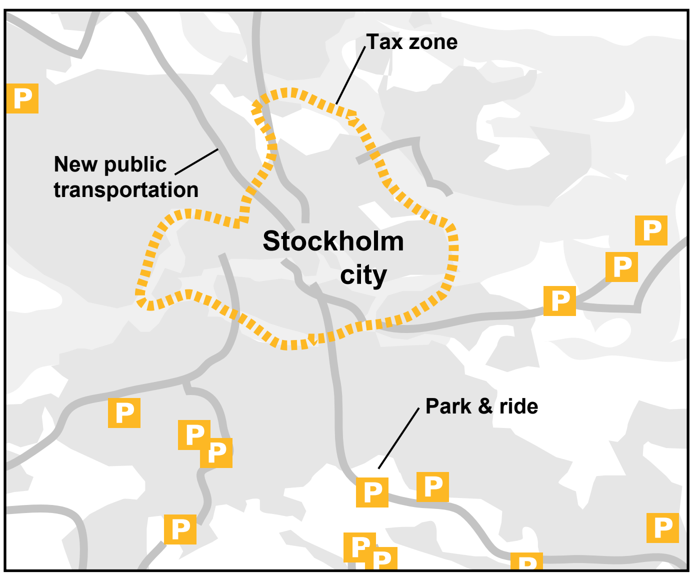


Figure 6. Stockholm pricing zone, new transit routes, and expanded park-and-ride facilities.

SEK200 million (US$28 million), plus ongoing exemption costs from system downtimes. For example, if even a single gantry is not functioning, all charges must be suspended on the entire system to avoid the possibility of an erroneous charge for an exempt through trip from Lidingö. Another exception is through traffic on the E4/E20 Essingeleden Highway going past Stockholm. In total, about 30 percent of vehicles passing through the city center are exempt from the congestion tax.

The toll collection system includes three overhead gantries at each control point (figure 7). The outer two gantries house the digital imaging cameras that capture front and rear license plate images of all vehicles. The middle gantry houses the dedicated short-range communications (DSRC) antennas used in conjunction with in-vehicle transponders available to travelers during the trial. With the adoption of the permanent system, officials decided that the automated number plate recognition (ANPR) system performed so well that the transponder-based option was not necessary, and eliminating it offered an opportunity to reduce overall system operating costs.

During the congestion tax trial, vehicles with transponder-based accounts and those that did not have transponders had until noon the following day to pay the charge via the Internet or at a physical retail location, which included 7-Eleven and Pressbyran convenience stores, Giro Banks, and stand-alone kiosks. Charges not paid during the grace period are assessed a SEK70 late fee (US$8) for the first reminder and SEK450 (US$62) fee for the second reminder. Swedish laws governing the collection of taxes required that the system capture all license plates, whether or not a transponder was used. Therefore, the transponder-based system was duplicative. Because of the extra operating costs resulting from administration and complexity of the transponder-based payment option, it was phased out with the implementation of the permanent system. The options for payment were also changed to increase convenience for taxpayers. Under the current arrangement, drivers receive a monthly billing statement from the state.

The Stockholm system processes about 450,000 transactions per day. The original IBM contract was worth SEK1.9 billion (US$265 million), and was contracted through the Swedish Road Administration. The gross revenue from the system in 2009 was SEK850 million (US$118.5 million). The cost of 2009 operations was about SEK320 million (US$44.5 million), or about 38 percent of total revenues. With anticipated process streamlining and operating cost reductions, operation costs were expected to decrease to SEK220 million (US$30.6 million) in 2010 and 2011.

The operating cost reduction initiative for the system is a serious multiyear effort with clear established targets. The fear of failure for the technology loomed large as the system was being designed for the trial period. The Stockholm system planners knew that the trial system needed to run nearly flawlessly to gain public confidence and acceptance. The consequence was an expensive system to operate. This has led to an aggressive refinement of operating practices to reduce ongoing costs.

Overall, the congestion tax reduced traffic volumes by 10 to 15 percent, and congestion fell by 20 percent in the CBD. Transit ridership grew by 6 to 9 percent during the demonstration. This resulted in a 14 percent reduction in vehicle-miles traveled and a 10 to 14 percent decrease in emissions. After the system was taken offline at the end of the demonstration, traffic volumes returned to about the same level as before the trial. After its permanent reintroduction in August 2007, the data show that access to the CBD improved, travel times were lower, and a 20 percent reduction in congestion was realized.

SOURCE: Gunnar Soderholm Presentation, City of Stockholm, Dec. 8, 2009

Figure 7. One of 18 control points using the three-gantry electronic toll collection system.

DEMAND MANAGEMENT:
London's Congestion Charge

In 2003, under the leadership of Mayor Ken Livingstone, London launched a bold initiative to designate a congestion charging zone in central London and charge vehicles to travel within the 8-square-mile (20.7-square-kilometer) area (figure 8, see next page). In 2007, the charging area was doubled in size with a western extension. Because of changes in leadership and public consultation, the western extension was scheduled to be repealed in 2010.

With London roads congested most of the day before the congestion charge, it was estimated that 40 percent of England's congestion was in greater London, with central London the most congested. Average all-day speeds were less than 9 miles per hour (mi/h) (14.4 kilometers per hour (km/h)) in central London. Delays were costing people and businesses £4 million to £6 million (US$7 million to US$10 million) per week in time and money. Thus, the objective of the congestion charge was to reduce traffic, improve travel times for buses, generate new revenues for public transit, and enhance the quality of life in central London. The mayor's vision included a 40 percent increase in public transit service by 2011, with the immediate expansion of bus services before the start of congestion charging in February 2003.

The flat weekday charge was set at £5 (US$10.50) initially and raised to £8 (US$13) in August 2005. The charge is in effect on weekdays from 7 a.m. to 6 p.m. (figure 9, see next page). Various exemptions and discounts are allowed, including a 90 percent discount for residents living in the

London's Congestion Charge

Purpose: Manage congestion (primary), promote transit and reduce emissions (secondary)

Application: Urban area pricing

Fee structure: Flat rate of £8 (US$12) per day (90 percent discount for residents in the zone)

Use of revenues: Fund improvements to London transit (80 percent) and transportation (20 percent)

Technology: ANPR

Milestones: February 2003 (central London zone began operations), August 2005 (charge increased), February 2007 (western extension of zone), 2010 (repeal of western extension)

Managing authority: Transport for London

Other highlights: Significant investment in transit, repeal of western extension in 2010, 30 percent of vehicles entering the zone are exempt

Results: 25 percent and 19 percent reduction in traffic (central and western extension, respectively), net annual revenues of £137 million (US$220 million) in 2008

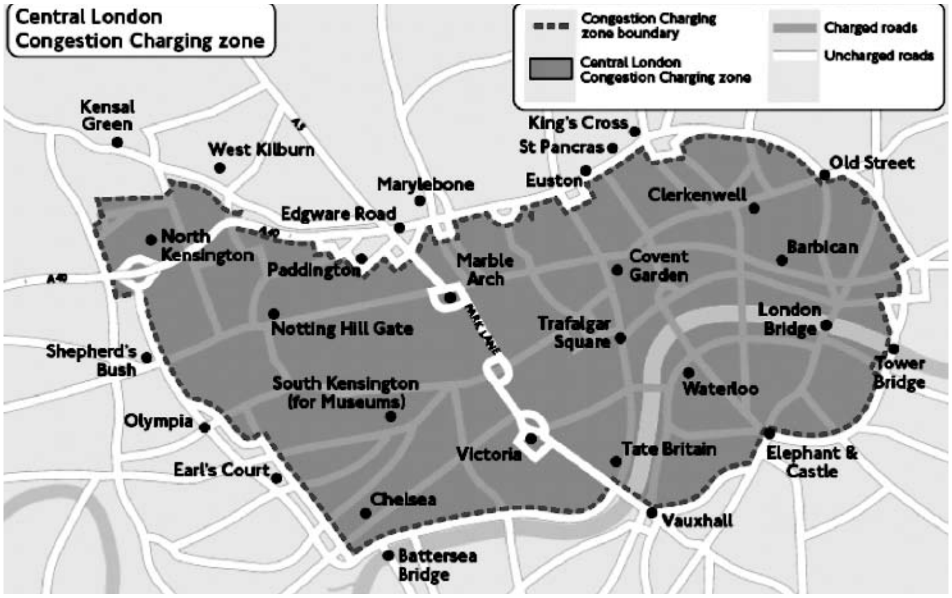


Figure 8. Central London congestion charging zone.

Figure 9. Congestion charging sign.

Figure 10. A total of 1,360 cameras are located on all routes into and out of the zone as well as within the zone.

Figure 11. Example of a penalty charge notice.

pricing zone. Buses, taxis, emergency vehicles, hybrid cars, and motorcycles are exempt as well.

Enforcement is conducted using 1,360 closed-circuit cameras at 348 sites along the cordon and within the zone with roving vans policing the zone, capturing live video images of the license plates of all vehicles (see figure 10). Every operational weekday, the ANPR system captures and processes 1.45 million images. The daily charge must be paid by the end of the day following the day the charge was incurred and can be paid online, by phone or text message, or in specific stores with the "epay" or "congestion charge" logo. If the charge is not paid by midnight of the day following the day of the charge, the cost increases by 25 percent to £10 (US$16.25). The penalty for nonpayment is about £40 (US$65) if not paid until after mail receipt of a penalty charge notice (figure 11). To minimize erroneous penalties, key data and images for every possible penalty charge is manually checked before being issued. The penalty triples to £120 (US$195) if not paid within 4 weeks. Users can pay up to 90 days in advance for travel within the charging zone. In addition, monthly and annual passes are available at a discounted rate.

After implementation of the London congestion charge, the number of vehicles (four or more wheels) entering the charging zone decreased by 25 percent, or 70,000 fewer vehicles per day, and has remained constant. The amount of circulating traffic fell by 15 percent after the first year of implementation. Travel speeds increased by 30 percent, trip times decreased by 14 percent, and traffic delays plummeted by 25 percent in the charging zone. Transport for London (TfL) reported an average of 70,000 fewer daily vehicle trips than in the year before the congestion charge. Of those reduced trips, an estimated 50 to 60 percent shifted to transit (figure 12), 20 to 30 percent of the trips were eliminated, and 15 to 25 percent involved carpooling.

Despite the successes of the London congestion charge, traffic congestion in central London has gradually returned. In 2009, congestion levels within the central charging zone were equal to those evident before 2003. This is partly because of the decision to take advantage of the lower vehicular use of London's central roadways by converting portions of various streets or entire streets for pedestrians and bicycles and for dedicated bus lanes. The reconstruction of urban infrastructure (e.g., water and sewer lines) and construction related to preparations for the 2012 Summer Olympics have also consumed some street capacity, adding to vehicle congestion levels.

Revenues from the congestion charge were £268 million (US$435 million) in 2008. When accounting for expenses (about 50 percent), the congestion charge generated about £137 million (US$222 million) in the same year, which by law must be spent on transportation in greater London. Of the 2008 net revenues, 82 percent went for bus improvements, 9 percent for roads and bridges, and the remaining 9 percent for road safety, pedestrian and cycling facilities, borough plans, and environmental improvements (figure 13).

While the objectives of the congestion pricing program in London were achieved, critics point to the high operating costs of the system as a drawback. Much of the success of the system from a user's perspective rests with its relative simplicity, with only one price (£8 per day) charged when the system is in operation. Based on TfL's 2006 and 2007 reports, the business and economic impacts of congestion pricing have been largely neutral. Furthermore, a 2007 Coordination of Urban Road-User Charging Organizational Issues (CURACAO) report stated, "The level of acceptability of road user charging before the introduction was rather stable at about 40 percent. This also holds true in comparison with other scenarios such as workplace commuter tax schemes. After the introduction acceptability has risen above 50 percent."

Other urban area pricing proposals have been pursued unsuccessfully in the United Kingdom, notably in Edinburgh, Scotland, and Manchester, England. In both cases, the proposals were put to voter referendums before implementation. Without the opportunity for constituents to experience the tangible benefits of the road pricing initiatives, both proposals failed to garner sufficient voter support at the polls. Nationally, because of the 2010 elections and perceived lack of public support, neither major party actively considered or embraced road pricing on a broader level at the time of the scan.

Figure 12. Public service advertisement promoting shift to transit.

Figure 13. Public service advertisement promoting use of 2008 congestion charge revenues.

DEMAND MANAGEMENT: Singapore's Electronic Road Pricing

Singapore is distinctive in its geography as an island city-state situated at the southern end of the Malaysian peninsula, which limits the capacity for physical growth. Singapore's politics and culture are supportive of its ability to address these constraints by integrating multimodal transportation policies that incorporate stringent land use and vehicle ownership standards.

In 1975, Singapore undertook a bold new approach to manage traffic and improve air quality by introducing a fee for vehicles entering the CBD during the morning peak period of 7:30 to 9:30 a.m. Since its inception as a nonelectronic, prepaid windshield permit, Singapore's road pricing system has expanded and modernized to become the most extensive congestion pricing system in the world.

The paper-based road pricing system was converted to fully electronic in 1998 with the adoption of standardized in-vehicle units that employ DSRC for road pricing. The system also employs ANPR technology for enforcement. Both technologies allow the system to operate with vehicles traveling at full freeway speeds (up to 120 km/h). Known as Electronic Road Pricing (ERP), the system is fully automated, with more than 60 charging points covering the center city and some primary high-volume expressways (see figure 14).

All vehicles registered in Singapore are required to have one of six types of in-vehicle unit (IU) installed (figure 15).

Electronic Road Pricing

Purpose: Manage congestion (primary), promote transit (secondary)

Application: Cordon with time-of-day pricing in city center, as well as expressway and outer ring roads

Fee structure: Varies by time of day, location, and vehicle classification, with prices revised quarterly to maintain travel speed standards

Use of revenues: Returned to vehicle owners through tax rebates (through the general fund)

Technology: DSRC with in-vehicle units (known as IUs) equipped to accept smart cards tied to banking for payment, ANPR for enforcement

Milestones: 1975 (original permit scheme opened), 1998 (electronic charging began)

Managing authority: Land Transport Authority

Other highlights: Multimodal investments, vehicle quota system, integration with land use and transit planning, smart card technology protects user privacy, use of interactive gallery exhibit to educate younger audiences about road pricing and other transportation options

Results: Achieved target speeds of 45 to 65 km/h on expressways and 20 to 30 km/h on arterials, net revenue of SG$100 (US$75 million) in 2008

SOURCE: Bhatt et al. Lessons Learned from International Experience in Congestion Pricing

Figure 14. Singapore's Electronic Road Pricing (2005).

Each type is programmed to charge different rates based on the vehicle type. For example, a passenger car or taxi is charged for one passenger car unit (PCU), the price (SG$2.00) shown in the upper right of the pricing sign (see figure 16, next page). A motorcycle is charged 0.5 PCU, in this case SG$1.00, while a small bus is charged 1.5 PCU (SG$3.00) and a large bus is charged 2 PCU (SG$4.00).

A separate prepaid, stored-value smart card is inserted into the IU by the driver when the vehicle is in use. The smart card protects user privacy by not storing personal data on the card. The IU has a visual display and audio signal that tells the owner when a toll is charged and when the smart card balance is low. The smart cards are available through various banks and can be replenished at automatic teller machines, kiosks, gas stations, online, and by telephone. A newer generation smart card, called CEPAS (short for Contactless E-Purse Application Standard), was introduced in 2006 with the intent of increasing the card's utility to holders. It can be used to pay for transit fares and parking and at various retail stores.

ANPR technology is used for enforcement. Vehicles without an active transponder detected face a SG$70 fine (US$50), while those with insufficient smart card funds are charged an administrative fee of SG$8 (US$6). This automated enforcement keeps violations at less than one percent. The introduction of ERP was accompanied by new park-and-ride lots, expanded transit service into the CBD, and a 30 percent decrease in CBD parking rates.

Because of the ERP system's longevity in Singapore, its effects on travel behavior and traffic conditions are well known and predictable. By some accounts, it would require a three-fold gas tax increase to cause the same travel behavior change as a one-fold increase in ERP. Overall, prices in the CBD are set to maintain average travel speeds at 25 km/h. In October 2005, the cordon was extended to include the Orchard Area, the region's most prominent shopping district. Traffic and retail sales data were collected before and after ERP was introduced in the Orchard Area. Analysis of these data showed that ERP did not affect destination traffic to the shopping district. Sales continue to be healthy and grow at the same rate as before the ERP system was introduced to the area.

Singapore's ERP system varies its prices by time of day, location, and vehicle classification. Both upward and downward adjustments to the pricing schedule are considered every 3 months based on routine collection of traffic data on roadway speeds. The prices are set to ensure that targeted speed standards are maintained at an 85th percentile level to ensure free-flow speeds for at least 85 percent of vehicles charged. Speed targets are 45 to 65 km/h on expressways and 20 to 30 km/h on other streets. ERP prices can vary for a passenger car from zero to about SG$3 (US$2) per CBD cordon crossing and are in effect from 7 a.m. to 8 p.m. on weekdays. In addition, ERP hours of operations for the Orchard District include Saturdays from 10 a.m. to 8 p.m. On the expressways, the price varies from zero to about SG$5 (US$3.50) and is in effect weekdays from 7 to 9 a.m. and

Figure 15. In-vehicle units (six types are available based on vehicle classification) with prepaid stored-value smart cards are required in every motor vehicle, including motorbikes, registered in Singapore.

Figure 16. ERP charging point.

5:30 to 10:30 p.m. Unlike in Stockholm and London, no vehicles are exempt from the charge in Singapore, except emergency and military vehicles.

A major review of the ERP system was conducted as part of the Land Transport Master Plan in 2008. A number of enhancements were advanced, including 16 new ERP gantry locations, changes to the performance criteria, and rate changes. Traffic analysis showed that these enhancements resulted in an 18 to 25 percent decrease in traffic volumes in the Bugis-Marina area and a 7 to 21 percent decrease in the Orchard District on Saturdays (table 2).

Table 2. Summary of traffic results in Orchard and Bugis-Marina areas on Saturdays after July 2008 enhancements.

	Traffic Volume Decrease	Traffic Speed	Traffic Speed Improvement
Within the Bugis-Marina Centre Cordon	18–25%	20–22 km/h	3–2%
Within the Orchard Cordon	7–21%	21–25 km/h	1–30%

In 2008, annual gross revenues were SG$125 million (US$90 million), with net revenues of SG$100 million (US$72 million). While all of the net revenues are directed to the general fund, vehicle owners receive periodic rebates on vehicle taxes funded by ERP net revenues. Investments from the general fund are provided to appropriately address the needs of Singapore's multimodal transportation system.

Singapore's demand management techniques involve a combination of vehicle ownership and usage measures. Usage measures include ERP charges, gas taxes, parking restrictions and fees, and offpeak car registration permits that are purchased at a discounted rate and allow use of the vehicle only during weekends and nonpeak hours during weekdays. Car ownership is closely controlled by a quota on the number of vehicle licenses permitted each year. This vehicle quota system was implemented in 1990 to regulate the growth of the vehicle population in Singapore. These permits, called Certificates of Entitlement (COE), are acquired through an open online auction. In November 2009, the cost for a COE ranged from about SG$16,500 (US$11,800) to SG$18,300 (US$13,100). Other costs of vehicle ownership include vehicle registration fees, excise duties, and road taxes. In total, these taxes and fees increase the price of new vehicle acquisition to three to four times the actual cost of the vehicle. For example, a new Toyota Corolla with a dealer cost of SG$17,850 (US$12,800), costs about SG$70,000 (US$50,200) to purchase.

The Singaporean government takes a long-term approach to public outreach and education. It recently opened the Land Transport Authority (LTA) Transportation Gallery, an interactive exhibit that targets school-age children and teaches them about the past, present, and future of transportation planning and policies in Singapore. Gallery admission is free and includes a 1-hour guided tour through the following six transportation exhibits:

- **Journeys**—Provides an overview of land transport systems in the world's major cities, including Singapore's own modes of transportation
- **Memories**—Brings visitors back to experience the transportation modes available during Singapore's preindependence era
- **Formative Years**—Highlights key milestones in Singapore's land transportation development and the challenges faced during the nation's formative years
- **Land Transport Today**—Explains how LTA addresses the challenges of managing road usage and meeting the diverse needs of people
- **Challenge Theatre**—Engages visitors by putting them in the role of a transport planner in an interactive, multiplayer game about how to best develop and manage land transportation
- **Vision and Aspirations**—Propels the visitor into the future via interactive multimedia activities that provide a peek at what the Singapore transportation landscape might be like in 2030

The LTA Transportation Gallery is a powerful and engaging tool that teaches the next generation about the need for good transportation planning and how ERP is an effective demand management tool (figure 17).

Figure 17. LTA Transportation Gallery interactive exhibit.

REVENUE GENERATION: Germany's Heavy Goods Vehicle Tolling

Germany is at the crossroads of Europe, with significant east-west and north-south freight movements via trucks. German motor fuel taxes did not prove to be an effective means of revenue generation to pay for highway infrastructure maintenance resulting from the volumes of heavy trucks moving across Germany. As a consequence, the Germans sought a new source of revenue through distance-based charging on the autobahns, the equivalent of the U.S. interstate highways. The German HGV tolling program began commercial operations in January 2005. It is the world's first satellite-based, countrywide electronic tolling system and applies only to trucks weighing more than 12 tons on the autobahns and a small number of other national highways.

Germany's HGV Tolling

Purpose: Generate revenue for transportation funding and shift to user-pays approach (primary), reduce emissions and modal shift to rail/water (secondary)

Application: Distance-based pricing on selected national highways for heavy trucks

Fee structure: Based on distance, vehicle type, and truck emissions rating

Use of revenues: 50 percent to roads, 38 percent to rail, 12 percent to waterways

Technology: GPS, GSM, and DSRC with OBU and ANPR for enforcement

Milestones: January 2005 (opened)

Managing authority: German Ministry of Transport and Toll Collect GmbH (contractor)

Other highlights: Dual automated toll collection system and manual booking system, 35 percent of trucks are foreign, less than 2 percent violations

Results: Empty trucks declined by 7 percent, 58 percent shift from dirtier to cleaner trucks, revenues of $5 billion in 2008

All trucks, irrespective of national registry, are tolled based on the number of axles, vehicle emissions rating, and distance traveled.

> The idea of a distance-based charge was conceived in 1989. Studies were conducted subsequently, and in 1995, based on the recommendations of the German High Commission (Paellman Commission) on Financing of Federal Transport Infrastructure, the federal government decided to introduce distance-based tolls. Initial opposition turned into acceptance because tolling of all heavy goods vehicles was considered fairer for German trucks vis-à-vis foreign trucks, which account for about 35 percent of all of the country's truck traffic.—Robinson, 2008

The key policy objectives were to raise revenue by imposing a national distance-based, user-pays infrastructure fee for trucks. The pricing is based on the distance traveled, vehicle emission class, and the number of axles. In addition to generating revenue, the objectives of the system were to create incentives to shift freight truck traffic to rail and waterways, promote the use of cleaner truck technologies, encourage more efficient routing and scheduling of trucks, and provide funding for maintenance and expansion of transportation infrastructure.

The system covers about 7,700 road miles (mi) (12,392 kilometers (km)), including 30-plus mi (48 km) of local roads and more than 2,460 access points (figure 18). Truckers have two payment methods (see figure 19):

- An automated system using a combination of satellite-based (GPS) tracking via onboard units (OBU), mobile communications (GSM), and DSRC for enforcement interrogation

- A manual booking system, which allows trucks without OBUs to book their travel via the Internet or through roadside terminal kiosks available to arrange for payments

Both payment methods are enforced through an ANPR system housed at 300 control point gantries, supplemented by 280 mobile enforcement vehicles. The dual system of stationary and mobile enforcement ensures that violations are kept to a minimum. Initially predicted to be 5 percent, the actual violation rate is less than 2 percent. Fines are €400 (US$580) for intentional violations and €200 (US$290) for unintentional violations. The maximum fine is €20,000 (US$29,000), with the responsibility for fines split equally between the driver and shipper.

While 90 percent of all payments are made with OBUs, the remaining 10 percent of the vehicles, most foreign, opt for manual booking. While manual bookings represent only 10 percent of all transactions, they represent more than one-third of total operating costs. There are 3,600 manual terminals in Germany and neighboring countries. Manual bookings require the acquisition of a ticket as proof of

Figure 18. German autobahn system.

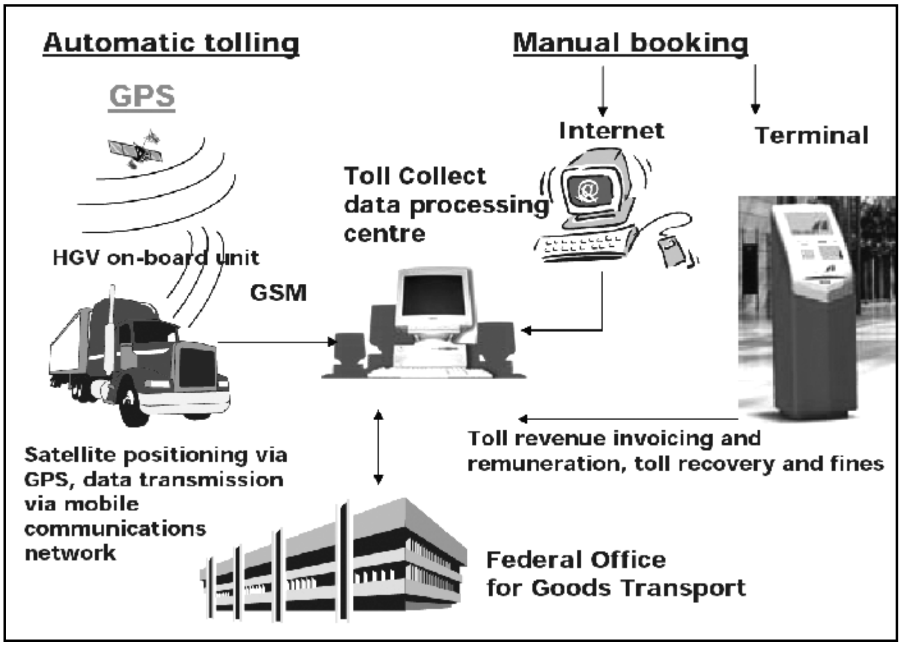


Figure 19. Automatic tolling and manual booking processes.

payment before using the autobahn. The system was designed to ensure nonstop, highway-speed tolling and has achieved this objective.

The OBU calculates the toll, adding segments together and charging the appropriate unit rates. As soon as the accumulated cost reaches €20 (US$29), the OBU communicates the cost information to the central processing unit. This threshold is established to avoid the costs of more frequent communication. The OBU also sends the data every 72 hours, or whenever the truck leaves the country. The OBU has three communication channels:

- GPS is used for georeferencing of when a tolled route is entered. Typically, three to four satellites at a minimum are required for accuracy.
- A DSRC module, employing infrared microwave technology, provides interoperability and communication with enforcement gantries while also supporting positioning.
- GSM communicates from the OBU to the central computing center. The GSM is a bidirectional communication stream through which the data processing center is connected to the OBU.

New tariffs are communicated to the OBU via this capability, with tariff tables stored on the OBU. The OBUs were specially designed and are provided by two competing vendors, which was a requirement of the government contract.

The OBUs will be a platform for future value-added services, but they only provide toll collection functionality today. Toll Collect is limited to toll collection functionality for OBUs by virtue of its government contract and cannot develop value-added services for the in-vehicle units. The cost of installing the OBU is paid by the hauler, and costs vary by country. It costs about €50 to €60 (US$73 to US$87) for installation. Many new trucks come equipped with the cables and connections for OBUs preinstalled. Toll Collect left the whole business of OBU installation to the private sector. The cost of the OBU, about €250 (US$363), has fallen significantly from the early days of the system's introduction.

A European Union directive lays out the principles for toll rates and revenues. Toll rates are based on the cost of the infrastructure on a life cycle basis. The toll rate is related to the cost of construction and periodic infrastructure upgrades and maintenance required. Toll rates range from about €0.141 to €0.288 per km (about US$0.327 to US$0.669 per mi). The average toll rate is €0.163 per km, or about US$0.378 per mi. Certain European Union directives restrict the highest toll rate from being more than twice the lowest toll rate. Annual gross revenues have grown steadily from €2.86 billion (US$4.1 billion) in 2005 to €3.5 billion (US$5 billion) in 2008.

To comply with European Union Directive 2004/52/EC, which requires equal treatment of foreign vehicles, accommodations were made to provide a manual payment option at the German border. While manual bookings represent about 10 percent of all transactions, they represent more than one-third of total operating costs. Those who use manual bookings have 3 days to make their trip once registered at one of the 3,600 terminals in Germany and neighboring countries. An online manual booking option is also available, but not well used. Truckers using the manual method are considered hard-core users and do not appear willing to install an OBU.

The GPS-based tolling system was procured through a public-private partnership (PPP) formed between the Ministry of Transport, Building, and Housing, responsible for contracting and system regulation; the Federal Office for Goods Transport (BAG, figure 20), responsible for enforcement; and Toll Collect GmbH, a private-sector joint venture responsible for the system's design, implementation, operations. and maintenance. Toll Collect is a private joint venture comprised of Daimler Financial Services (45 percent), Deutsche Telecom (45 percent), and Cofiroute (10 percent). Cofiroute provided the international tolling experience dictated by the German procurement. The Ministry of Transport entered a 15-year design-build-finance-operate contract with Toll Collect GmbH. As part of this procurement, Toll Collect paid for the system's capital cost and is required to maintain system accuracy and availability at or above 99 percent. The specifics of the PPP contract are not publicly available because of confidentiality agreements that protect sensitive details related to Toll Collect's proprietary software, technology, and business processes.

Toll Collect received €598 million (US$868 million) in compensation for services in fiscal 2007–08. This includes operations of the automated and manual toll collection systems; service fees for payment providers; operation of the toll terminals, enforcement gantries, and mobile enforcement equipment; mobile communications; system depreciation; and net income before taxes and interest. In 2009, it was expected that 11 percent of total toll revenue would be required for Toll Collect's compensation. While it is difficult

Figure 20. Federal Office for Goods Transport mobile enforcement vehicle.

to ascertain specific operating costs and profit for Toll Collect, annual operating costs are estimated at 15 to 20 percent of revenues, about US$0.057 to US$0.076 per mi. Costs of operations have been reported in the media to be as high as 30 percent of revenues, which would be about €1.05 billion for 2008. Toll Collect officials claim this is misleading because the manual system is responsible for €140 million of the cost and depreciation is €120 million.

Revenues are allocated by Parliament using the framework of 50 percent to roads, 38 percent to rail, and 12 percent to waterways. Initially, to gain support from the German trucking industry, these additional revenues were added to the general fund allocation for roads, rail, and waterways. In addition, a freight mitigation fund was created to help truckers purchase more environmentally friendly equipment and provide training. An annual appropriation of €560 (US$815 million) derived from the net HGV toll revenues was budgeted by Parliament to support this harmonizing fund. However, the level of funding allocated from the general fund has been reduced by an amount about equal to the new revenue generated by HGV toll collections. Although the harmonizing fund continues to be fully supported, the promised funding increase for roads using revenues from HGV tolls has not materialized because of significant federal budget shortfalls. Since roadway funding continues to be flat, the original promise to dedicate all new revenues generated by HGV tolling to the transportation system has not occurred.

Initially, there were concerns that HGV tolling would divert freight trips from the autobahns to toll-free local routes. To address these concerns, three connector segments that total a little more than 30 mi (48 km) of nonautobahn roadways were integrated into the HGV tolling system. Initially, some truckers tried to bypass the HGV tolls by using local routes, but they quickly realized that the cost in time and additional operating expenses exceeded the cost of the toll. Diversion to alternative routes faded and the proportion of trucks shifting from the freeway system to local roads is now negligible.

In part because of the imposition of higher tolls on higher polluting trucks, a dramatic growth in cleaner trucks was observed. Based on the European Union's five-step emission classification scale (with Euro 5 being the cleanest vehicles and Euro 1 the dirtiest), the number of vehicle-miles using cleaner trucks (Euro 4 and 5) rose from 2 percent in 2005 to over 62 percent in 2009. Conversely, the number of vehicle-miles driven by dirtier trucks (Euro 1, 2, and 3) declined by 60 percent, from 98 percent to 38 percent of the fleet-miles traveled (figure 21).

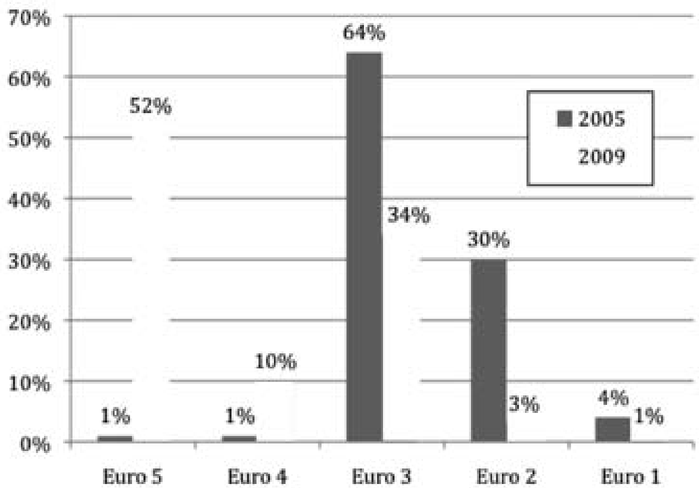


Figure 21. Truck vehicle-miles show a shift from dirtier (Euro 1, 2, and 3) to cleaner (Euro 4 and 5) trucks (2005 to 2009).

While the costs for operating the HGV tolling program are considerable, Germany has demonstrated that distance-based tolling can be successfully implemented at a national level to accomplish the following:

- Shift to a user-pays approach.
- Improve system efficiency by creating incentives to reduce empty truck trips.
- Reduce greenhouse gas emissions by promoting the use of cleaner trucks and truck technology.
- Generate substantial new funding for infrastructure.

Tracking about 1.5 million trucks annually, the system is flexible, scalable, and robust. Road segment distances are regularly audited to ensure accuracy. In addition, road segments can be added, time-of-day toll rates applied, and differentiation by road type introduced without the need for costly roadside infrastructure. While there is no public interest to expand the HGV tolling system to all vehicles, the technical feasibility of adapting the system to accommodate such an effort would be relatively straightforward.

REVENUE GENERATION:
Czech Republic's Truck Tolling

Like Germany, the Czech Republic's central location in Europe draws high volumes of through truck traffic both east-west and north-south. About 40 percent of the trucks using the Czech highway system are foreign based. Thus, the primary goal of the Czech truck tolling program is to generate revenue from foreign trucks that were perceived to not be paying their fair share of system costs, including infrastructure wear and tear. The tolling program began operations in January 2007 and uses a transponder-based system relying on DSRC-based tolling points on the highways' main line to calculate distances. ANPR equipment is employed for enforcement. At the outset, the toll applied only to trucks weighing more than 12 metric tons. In January 2010, the truck toll was applied to all commercial trucks weighing more than 3.5 metric tons.

The Czech government approved moving forward with the truck tolling program in 2004. The procurement documents for the tolling system were issued in 2005 with four suppliers responding. After the selection of the winning bid, the unsuccessful bidders filed objections and complaints.

Czech Republic's Truck Tolling

Purpose: Revenue generation

Application: Truck-only distance-based pricing on selected national highways

Fee structure: Distance, vehicle classification, emissions rating

Use of revenues: Road and railway improvements

Technology: DSRC for toll collection and ANPR for enforcement

Milestones: January 2007 (all trucks 12 metric tons or more pay toll), January 2010 (expansion to include trucks 3.5 metric tons or more)

Managing authority: Czech Ministry of Transport

Other highlights: 40 percent foreign trucks, implemented in under 10 months, special law prohibiting truck operations on Sundays and peak times on Friday evening and Saturday morning

Results: Average toll rate of CZK4.05 per km (US$0.36 per mi) for highways and CZK1.90 per km (US$0.17 per mi) for first-class roads, revenues of CZK6 billion (US$340 million) in 2008

Construction of the phase I tolling system was scheduled to begin in January 2006, but was delayed by the unresolved complaints surrounding the procurement. On March 29, 2006, the Czech Office for Economic Competition ruled in favor of the selected bidder, and a 10-year design-build-finance operate contract was signed. The procurement delays forced the stage I construction period to be reduced to 9 months. This aggressive delivery timetable was achieved by using a 5.8 gigahertz system similar to one recently deployed in Austria. Pilot operation of the electronic tolling system started in the Czech Republic on Dec. 15, 2006, and the system was launched on Jan. 1, 2007. The open road tolling system was designed and implemented based on European Union directives 1999/62/EC, 2006/38/EC, and 2004/52/EC, which address environmental consequences of roadway use, cost constraints, and interoperability of electronic toll services.

The Czech tolling system has the lowest rates of those charged in central Europe, significantly lower than the roadway charges in effect in Germany and Austria. As a consequence, there has been some commercial traffic diversion of trans-European cargo movements from other countries to the Czech highways.

Revenues from the program generated about 6 billion Czech korun (CZK) (US$340 million) in 2008, with an average toll rate of CZK4.05 per km (US$0.36 per mi) for motorways and highways and CZK1.90 per km (US$0.17 per mi) for first-class roadways (i.e., principal arterials). The Czech government requires that all trucks using Czech roads install an OBU. Certain types of vehicles, including first responders and law enforcement, are exempt from the toll, but are still required to register and install an OBU. While specific system operating costs are not publicly available, it is estimated to be about 30 percent of gross annual revenues.

Truckers or their firms submit a deposit of CZK1,550 (US$88) to the government, which pays for the cost of the OBU, its installation, and administration. In December 2009, 420,000 transponders were in use with another 100,000 transponders expected to come online in 2010 because of the change in the gross vehicle weight threshold subject to a charge from 12 metric tons to 3.5 metric tons. Changes to the toll rate are proposed by the transport minister and require approval by the Czech Parliament.

When the scan team met with Czech tolling representatives, national laws were being debated that impose unique restrictions limiting truck movements on Friday afternoon and weekend days to preserve roadway capacity for nonfreight trips on weekends. Resistance to these measures was significant from freight interests unable to work a full week. Other problems with the Friday restrictions were lack of capacity for truck parking and incompatibility with driver restrictions in other countries. The restrictions on Friday truck traffic reduced traffic

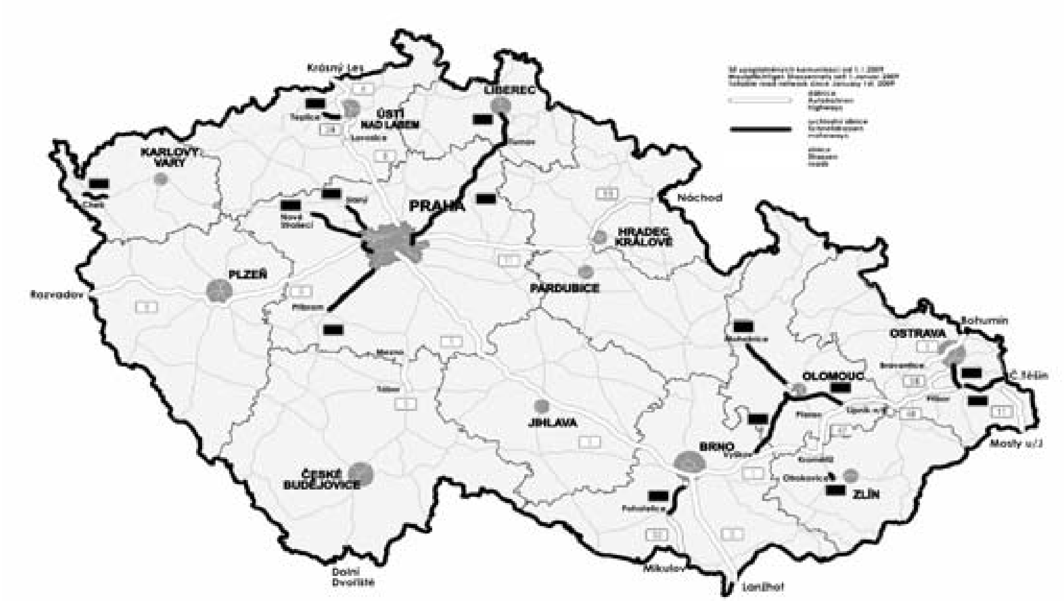


Figure 22. Czech truck tolling network.

congestion on Czech highways 50 to 60 percent, according to Czech officials. Toll rates were changed on Feb. 1, 2010, to increase regular truck toll rates by 25 to 50 percent on Fridays from 3 to 9 p.m. in an apparent effort to use market pricing rather than vehicle restrictions to manage commercial traffic demand during that peak congestion period.

This implementation of truck tolling on freeways and expressways is considered the first phase of a more comprehensive road pricing system (figure 22). Future plans (phase 2) are to extend tolling to 800 km of additional roadways by 2017 by including some arterial and local roads. Capital costs for the initial implementation (phase 1) and future expansion (phase 2) of the system are estimated at about CZK18 billion (US$1 billion). When complete, phases 1 and 2 will include 1,120 mi (1,802.4 km) of expressways and freeways and 43 mi (69.2 km) of connecting main roads. This expansion of the existing system will seek to employ microwave technology and GPS-based OBUs because the cost associated with installing additional gantries on arterials and local roads is considered excessive.

DEMAND MANAGEMENT AND REVENUE GENERATION: The Netherlands' Proposed Distance-Based Tax

The Netherlands is a small, densely populated country with an integrated, multimodal transportation system, but it nonetheless experiences highly congested roads. As a consequence, the Netherlands has been planning an ambitious national road pricing program. The plans have been to introduce a countrywide distance-based road user fee for trucks by 2012 and to expand the system incrementally to all vehicles (about 8 million) by 2018.

In late 2007, the Dutch Cabinet decided to implement a national road payment based on the following policy goals:

- Improve mobility and accessibility to benefit the economy.
- Develop a more fair system that focuses on use of the road system rather than on vehicle ownership and replace current license fees and vehicle taxes.
- Enhance the environment.
- Improve road safety.

The Dutch Cabinet considers a distance-based road-user fee to be a more transparent and equitable method to fund the transportation system and effectively manage congestion. The new system is designed to be revenue neutral by phasing out high license fees and other vehicle ownership taxes and introducing a per-kilometer charge in their place. While the precise price per kilometer is still in planning, the expected tariff for autos at the start is €0.030 per km (US$0.07 per mi), with the rate expected to reach €0.067 per km (US$0.155 per mi) at full implementation. The lower rates at the program's start reflect the fact that vehicle ownership taxes will be phased out over time and user fees will increase. The per-kilometer tariffs for other vehicles at implementation are planned to be €0.017 per km (US$0.039 per mi) for commercial vans, €0.028 per km (US$0.065 per mi) for buses, and €0.024 per km (US$0.056 per mi) for trucks. The relatively low rate for trucks corresponds to the fact that trucks pay relatively lower rates for the vehicle taxes that will be replaced by the road charging system. In addition to pricing by vehicle type, the system was planned to take into account vehicle emission class and time-of-day pricing for peak and

The Netherlands' Kilometer Tax

Purpose: Improve mobility, manage demand, and shift to user-pays approach (primary)

Application: National distance-based pricing of all roads for all vehicles

Fee structure: Based on distance and vehicle type with option to include emissions class and time of day

Use of revenues: Replacement of vehicle ownership taxes now in place

Technology: GPS, ANPR, GSM

Milestones: 2012 launch (trucks only), 2018 (all vehicles)

Managing authority: Dutch Ministry of Transport

Highlights: In planning stages and under development, unique requirements that minimize system installation and operating costs, revenue neutral (offset by reduction in other transportation taxes)

Forecasted results (2020): 10 to 15 percent reduction in vehicle-miles traveled, 10 percent reduction in CO_2 emissions, 6 percent increase in public transit use offpeak travel. All revenues will be dedicated to the road system to offset existing license and registration fees.

Based on 2020 forecasts, the distance-based tax would result in the following:

- Ten to 15 percent reduction in kilometers traveled
- Travel time savings of 40 to 60 percent
- Ten percent reduction in CO_2 and PM_{10} emissions by passenger cars
- Six percent increase in miles using public transport
- Seven percent increase in traffic safety

The method for toll collection and vendor selection has not been decided, but the Dutch high-level system design envisions a satellite-based (GPS) technology combined with in-vehicle equipment and mobile communications. The procurement approach will be to employ open systems design standards that comply with the European Union's future standards for tolling interoperability. The intent is to enable free marketplace access to the road-pricing system by certified suppliers of products and services. The procurement will involve market-based parties whenever possible, leaving detailed system designs, system implementation, and equipment installation in vehicles to private sector companies and giving the government the role of ensuring installation quality. This open approach to design, implmentation, and installation is intended to create market competition and provide private interests with the incentive to develop value-added services for the equipment being deployed. Similar to what is occuring in the mobile device industry, this would enable a wide variety of developers to provide enhanced applications and services that deliver the basic toll collection function, but also provide greater value to users. This approach is expected to yield revenues that may offset the cost of initial implementation and ongoing operating costs.

Figure 23. Congestion on the roadway system in the Netherlands.

Administrative costs are a major concern for the Dutch. To manage costs, they have looked aggressively at technologies and business processes to minimize them. The Dutch Parliament has set a goal for operating costs to not exceed 5 percent of gross revenues and for OBUs to cost less than €100 (US$145) installed. At the proposed fee structure, it is estimated to cost US$0.0075 per mi, based on 5 percent of US$0.155 per mi, to collect and enforce the Dutch kilometer tax program.

The Dutch have also created a €100 million (US$145 million) fund to support innovative congestion management projects from 2007 to 2011. This fund is intended to provide more immediate, short-term congestion relief through road pricing pilots in selected corridors without adding new roadway capacity. Next steps include extensive consultation, amendment of legislation, and development of a more detailed migration plan from vehicle taxes to the distance-based tax. While the Dutch political climate is unsettled because of upcoming elections, steps have been taken to conduct a large-scale system test in 2010.

On Feb. 20, 2010, about 2 months after the scan team returned to the United States, the three-party majority coalition comprised of the Christian Democratic Alliance, Christian Union, and Labor Party collapsed over the issue of continued Dutch troop support of North Atlantic Treaty Organization efforts in Afghanistan. The coalition government held only 46 of the 150 Parliament seats with the departure of the Labor Party and was relegated to a caretaker government role until the June 2010 elections. With Camiel Eurlings' resignation in March 2010 from the post of transport minister, the fate of a future large-scale test and overall implementation of the Netherlands' distance based tax was uncertain.

Chapter 3 | Major Findings

The countries the scan team visited are ahead of the United States in broadscale road pricing implementation. They each provide valuable case studies for learning for U.S. transportation professionals and decisionmakers. Overall, the experience in each host country proved that road pricing is an effective tool to manage demand and raise revenue.

The scan team developed the following nine major findings:

1. Host countries and regions with clearly defined and well-understood policy goals were able to achieve their targeted outcomes most effectively.

The city-center urban road pricing programs visited all targeted congestion mitigation as a central goal. Generally, road pricing was one element of a larger program of initiatives working collectively to address traffic congestion and its impacts. Programs that sustain a focus on traffic congestion have sustained traffic-reduction benefits.

- Singapore identified clear transportation goals as a critical foundation for urban development and economic growth plans and has maintained this focus for many years. Congestion management objectives include road pricing tied directly to targeted minimum- speed thresholds for urban streets and arterials. In addition to the ERP system, congestion management is also addressed through multimodal transportation investments as alternatives to driving, parking management systems to facilitate identification of available parking, and national quotas that cap increases in vehicle ownership. Highly integrated land use and transportation planning also support congestion management objectives.

- Stockholm's congestion tax was designed to reduce congestion in the city center in a manner that promoted public acceptability and fairness through reasonable toll prices, daily maximum charges, expanded transit and park-and-ride services as alternatives to driving, and exemptions for Lidingö Island traffic unable to avoid traversing the city center. The congestion pricing program improves the quality of life in the city center for residents and travel options for drivers. In Germany and the Czech Republic, the distance-based charging of commercial vehicles was designed to capture revenues aligned with the infrastructure life cycle costs required to maintain roadways for HGV use. Political decisions in Germany to divert existing general funds from transportation to address other budget shortfalls contradicted commitments to use road-pricing revenues to augment existing infrastructure investment, fueling resentment and skepticism from trucking interests.

- The Germans and Czechs viewed their pricing programs as an opportunity to capture road revenues from foreign through truck traffic, but found that manual booking systems for those without in-vehicle units are expensive to operate.

- The Netherlands plans to introduce a distance-based charge for all vehicles and roadways. This kilometer-priced system would replace motor vehicle taxes on passenger cars and commercial trucks and eliminate vehicle purchase taxes on passenger cars and motorcycles. As such, roadway network users would pay for vehicle use, not vehicle ownership. Existing fuel taxes would remain in place. Thus, the government's policy goal is to improve mobility and quality of the environment. The Dutch government believes a true user tax would be more effective for managing demand than the current ownership taxes, which have the effect of overcharging car owners who do not drive much.
For example, owners of classic cars pay an ownership tax even if they do not drive the cars. The universal user-pays principle in the Netherlands is expected to generate strong environmental benefits from trip consolidation and alternative mode choices. The environmental benefits achieved by the Germans and Czechs are evident through price incentives for cleaner vehicles and a reduction in empty truck movements.

2. **A large-scale demonstration project is a powerful tool for building public acceptance, allowing people to experience the benefits of congestion pricing.**

Stockholm's trial of the congestion tax system from January to July 2006 demonstrated the benefits of congestion pricing firsthand. Sequencing a referendum vote after the trial concluded was instrumental in garnering public support. The pilot demonstration also provided technical and administrative staff with opportunities to refine the system and its performance, streamline business processes, and reduce operating cost.

3. **Thorough planning and performance measurement pay benefits in ensuring achievement of overall goals, managing the pricing program as an element of overall transportation system performance, and directing implementation and operations effectively.**

Comprehensive network planning was integral to the preimplementation efforts for the road pricing systems examined on this scan. The best-in-class road pricing programs have integrated public transport options into their planning and preimplementation actions.

- London, Singapore, and Stockholm made significant advance investments in transit equipment, facilities, and services.
- In planning the Stockholm system, internationally recognized traffic experts were retained to measure network effects of various configurations of the charging zone to ensure that there were no unintended effects outside the congestion charging zone.
- The Netherlands has undertaken comprehensive planning exercises to look at network effects of proposed tariffs across several modes, as well as the operating performance of the network when travel demand is redistributed by time of day.
- Singapore uses advanced analytics and traffic models to better understand the network impacts of pricing on parking and transit.

Performance measurement is key to managing and maintaining goal attainment.

- All new pricing systems adopted direct performance measurements of traffic reductions, travel speed increases, mode shift, and clean vehicle adoption, as well as estimates of business impacts and emissions reductions.
- Singapore's ongoing management of its congestion charge includes quarterly verification of travel speeds and refinement of prices to ensure that 85th percentile travel speed standards are maintained on two different classes of roadways.
- The Netherlands has adopted comprehensive risk analyses to manage program schedules and budgets.

Postimplementation planning and performance assessments focused on the right measures have ensured cost efficiency and operating effectiveness.

- Stockholm has benefited from ongoing assessments of system redundancies and business practices to reduce operating costs while maintaining system performance. Changes to payment methods, payment processes, and image processing have saved systems and operating costs.
- The Czech Republic is seeking relief from contractually high DSRC OBU costs by planning system expansion to employ GPS and microwave technologies.
- Germany's truck tolling system suffers from high costs for manual bookings, but the joint venture contract incentivizes system accuracy, not cost performance.

4. **Linking the pricing structure to the benefits the user receives contributes to public acceptance and helps avoid potential negative impacts from traffic diversion.**

To maintain support for road pricing, some of the sites studied attempt to connect the pricing structure to the benefits received by the toll payer.

- In Sweden, toll rates on new roadway infrastructure are set at levels that reflect the value of the reduced travel time and operating costs compared to existing non-priced routes. While this strategy may not fully recover the costs for the new infrastructure (thus requiring public subsidy), it ensures that the new infrastructure will be used optimally (i.e., traffic will not stay on existing free routes simply to avoid the toll). In Stockholm, the price schedule for the cordon charges was set to reflect the expected benefits to those who would pay the new charges. The concern was that if the public perceived tolls to be too high, they would not accept them. Toll rates were set at the minimum levels needed to manage congestion, not to achieve a specific revenue target. The congestion tax rates were set to match the value of time saved. Since its introduction, the congestion charging rates have not been changed. While there is a recognition that future increases will be needed to address growing travel demand and inflation, public acceptability of any rate changes is an important consideration. Because the congestion charge is defined as a national tax, it can be changed only by an act of Parliament, which makes it less nimble.

- In Singapore, the price is reviewed and can be adjusted every 3 months to ensure that targeted optimal speeds can be maintained for at least 85 percent of vehicles that pay the toll. The concern is that the public obtain value in the form free-flowing traffic in return for the tolls paid. In the early days of operation, LTA attempted to set toll rates to achieve the targeted speeds on average. It quickly learned that this meant that only about half of the toll-payers received the targeted service levels, and the public perceived it had not received value for tolls paid. This led the authority to institute the 85th percentile standard. All net funds collected via ERP are returned to the general fund and redistributed to road users in the form of vehicle ownership tax rebates, which further emphasizes that the purpose of road pricing is not to generate revenue, but to improve service levels during peak hours. Singapore's ERP has the most dynamic and flexible pricing structure of the sites visited.

- The German truck toll rates for use of the freeway system (i.e., autobahns) are low enough that little or no truck traffic is diverted to toll-free alternatives. While there was some diversion immediately after implementation in 2005, truckers quickly realized that time and operating cost savings on the autobahn system more than compensated for new toll charges for using the autobahns. The Germans set the truck toll rates to average €0.163 per km (US$0.378 per mi) to capture the impact of HGVs on the transportation system. The fairness of the toll rates as charges for services is reinforced by the way toll rates are calculated. To determine the average toll rate, the estimated infrastructure cost imposed by HGVs (estimated in 2010 at €5.2 billion) was divided by the total number of HGV km on the highway system (29.8 billion km). This is calculated at €0.174 per km, so the €0.163 per km actual average toll rate is perceived to be fair. It captures more than 90 percent of the estimated HGV impacts on the highway network. In addition, the €560 million (US$815 million) annual harmonization fund for truckers is dedicated to trucking community use for safety training and equipment purchases, which provides a direct nexus between the funding source and the use of funds.

5. Public outreach and communications were key components of the program at every stage: before the implementation decision, during the program design process, and during the operational phase.

Both London and Stockholm had years of public debate about congestion charging before the political decision to implement was made. London's program benefited from promotion by business groups concerned about congestion, while the Stockholm program was spearheaded by environmental groups. Both programs were designed to address public concerns and include a number of exemptions and discounts to mitigate negative impacts on particular segments of the public.

After several attempts to implement a distance charge, the Dutch realized that proactive stakeholder outreach during the planning and concept development stage is essential. Over the past 2 years, staff and leadership at the Dutch Ministry of Transport have invested heavily in public outreach and education. By engaging in a thorough and thoughtful planning and public involvement process, the Dutch developed clear, salient, and timely messages about the purpose and benefits of pricing. A key message is "drive less, pay less."

In Singapore, key messages continue to be conveyed to the public to ensure continued support. These messages include the following:

- "Keep roads free-flowing"
- "People-centered transportation"
- "Public transit is a viable choice"

As system expansion continues, before a new gantry is installed, there is extensive outreach in affected neighborhoods to address concerns. For example, the times for operation of expressway pricing were modified to respond to public comments.

The Czech and German programs achieved support from local truckers by emphasizing the effect on leveling the playing field with foreign haulers and the fairness of the user-pays concept.

6. **Open-source system designs offer long-term advantages in leveraging market competition to manage costs of implementation and operations, ensure system flexibility and scalability, and establish a foundation for system interoperability.**

The Dutch plan will establish standards and requirements that will allow multiple vendor solutions to create a competitive environment.

- The Dutch procurement will encourage market engagement in all aspects of the system, driving down costs for system implementation, equipment, and in-vehicle installations.

- Through open standards and private sector engagement, the Netherlands will encourage private value-added services for onboard devices that help defray operating costs as well as drive consumer adoption and public acceptance of road pricing.

- The Dutch goal is for system operating costs to not exceed 5 percent of gross revenues.

Singapore's second-generation smart card for the in-vehicle unit financial purse is designed to be interoperable with the transit fare media and parking payment systems, as well as accepted for retail purchases and linked to bank accounts.

7. **Interoperability among states and countries is recognized as a critical issue that needs to be addressed at high levels.**

The European Union has adopted Directive 2004/52/EC, which outlines requirements for member countries to adopt interoperable standards (i.e., European Electronic Toll Service (EETS)) for electronic tolling, allowing one vehicle to pay road user fees anywhere in the European Union via one contract and with one OBU.

- Technical, administrative, and legal hurdles have made advancing interoperability time-consuming and challenging. The European Parliament and European Union Council approved the directive in 2004. Five years later, a decision on the EETS definition was approved in October 2009.

- Existing systems with large sunk costs in proprietary applications and equipment heighten the challenge of transition.

Interoperability addresses technical, business, administrative, financial, and legal issues, requiring thorough treatment and multidisciplinary expertise.

Intergovernmental coordination in sharing national vehicle registry information between agencies is key to today's operations and enforcement and for interoperable systems of the future.

- All sites visited have procedures in place between agencies in their own country to share vehicle registry data for easy applications of license plate imaging for invoicing and violation processing.

- The use of ANPR technologies for enforcement is ubiquitous. It is used in the Czech Republic, Germany, London, Singapore, and Stockholm, but more agreements to share information across borders are needed.

- Clearly defined and well-understood policy goals in Stockholm guided decisions large and small, such as revenue use, rate schedule, and appropriate technology solutions.

- The Netherlands plans to use a tax-consolidation approach to transition fragmented vehicle ownership taxes to a single distance-based user fee.

8. **Equity and privacy concerns are addressed by host countries through exemptions, revenue use, technology, and business rules.**

- Exemptions are used in London and Stockholm to help address issues of equity. In addition, the emphasis on using toll revenues to fund transit sends a strong, clear message about equity and the project purpose.

- Privacy was elegantly handled by Singapore's use of a smart cash card that does not contain user data. The primary data on the smart card is the account balance, which can be used to pay for parking or other amenities.

9. The urban area pricing projects integrated public transit investments and land use planning to manage congestion.

- Stockholm and London made robust investments in public transit and alternative modes leading up to and following the introduction of road pricing. In Singapore, officials adopted and committed funding to realize a master transportation plan that integrates road pricing, transit, roadway expansion, and land use.

- The coordination of road pricing policy with public transportation investments is best accomplished by a single entity. In London, TfL is responsible for implementing the mayor's Transport Strategy for London and managing transportation services for all modes of transportation and throughout the city. In Singapore, LTA plans the long-term transportation needs of Singapore for those who drive and those who take public transportation. The Swedish government is in the process of consolidating its transportation agencies to bring all modes under one umbrella.

Chapter 4 | Lessons Learned

In addition to the major findings cited in the last chapter, the scan team found it useful to consider a number of lessons learned that are characterized by functional categories and business disciplines. The seven categories of lessons learned discussed in this chapter include the following:

1. Political and policy considerations
2. Legal and institutional issues
3. Planning and performance measurement
4. Procurement
5. Technology
6. Operations and enforcement
7. Outreach and communications

The lessons learned are intended to provide more indepth discussions of the findings from discussion with the host countries. They are organized to enable subject matter experts to examine the areas of greatest interest most effectively.

1. Political and Policy Considerations

A. Strong champions were critical to initial implementation of road pricing in several countries. The successful programs blend government leadership to guide executive and legislative government agendas with strong program manager champions in the implementing agency.

Executive champions, such as former London Mayor Ken Livingstone and Stockholm Mayor Annika Billstrom, led the charge to implement road pricing to improve livability and sustainability in their capital cities, despite fervent opposition and divided public support. Their vision, understanding, and political aptitude created the executive mandate for road pricing and laid the framework for the political coalitions and legislative changes required to institute congestion pricing. In Stockholm, a strong city manager directed the congestion pricing program implementation, while the London program management benefited from key leadership appointments at TfL. In both cases, agency leaders worked in concert with elected city executives to ensure implementation aligned with overall objectives of the pricing program.

After the scan team's visit to the Netherlands, the ruling government coalition dissolved and the Dutch champion of road pricing, Transport Minister Camiel Eurlings, resigned. Eurlings set road pricing as a national priority, so his departure created a vacuum in leadership, project guidance, and legislative action in early 2010. A number of political parties still support the distance-based road pricing system, and the leading party in the former government coalition, the Christian Democratic Alliance, has said it will recommend a revised version of the distance-based charge in an upcoming proposal. Nonetheless, the Netherlands' comprehensive, multidisciplinary approach to guiding implementation has suffered a setback because of changes in leadership and champions.

In contrast, the consistency of Singapore's government leadership and singleness of purpose at LTA to strive for a sustainable and effective transportation system have been hallmarks of the road pricing program's success.

B. Simplicity matters on policy goals, messages, business rules, and technology solutions.

Stockholm's Lidingö Rule was created to provide an exemption from the congestion tax to Lidingö Island residents, who must cross the Stockholm charging zone to access the national road network. The rule allows free passage for any vehicle that exits the charging zone within 30 minutes of entering the zone at the Lidingö Island control point or vice versa. This exemption maintained a policy of free access to the national highway network, but added more than US$20 million in capital and operating costs. It also added considerable system complexity to toll operations because every vehicle needs to be tracked to verify if it is making a qualifying trip for this exemption. If one gantry fails to operate properly, all vehicles during that period must be assumed to qualify for the Lidingö Rule and are exempt from the congestion charge.

Stockholm advanced simplicity in its permanent system implementation through a number of revisions during the 11 months between the referendum and the activation of the permanent system. The first was a conversion to fully video-based transactions, eliminating the cost of transponders, DSRC field equipment, and operations to support a second payment method. Second, a rule requiring that congestion taxes be paid by the day after the charge was incurred was revoked. This allowed the elimination of a costly system of payment channels, including Internet, retail locations, and stand-alone kiosks. Instead, drivers receive a monthly billing statement from the state for their congestion tax transactions, which saves significant operating costs and simplifies the system for drivers. Finally, these changes were accommodated by an alignment that placed the congestion tax program and the national vehicle registry under the same organizational oversight, creating efficiencies in data sharing and invoicing.

To comply with European Union Directive 2004/52/EC, which requires equal treatment of foreign vehicles in domestic road pricing programs, the German truck tolling system was required to establish a manual payment option for trucks that did not acquire an in-vehicle unit. While only 10 percent of truck transactions are paid via the manual system, manual transaction processing represents over one-third of the total operational costs.

German business objectives for the truck tolling system included the ability to have a flexible road network for expansion and scalability, as well as a flexible tariff schedule. These objectives were achieved through a complex remote device management process by which changes in the road network and pricing are centrally propagated to all users' OBUs in a seamless and consistent manner. The system's sophistication requires maintenance of a complex network of geographic data in five distinct layers to detail roadway links, distances, locations, and related tariffs and decision analytics. System maintenance requires regular updates of 640,000 OBUs with 600 geographic data changes per year and 400 annual tariff changes. While the system meets the goals established, it requires a high level of technical input and system administration to ensure accuracy of OBU functionality in a secure manner.

London began its congestion charging program with a simple set of policy objectives that prioritized reductions in traffic volumes and related congestion. The program's well-documented success in both the original charging zone and the western extension created roadway capacity. This newfound capacity provided an opportunity to address a larger set of urban needs, including new bicycle and pedestrian uses of streets in the city center and infrastructure modernization such as water supply. These actions have consumed street capacity to the extent that traffic congestion in central London is reportedly back to levels experienced before congestion charging. By attempting to address a broader set of objectives after successes in congestion reduction, the London system has lost ground in its simple origin of congestion reduction.

C. Equity concerns and perceptions of fairness can be addressed on multiple levels.

Equity concerns are typically addressed via exemptions and discounts to the congestion charge. For example, traffic passing through Stockholm's city center is exempt from the congestion tax to ensure that residents of Lidingö Island have access to the national highway network. Among its various discounts, London also maintains a 90 percent discount for residents in the central London congestion charging zone.

In London, Singapore, and Stockholm, where demand management was a prime objective for urban road pricing, significant investments in transit were made in tandem with the implementation of the road pricing program to ensure viable options to driving. Furthermore, the net revenues, directly or indirectly, are used to fund future multimodal enhancements.

The use of revenue has been another means of addressing equity and perceptions of fairness. In Germany, a truck harmonization fund created from road pricing revenue pays for new truck equipment and training for cargo haulers. In Singapore, net revenues not invested in transportation projects are returned to motorists through rebates in vehicle taxes.

D. Political timetables and deadlines create opportunities and challenges for implementation.

The Stockholm demonstration period was a prescribed timeframe in which the areawide pricing system needed to be operational on a trial basis before the planned referendum. While the schedule created urgency for system delivery, it also caused problems because of legal challenges to the procurement. The Stockholm trial was delayed 5 months from its original planned startup, requiring extraordinary effort by business consultants, the system integrator, and agency staff to deliver the system as a 7-month trial. The Czech Republic also experienced a compressed delivery schedule because of procurement challenges. The system integrator and construction contractors had only 9 months to install and test the Czech truck tolling system.

These examples illustrate that expedited delivery of high-functioning and reliable pricing systems is possible. However, both Stockholm and the Czech Republic are managing systems that are expensive to operate and maintain. The Stockholm program is undergoing a multiyear program of business process and systems reengineering to reduce operating costs.

2. Legal and Institutional Issues

A. The statutory and legal authority for road pricing was an essential foundation for all programs and often requires time to establish.

Road user fees first became possible in Sweden in 1988 through a change in law, which allowed tolls on the bridges to Norway and Denmark. Stockholm's congestion-pricing proposal became a matter of national debate and legislation because the city has no power or authority to charge nonresidents.

B. The statutory and legal basis for road pricing programs has implications for system design, operations, and enforcement.

Stockholm defines its road pricing as a national tax, since the city of Stockholm has no power to tax nonresidents. As a consequence, changes to the fee schedule require parliamentary action. In London and Singapore, the congestion charge is considered a fee, which allows the rates to be adjusted by the managing authority and fines to be resolved through administrative actions. Stockholm officials report that the benefit of treating congestion charges as a tax is higher collections because taxes are paid with higher frequency than other fees.

C. Interagency agreements and relationships were evident for effective operations and enforcement.

All pricing programs reviewed on the scan have procedures and relationships in place to share vehicle registry data for operations and enforcement among agencies. Some agencies, such as the new Swedish Transport Agency, operate the priced facility and manage vehicle registration, further streamlining data sharing, billing processes, and associated costs.

D. Legal requirements governing the use of road pricing revenues can protect revenues for targeted transportation investment, but flexible provisions for revenue use have leveraged revenues to their best advantage.

In Germany, the revenue generated from the truck tolling program is legally required to be allocated to projects for roads (50 percent), rail (38 percent), and waterways (12 percent). This preserves the majority of the revenue benefit for road users, but helps meet a national goal of multimodal transportation solutions to address mobility and future capacity needs.

In Sweden, the national government has established a long-term 2010–2030 investment plan for infrastructure investment, with the equivalent of US$14.5 billion programmed from a variety of revenue sources, including the Stockholm congestion tax and plans for congestion taxing in Göteborg. The investment plan allocates 53 percent of the funding to road projects and 47 percent to rail projects. The Swedish policy of "advancement" is incorporated in the Road Act to allow municipalities to augment national funding, making more investment possible and creating higher design and operating standards.

E. Limits to the price-setting mechanism through laws and directives may be required to gain public acceptance, but may also constrain the ability to use price signals most effectively.

A European Union directive dictates that the differential between the highest and lowest toll rate cannot be more than two times the lower value. Some European officials claim that this differential is not significant enough to manage traffic effectively in urban areas. The argument is that the limited price differential is insufficient to allow efficiencies to be realized through substantial temporal or mode shifts or avoided road trips.

European Union Directives 1999/62/EC and 2006/38/EC cover vehicle taxes, tolls, and user charges imposed on vehicles intended for the carriage of goods by road and having a maximum permissible gross laden weight of not less than 12 metric tons. The directives establish total revenue thresholds that must not exceed infrastructure costs, which some officials view as limiting for network investment purposes.

3. Planning and Performance Measurement

A. The best planning practices address education, outreach, and stakeholder management comprehensively.

The Dutch have studied distance-based charging and engaged key stakeholders on the subject several times since the 1980s. Recent implementation planning in the Netherlands involved extensive outreach during the system design and development process with a wide range of public agencies, private interests, and industry user groups. The Dutch provided significant funding for implementation research in a US$150 million congestion mitigation program.

Singapore, on the other hand, used grassroots representatives to gauge public sentiment before expanding the charge to the Orchard Area shopping district and expressways. Consultation typically starts with core stakeholders and later reaches out to the public through communications programs.

B. For many of the pricing programs reviewed, comprehensive network planning and performance measures were integral to preimplementation efforts, as well as ongoing system management.

Most sites use advanced analytics and traffic models to better understand the network impacts of pricing on parking, transit, and system diversion issues. In planning the Stockholm system, internationally recognized traffic experts were retained to measure network effects of various configurations of the charging zone to ensure that there were no unintended effects outside the congestion-charging zone. Similarly, the Netherlands has also undertaken comprehensive planning exercises to look at network effects across several modes.

Singapore's ongoing management of its congestion charge includes quarterly verification of travel speeds and refinement of prices to ensure that 85th percentile travel speed standards are maintained on two different classes of roadways.

C. The best-in-class road pricing programs have transport options integrated into their planning and preimplementation actions.

London, Singapore, and Stockholm made significant investments in transit to ensure that those impacted by the new road-user fees would have alternatives to driving. Such plans provided adequate capacity and service levels to ensure balanced transportation network demand, and limited minimal impacts to mobility and businesses with urban charging zones.

When provisions of modal alternatives to driving are not feasible, several pricing programs have employed exemptions or discounts to the road-user charge. Stockholm exempted Lidingö Island residents who pass through the city center to access the national highway network from the congestion tax. Similarly, residents in the central London and western extension charging zones enjoy a 90 percent discount on the congestion charge.

D. Geography has played a role in the design and business rules of many of the pricing programs visited.

Stockholm's city center is an island with well-defined access points that served to define roadside equipment locations and customer understanding of the limits of the charging zone.

Both Germany and the Czech Republic are central to European goods movement, handling high volumes of out-of-country movements on their national highways. Pricing system designs and business rules were established specifically to meet objectives for both native and foreign truckers.

Singapore is an island city-state with limited land available for development and economic expansion. As a consequence, Singapore has instituted regulations and planning processes to target specific land uses, encourage high-density development linked to transit, and manage the demand for new vehicles through its vehicle quota service.

A public consultation process preceded the London congestion charge, leading to many exemptions from the charge. A public consultation held after Mayor Boris Johnson took office recommended discontinuing the congestion charging in London's western extension.

4. Procurement

A. Open-source system designs provide significant advantages.

Open-source system designs create a competitive bidding environment for capital and operating costs associated with initial implementation, including system development and integration, roadside and in-vehicle equipment, construction, and back office (figure 24).

The German truck tolling system contract required a minimum of two vendors capable of providing in-vehicle units to ensure a competitive pricing environment. The Dutch system planning has expanded on this concept by proposing to allow multiple vendor solutions, creating a competitive environment for equipment and systems development and an open environment for value-added services that may defray costs and support public acceptance.

In Singapore, second-generation stored-value smart cards for in-vehicle units are designed with an open standard to be interoperable with the transit system and permit interfaces with financial institutions and businesses. The new smart cards will allow value-added services and cashless payment options for many goods and services.

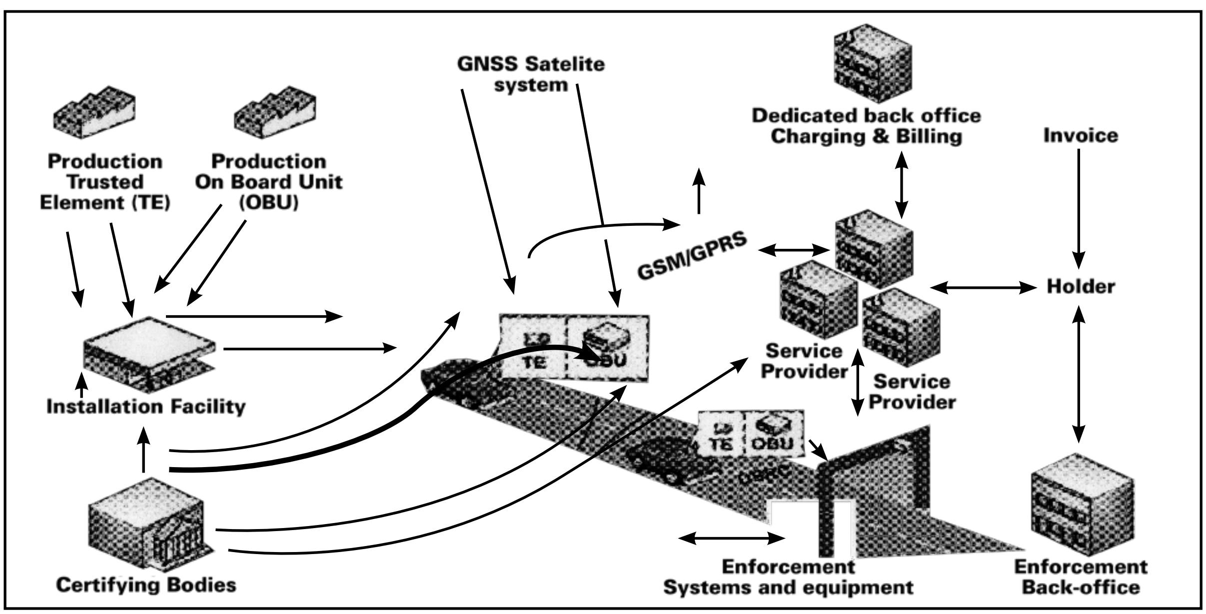


Figure 24. Example of open-source system design.

B. Road pricing system contracts have been competitive and lucrative for the businesses supporting them, inviting contentious legal challenges to procurement decisions.

Legal procurement challenges from vendors in the Czech Republic, Germany, and Stockholm affected implementation schedules and some system requirements. Procurements of this type are often delayed by challenges to the selection process, so it is advisable to build in schedule contingencies to accommodate these circumstances.

The complexities of the Dutch procurement plans for open systems designs and significant private sector participation led the Netherlands to employ extensive risk assessment and cost estimation planning to assess private sector procurement options.

C. Rapid implementation schedules for pricing projects are possible, but have driven up capital and ongoing operating costs. Clarity and specificity of the project scope greatly influence cost and schedule.

Stockholm worked with an open scope, which was deemed necessary to deal with the compressed delivery schedule for the trial program and evolving legislation that was not resolved at the time of the procurement. The consequence was schedule delays in the trial startup because of scope changes to access legislative outcomes and high implementation and operating costs.

The Czech Republic selected an off-the-shelf DSRC-based system that had relatively high OBU costs and a design-build-finance-operate PPP contract over 10 years. The contractor started receiving payments after 6 months' worth of revenues were generated. The German private consortium also fronted the capital cost for a 15-year design-build-finance-operate PPP contract.

Stockholm and London used more traditional design-build-operate procurement methods and found that initial capital and operating costs were high, requiring subsequent actions to reduce ongoing costs.

D. PPPs have been used in some road pricing deployments, leveraging no upfront costs for implementation, but incurring high operating costs.

The German Toll Collect consortium put up all the money required to develop and implement the German system through 2005, with no public funding. The private consortium is bound by contractual standards for availability and accuracy and is audited by the federal government on a regular basis. Toll Collect's compensation is about 11 percent of total toll revenue and includes operation of the automated and manual systems; a service fee for payment providers; operation of the toll terminals, enforcement gantries, and mobile equipment; mobile communications; system depreciation; and net income before taxes and interest. The nature of the contract provides little incentive for cost efficiency, which drives disproportionate spending to ensure performance standards.

Similarly, the Czech system is a PPP with a long-term contract that locks in relatively high costs of operations.

5. Technology

A. Business and functional requirements should guide technology selection.

Several pricing programs realized benefits from a requirements-based approach to program development and systems design. Countries that had business, functional, and technical requirements at the core of their procurement processes tended to be more successful in engaging public and private partners to achieve objectives.

The Germans chose GPS-based technologies to meet their business requirements of an easily expandable and scalable priced roadway network. The functional requirement for OBUs to be managed remotely with downloadable roadway location networks and tariff schedules drove the technology selection.

The Czech Republic opted to prioritize the implementation schedule as a critical consideration. As a consequence, the Czechs chose an off-the-shelf DSRC/radio-frequency identification system, which was rapidly deployable. Relatively high unit costs and a long-term contract constraint have given the Czechs a reason to explore alternative technologies as they plan to expand the pricing system to new roadways.

Addressing privacy protection and the perception of privacy was a key consideration in Singapore and in the plans for the Netherlands. In Singapore, privacy concerns were mitigated by a requirement for OBUs to accept a stored-value smart card as the payment mechanism. Since the prepaid smart card is portable and does not hold any personal data, an individual's privacy is protected. Similarly, the Dutch plan to require a trusted element as a feature for privacy protection.

B. Initial technology applications often evolve after implementation, especially with the experience of full-scale operations.

Stockholm migrated from a system that employed both transponders and a video toll collection system to one that relies solely on ANPR. The dual payment methods were costly to operate and Swedish tax law required that the Stockholm congestion tax system capture photos of all license plates. After the demonstration period, the system was permanently reopened and the transponders were phased out, allowing the conversion to a monthly billing statement rather than requiring users to pay per trip.

Singapore migrated from a paper permit to a transponder-based system and is now exploring GPS technologies.

London is reviewing its charging techniques to find ways to reduce the operational costs of the system.

C. Requirements that add complexity to the collection system also have significant impacts on costs.

A fundamental decision in Singapore was to require an OBU in every vehicle, which greatly simplified technology requirements and keeps ongoing operating costs low.

While only 10 percent of transactions in the German system are manual, they account for over one-third of the total operating costs.

The Lidingö Rule in Stockholm added substantively to the systems development and processing requirements to handle the complexity of the decision algorithms required to check for exempted through-traffic movements. The increased complexity has added significantly to capital and ongoing operating costs.

D. Interoperability of road pricing systems among European Union member states is a challenge.

The European Union has adopted Directive 2004/52/EC, which outlines requirements for member countries to adopt interoperable standards (i.e., EETS) for electronic tolling that allow a vehicle to pay road-user fees anywhere in the European Union via one contract and with one OBU. Technical, administrative, and legal hurdles have made advancing interoperability time-consuming and challenging. The European Parliament and European Union Council approved the directive in 2004. Five years later, a decision on the EETS definition was approved in October 2009.

While interoperability may be viewed as a technological concern, it interfaces with a full range of business, administrative, financial, and legal issues. Establishing standards is a critical first step, but ultimately interoperability will require multidisciplinary approaches. Existing systems with large sunk costs in proprietary applications and equipment heighten the challenge of transition.

6. Operations and Enforcement

A. Enforcement is key to ensuring a financially viable and fair system.

Video enforcement is an essential element in every site visited. Enforcement has played a large role in public acceptability by ensuring fairness because those paying for use of the road want to know that others are paying as well. Many pricing programs do not consider enforcement penalties as a revenue tool (i.e., fines and fees need not be higher than administrative costs), but do view enforcement as a critical element of ensuring that base road charges are collected without substantial leakage. All of the sites studied, except Stockholm, treat violations as administrative fees, not as criminal acts.

B. Violation enforcement systems require effective system integration and linkages with motor vehicle registries.

Typically, enforcement is managed through video capture of license plate images and an ANPR system. Back office processing centers use license plate information to identify the vehicle owner and collect payment.

In systems that rely on video systems and ANPR as the means of charging for road use, the enforcement process is an exception-based business process to pursue those who have not paid after some period of time. This process leverages one set of roadside equipment for dual functionality (i.e., primary collection and enforcement). This is the case in London and Stockholm.

In systems that rely on OBUs (i.e., transponders or GPS) for toll collection, the video enforcement process is a stand-alone subsystem that requires roadside video equipment for enforcement and systems integration to ensure violation transactions and electronic toll transactions are uniquely identified and properly distinguished. The systems in the Czech Republic, Germany, and Singapore rely on separate violations enforcement subsystems. All these systems supplement the automated violations enforcement systems with mobile and roadside enforcement efforts for periodic spot enforcement.

The use of ANPR enforcement requires an effective working relationship with motor vehicle registries for accurate information of vehicle owners from license plate data. Systems that include pricing for significant populations of foreign-registered vehicles (e.g., Germany and the Czech Republic) have a more complex set of relationships to establish and maintain in a cost-effective manner.

C. Performance standards ensure operational effectiveness through requirements in system design and procurement, as well as in service-level agreements for operations.

Performance standards cover a wide range of operating interests. For roadside operations, they often address system and roadway availability, traffic data capture requirements, and image reject rates of video equipment. For back office operations, typical performance standards include the error rate in invoicing, call center customer wait times, unprocessable image rates, and uncollectable transactions. The best practice in pricing programs is to establish service-level agreements with both external contractors and internal agency service providers to maintain operating performance with financial incentives.

Careful selection of performance standards is critical to ultimate outcomes. Systems that have emphasized accuracy and availability over financial performance have experienced high-cost operations with redundant systems and processes.

D. Best practice for back office operations depends on translating operating concepts into clear business rules and refining practices based on operating experience.

Business rules are the foundation of successful back office operations. Agencies involved in their development and refinement tend to gain advantages in managing operating performance and costs. For instance, Stockholm's move to a complete video-based system has resulted in 47 business rules governing the optical character recognition aspects of image processing, driving performance in accuracy and collections. Germany's decision to outsource the entire toll operation to Toll Collect has resulted in good system and operating performance, but relatively high operating costs.

Many programs have found the need to refine operating practices after implementation to manage costs more effectively. Over time, this has resulted in contractor changes in several pricing programs to best meet the operational and technical requirements at a competitive cost. London and Stockholm have both recently changed operators, while Germany and the Czech Republic face long-term contracts that provide less flexibility for managing operating costs more effectively.

Stockholm has also adopted a policy of insourcing that seeks to identify elements of the operation that may be managed with effective performance and lower costs by in-house resources rather than by outside services.

E. Payment channels and methods add operational and system complexity, but not always commensurate benefits.

During the congestion tax trial in Stockholm, vehicles without transponders had until noon the following day to pay the charge via the Internet or at a physical retail location, which included convenience stores, banks, and stand-alone kiosks. Charges not paid during the grace period were assessed a SEK70 (US$8) late fee for the first reminder and a SEK450 (US$62) fee for the second reminder. Since Swedish laws governing the collection of taxes required that the system capture all license plates as evidence of incurring the congestion tax, the transponder-based system was duplicative. The permanent Stockholm program phased out the transponder payment option and the associated costs of distribution and account maintenance. Adopting an all video-based system also created the opportunity to reduce the systems and accounting required for multiple postpayment channels. Instead, Stockholm placed the congestion pricing program and national vehicle registry in one organization that could take advantage of monthly invoices for the congestion tax. This reduced the cost of collection substantially and improved the collection rate.

Despite the many successes of the London congestion-pricing program, the high costs of operations have been often criticized. While transaction processing costs in a video-based system tend to be higher than those with OBUs (i.e., DSRC or GPS units), the multiple payment channels also add cost to the London system. Germany is also faced with high operating costs of its manual booking system, which requires more than one-third of its operating costs to handle 10 percent of the traffic volume. In Singapore, the payment method was simplified by standardizing in-vehicle units and designing a stored-value smart card interface that allows replenishment at banks and other outlets.

7. Outreach and Public Acceptance

A. Many forms of public involvement based on the cultural and political context of the host country were used to address public concerns about road pricing.

After several attempts to implement a distance charge, the Dutch realized that proactive stakeholder outreach during the planning and concept development stage is essential. Over the past 2 years, staff and leadership at the Dutch Ministry of Transport have invested heavily in public outreach and education. By engaging in a thorough and thoughtful planning and public involvement process, the Dutch developed clear, salient, and timely messages about the purpose and benefits of pricing, including “drive less, pay less.”

Public outreach in Singapore included the opening of the LTA Transportation Gallery, an interactive exhibit that teaches younger audiences about concepts such as mobility, access, sustainability, land use, and demand management. The gallery is a powerful educational tool that explains the history, context, and future of ERP and other transportation options in Singapore.

B. Clear, salient, and timely messages about the purpose and benefits of pricing were used to help educate key stakeholders and garner public acceptance.

Singapore targets education about transportation solutions such as road pricing at youth with an interactive transportation gallery. Key messages used in Singapore include “keep roads free-flowing,” “people-centered transportation,” and “public transit is a viable choice.”

Czech and German truckers supported pricing in an effort to “level the playing field” with foreign haulers and promoted the message of “user pays.”

Based on prior false starts, the Dutch are investing heavily in stakeholder outreach and are committed to a revenue-neutral road-pricing scheme. Their mantra is “drive less, pay less.”

C. Issues of equity and privacy were dealt with differently in each locale.

Equity issues related to a person’s ability to pay the fee were not widespread in London, Singapore, or Stockholm because of the high cost of car ownership and existence of good transit alternatives in all three cities. Lower income commuters in these cities tend to use transit because the driving cost differential is significant. In addition to substantial transit investments, London and Stockholm provide a variety of exemptions and discounts to various users (i.e., transit vehicles, taxis, hybrids, monthly and annual pass purchasers, residents within the charging zone or in adjacent communities). Singapore, on the other hand, provides few exemptions (only for military and emergency vehicles). Because many transit providers in Singapore are privately contracted and operated, all transit vehicles are required to pay.

Privacy concerns were not as prevalent with the German and Czech truck toll systems because of the commercial nature of the enterprise. In Singapore, the privacy issue was dealt with through the use of an IU that requires a prepaid, stored-value smart card that did not hold any personal data. The smart card provides users with a high level of anonymity.

D. Short-term gains may negatively impact longer term program sustainability.

The western expansion of London's congestion charging zone was championed by Mayor Ken Livingstone and made effective in 2007. In 2010, under the administration of Mayor Boris Johnson, the western expansion was repealed after a series of public consultations.

Commitments from the German Parliament that HGV toll revenues would augment roadway funding were not kept, which jeopardizes future prospects to price other vehicles based on distance traveled or emissions class.

E. The focus on changing behavior through pricing is clear.

The Dutch Ministry of Transport's goal is to shift the cost from vehicle ownership to usage to create a more sustainable transportation system.

The Germans have adopted a user-pays principle for freight haulers. In addition, by having a graduated toll schedule for cleaner trucks, they have seen a 60 percent shift away from the Euro 1, 2, and 3 emission-level trucks to the cleaner Euro 4 and 5 emission-level trucks.

Singapore estimates that its gas tax would need to be raised by SG$3 to achieve the same traffic reduction that a SG$1 increase in its ERP system because of the transparency and direct price signal of the system.

Chapter 5 | Implementation Recommendations

Over 2 weeks in December 2009, the scan team engaged with practitioners, champions, and the foremost international experts on road pricing. In some respects, the host countries are akin to individual States or regions in the United States. Thus, from an implementation perspective the findings and lessons learned that form the basis for implementation ideas may be best suited for application at the State or regional level.

While all scan team members are integral to implementation, a six-person subset of the scan team, known as the Implementation Team, will facilitate efforts to advance the application of road pricing in the United States. The team, chaired by Patrick DeCorla-Souza, developed an Implementation Plan designed to capture and cultivate the key findings and lessons learned. The team recommends that additional resources and effort be focused on the following three strategic areas:

1. **Enhanced outreach and communications**—To advance the use of road pricing in the United States, it is paramount that transportation leaders, policymakers, key stakeholders, and a larger cross-section of the public understand the benefits and implications of broader road pricing.

2. **Additional research needs**—With the application of road pricing in the United States limited to HOT lanes, there is continued need for additional research to better comprehend issues related to public perception, implementation barriers, behavioral effect, and integration of road pricing with multimodal land use and transit options.

3. **Road pricing toolkit**—Transportation professionals lack a comprehensive decision analysis tool to assess the merits of various road pricing options to address specific problems. The toolkit would include a module to assist in making design decisions, a guidebook or primer to assist technical managers in developing financing and procurement strategies, comprehensive and synergistic transportation plans that incorporate road pricing concepts applicable in the U.S. context, and analytical tools to estimate performance and costs of alternative concepts in comparison with conventional tax-based approaches. The tools would culminate in a decision tree tool to help transportation leaders make informed decisions on the relevance and feasibility of a road pricing alternative.

It will require strategic partnerships as well as social capital and funding to initiate the first phase of a technology and policy program that captures the best of the findings from the scan. The scan team will use the products developed in the efforts outlined to target selected States and regions that are the most likely candidates for the advanced road pricing approaches the scan team observed firsthand in the countries visited.

The following describes a series of foundational implementation items that would enable practitioners, elected officials, and other key stakeholders to advance the state of the practice in road pricing in the United States:

1. **Outreach to transportation agency leaders and policymakers**—This effort will involve targeted outreach to transportation leaders, policymakers, and various stakeholder organizations. This will include short briefs on how road pricing helps achieve various societal goals and a document providing responses to questions and concerns often made about road pricing.

2. **Messaging and public involvement**—This effort will focus on the psychology and messaging issues around pricing. It will include developing a more detailed understanding of the Dutch and Singaporean approach to communicating a radical change in paying for transportation to the public and stakeholders and translate it to the U.S. context.

3. **Behavioral implications and impacts of various pricing concepts**—This effort will include development of sketch-planning tools to estimate the travel behavior and consequent traffic, environmental, and economic

impacts of various alternative pricing concepts in comparison with traditional methods of road funding. An example is the analytical approach used in Singapore to estimate that it would need a SG$3 gas tax increase to effect the same behavior change as a SG$1 increase in the ERP system.

4. **Road pricing decision tree**—This will provide a tool to assist transportation leaders in defining a road pricing scheme that best suits identified needs, socioeconomic climate, terrain and network constraints, and available technology and resources. It will address such issues as the specific purpose for pricing, potential negative impacts of change to the status quo, public acceptance, capital and operating costs, speed of implementation, potential for private participation, procurement alternatives, and technology options.

5. **Technology, procurement, and PPPs to implement pricing**—This effort will provide guidance on defining business and system requirements that are aligned with the stated objectives of a program that employs pricing as a fundamental element of its approach to transportation management and infrastructure improvement. It will build on an understanding of the procurement processes and financing techniques employed in the Czech Republic, Germany, and the Netherlands, including PPPs and other private sector roles in advancing pricing programs and the related infrastructure improvements and operations. This effort will attempt to develop guidance and specific applications for sustainable program successes in the U.S. context.

6. **Developing concepts applicable to the United States based on lessons learned**—Not all lessons learned on the scan are directly transferable to the U.S. context because of the differing political, social, urban development, and transportation mode characteristics in the areas visited. This effort will develop an array of alternative concepts based on the lessons learned that could potentially be applied in various U.S. contexts. These concepts would be promoted to targeted metropolitan areas and regions, potentially one or more of the areas represented on the scan team.

7. **Integrating pricing, land use, and transportation investment**—This effort will provide guidance on developing synergistic pricing, land use, and transportation policies and investment strategies. It will build on the approach used in Singapore to develop synergistic policies to create an efficient and effective transportation system by integrating demand management (including land use) and multimodal investment strategies.

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Biographies

Robert E. Arnold (FHWA cochair) is the acting director of the Federal Highway Administration's (FHWA) Office of Transportation Management and director of the Office of Transportation Operations. These offices are responsible for national programs focused on reducing roadway congestion. The Office of Transportation Management deals with recurring congestion in such areas as pricing, active traffic management, and traveler information, while the Office of Transportation Operations has the nonrecurring side. This includes incident management, work zone operations, emergency transportation and organizational preparedness, the *Manual of Uniform Traffic Control Devices,* and various road weather management programs. As a member of FHWA's Senior Executive Service, Arnold is responsible for contributing to the development of overall strategic planning, policies, and legislative proposals for the administration. He was FHWA's New York Division administrator from February 2001 to September 2007. FHWA Divisions work primarily with State departments of transportation to ensure that each State's highway system is an integrated, effective, and efficient part of the national transportation system. Arnold has also held positions with FHWA as assistant division administrator in New Jersey, district engineer in New York, field operations engineer in Oklahoma, construction engineer in FHWA's Western Region, and area engineer in Baltimore, MD. He received a bachelor's degree in civil engineering from Ohio Northern University in 1983 and has worked for FHWA since graduation. Arnold is also a 2006 graduate of the U.S. Office of Personnel Management's Federal Executive Institute.

Vance C. Smith, Jr. (AASHTO cochair) is the commissioner of the Georgia Department of Transportation. He was elected to the Georgia House of Representatives in 1993 and has continuously served Georgia's 129th District. Smith has chaired the House Transportation Committee for the past 5 years and served as a member of the Appropriations, Economic Development, and Tourism and Rules committees. He was cochair of the General Assembly's 2007 Joint Study Committee on Transportation Funding. Smith is a graduate of Columbus State University with a bachelor's degree in business. He is a graduate of the Leadership Georgia program. Smith has held posts with the Council of State Governments, National Conference of State Legislatures, Southern Legislative Conference, and American Legislative Exchange Council.

John Q. Doan (report facilitator) is a senior associate at SRF Consulting Group in Minneapolis, MN. Doan leads SRF's road pricing practice with national and local expertise in transportation planning, innovative finance, public involvement, and intelligent transportation systems (ITS). At SRF, he helped develop the Minnesota Urban Partnership Agreement proposal and is the lead public outreach consultant for the Interstate 85 high-occupancy toll (HOT) lanes conversion project in Atlanta, GA. Before joining SRF, Doan worked in Wells Fargo's Public Finance Division, was assistant to the commissioner at the Minnesota Department of Finance, and most recently served as the MnPASS program director for the Minnesota Department of Transportation. He earned his bachelor's degree in civil engineering and public policy from Carnegie Mellon University and a master's degree in public policy from Harvard University's Kennedy School of Government. Doan is a registered engineer, member of the University of Minnesota Transportation and the Economy Research Council, SRF's liaison to the International Bridge, Tunnel, and Turnpike Association, and member of the Transportation Research Board's (TRB) Congestion Pricing Committee.

Rodney N. Barry is the division administrator of FHWA's Georgia Division. Barry directs a staff of 31 responsible for administering the Federal-aid highway program in Georgia.

Since arriving in Georgia in 2007, he has worked with the Georgia Department of Transportation (GDOT) and various other State and local transportation agencies to address congestion in the Atlanta metropolitan area, one of the nation's most congested cities. He is assisting GDOT in implementing an HOT lane facility. Barry has been with FHWA for 23 years and held positions in North Carolina, Florida, Kansas, Nebraska, and FHWA headquarters in Washington, DC. He has bachelor's and master's degrees in civil engineering from Auburn University. He is a licensed professional engineer in North Carolina.

Jayme L. Blakesley is an attorney-advisor with the U.S. Federal Transit Administration (FTA) Office of Chief Counsel. He is FTA's lead attorney on road pricing, transit-oriented development, and public-private partnerships. Blakesley entered Federal service through the Presidential Management Fellowship Program, of which he is a graduate. Before joining FTA, he worked on transportation issues for the Office of the Utah Attorney General and the Utah Transit Authority. Blakesley has been recognized for work he performed to implement the National Strategy to Reduce Congestion on America's Transportation Network and for his significant contributions to the public transit industry. Blakesley is a graduate of Brigham Young University and has a law degree from the University of Utah's S.J. Quinney College of Law. He is a licensed member of the Utah State Bar. Blakesley is vice chair of the Alexandria (VA) Transportation Commission and a member of TRB's Committee on Transit and Intermodal Transportation Law.

Patrick T. DeCorla-Souza is the program manager for tolling and pricing in the FHWA Office of Innovative Program Delivery in Washington, DC. DeCorla-Souza has led U.S. Department of Transportation efforts to promote congestion pricing since 1999. He oversees congestion pricing initiatives across the United States, working with public and private sector partners to implement innovative road pricing strategies. DeCorla-Souza has developed new approaches to address public acceptance issues related to road pricing, new performance-based public-private partnership approaches for implementing pricing with complementary transit services, and simplified analytical tools that make it easier to provide critical impact information on road pricing strategies to decisionmakers. His ideas and research have been published in various U.S. and international professional and trade journals. He is the author of more than 100 technical papers and articles on road pricing, public-private partnerships, multimodal transportation evaluation using benefit-cost analysis, travel demand modeling, air quality analysis, and public involvement. DeCorla-Souza has master's degrees in transportation planning and civil engineering and cochairs the TRB Congestion Pricing Committee.

Mark F. Muriello is the assistant director of tunnels, bridges, and terminals for the Port Authority of New York and New Jersey. He is responsible for the six vehicular bridges and tunnels between New York City and New Jersey and two interstate bus terminals, which collectively serve 1.25 million customers each weekday. Muriello directs a wide range of functions, including transportation planning and policy, traffic and revenue programs, business and strategic planning, and operation and maintenance of the Port Authority's E-ZPass electronic toll collection system and time-of-day toll pricing program. He has 27 years of experience in transportation and public finance, covering toll, bus, rail, and marine terminal operations, as well as the electric utility industry. Muriello has a bachelor's degree in industrial engineering and operations research from Columbia University and a master of business administration in finance from New York University. Muriello cochairs TRB's Congestion Pricing Committee, represents the Port Authority on the E-ZPass Interagency Group's Policy Committee, chairs the Technical and Operations Committee for TRANSCOM (Transportation Operations Coordinating Committee), cochairs the Policy and Strategic Planning Committee of the I-95 Corridor Coalition, and is a member of the International Bridge, Tunnel, and Turnpike Association's Communications and Outreach Task Force.

Gummada N. Murthy is the director of the Operations and Security Division at the Virginia Department of Transportation (VDOT). He is responsible for developing and issuing statewide policy and procedures for all operations related to technology and ITS programs that support incident management, roadway weather information systems that support snow and ice removal programs, and VDOT's HOT and pricing programs. Murthy also has a responsible role in research and implementation of innovative technology in VDOT operations programs such as Global Positioning System (GPS) -based roadway information mining programs, and active traffic management and commercial vehicle operations. He served with VDOT for 3 years and has more than 25 years of experience in all phases of transportation planning and engineering with a focus on operations of roadway and roadside infrastructure, including ITS, signal systems, ITS deployment and operations, and roadway maintenance programs. Murthy has a bachelor's degree in civil engineering from the University of South Florida. He is a licensed professional engineer in

Virginia and serves on several technical committees of the American Association of State Highway and Transportation Officials (AASHTO).

Patty K. Rubstello is the tolling and systems development engineer for the Washington State Department of Transportation (WSDOT). Rubstello is responsible for developing and implementing toll systems for the State of Washington. This includes conducting public education and outreach for, assessing the environmental effects of, and constructing toll systems. Over the past 7 years, she has managed several studies on how pricing could improve the operations of a number of highways in the Puget Sound region. In 2008, Rubstello implemented the first HOT in Washington State. She manages the implementation of pricing on an existing toll-free highway in the Seattle area. Rubstello's educational background is in mathematics and civil engineering. She is a licensed civil engineer in Washington. Rubstello participates in a number of pricing-related forums, such as the TRB Congestion Pricing Committee and the National Pricing Discussion Group hosted by WSDOT.

Nick A. Thompson is the director of policy analysis, research, and innovation for the Minnesota Department of Transportation (Mn/DOT), in St. Paul, MN. Thompson directs the implementation of Minnesota's Urban Partnership Program, which includes a project to expand Minnesota's congestion management HOT lane program, MnPASS, to its second transportation corridor. He has worked for Mn/DOT for 13 years. Before his current position, he was the project manager for implementing Minnesota's first congestion pricing HOT lane, freeway operations manager, and area manager responsible for transportation project development in suburban and rural communities. He holds a bachelor's degree in geography from Gustavus Adolphus College and a master of urban planning degree from the University of Wisconsin-Milwaukee. Thompson has served as a member of TRB's Freeway Operations Committee, chaired the Transportation Management Center Pooled Fund Study, and served on the board of ITS Minnesota.

Appendix B | Scan Preparations and Itinerary

Scan Preparation

Planning for the road pricing scan trip began in February 2009 with a kickoff meeting that included original cochairs Peggy Catlin of the Colorado Department of Transportation and Regina McElroy of the Federal Highway Administration. The initial preparation culminated with the completion of a desk scan in April 2009 and an organizational meeting in Washington, DC, on April 30, 2009. The following were the objectives of the desk scan:

- Further the efforts of the full scan team in acquiring information of value to the U.S. transportation community.
- Increase the cost-effectiveness of the full scan by advising the team where best to commit its limited time abroad.
- Refine the scope of the scan by identifying relevant sources of information abroad and clarify the focus of the scan if it is determined to be too broad.

The scope of the desk scan was limited to office-based information gathering, designed to supplement and further refine the broader issues associated with implementing road pricing. The information that supported this desk scan originated from three primary sources: published literature, various Internet sites, and U.S. and international experts in the field.

A review of relevant published literature was conducted using the Transportation Research Information Services (TRIS) Online, with a particular emphasis on articles published in the last 10 years. In addition, other online tools such as Google, Wikipedia, and official road pricing program or project Web sites published by the sponsoring authority provided further project details. A list of relevant published literature and Web sites used for the desk scan is in Appendix C.

U.S. and international experts in the field of road pricing were identified based on the literature review, the report facilitator's contacts through the Transportation Research Board's (TRB) Congestion Pricing Committee and International Bridge, Tunnel, and Turnpike Association, and recommendations from other experts.

The desk scan recommended that the team visit Germany, the Netherlands, Singapore, Sweden, and the United Kingdom. After the desk scan was completed, a request was made to add meetings with representatives from the Czech Republic based on new information. While other countries, including Australia, Chile, Italy, Norway, and South Korea, were considered, the selected six countries could be visited within the constraints of a 2-week scan and provided the optimal combination of advanced practices and innovative implementation.

Team Meetings and Travel Itinerary

During the scan, the team visited representatives in five countries: Germany, the Netherlands, Singapore, Sweden, and the United Kingdom. Because of the logistical challenges of making a sixth country stop, representatives from the Czech Republic met with the scan team in London. The team members left the United States on Dec. 4, 2009, and held their first team meeting on Dec. 6 in Stockholm, Sweden. They met with Swedish representatives Dec. 7 and 8, and then flew to Berlin, Germany. Meetings with the German delegation occurred Dec. 9 and 10.

The first week ended in The Hague, Netherlands, with discussion on the upcoming Dutch implementation of a distance-based user fee on Dec. 11. The midpoint team meeting was held Dec. 13 in London, followed by meetings with British officials on Dec. 14 and the Czech delegation on Dec. 15. The team left the United Kingdom Dec. 15 and arrived in Singapore on Dec. 16. Meetings with representatives in Singapore occurred on Dec. 17 and 18, and the wrap-up team meeting was held Dec. 19 in Singapore.

The team developed a scan summary presentation and shared it with various TRB committees and subcommittees at the annual TRB Conference in Washington, DC, in January 2010. A summary report as well as drafts of the final report and implementation plan were written and produced for distribution at the team's reassembly meeting in Washington, DC, on March 10 and 11. The following chart summarizes the team meetings and travel schedule.

Date	Location	Purpose or Hosts
April 30, 2009	Washington, DC	Initial team meeting to determine emphasis areas and countries to visit and develop amplifying questions
Dec. 6, 2009	Stockholm, Sweden	Kickoff trip meeting to review travel plans, set personal scan goals, and assign roles
Dec. 7–8, 2009	Stockholm, Sweden	Meeting with Swedish Road Administration, Traffik Stockholm, and City of Stockholm
Dec. 9–10, 2009	Berlin, Germany	Meeting with Federal Ministry of Transport, Building and Urban Development, Federal Infrastructure Finance Group, Toll Collect GmbH, and German Trucking Association
Dec. 11, 2009	The Hague, Netherlands	Meeting with Ministry of Transport, Public Works, and Water Management
Dec. 13, 2009	London, United Kingdom	Midtrip meeting to review findings to date
Dec. 14, 2009	London, United Kingdom	Meeting with British Department for Transport and Transport for London
Dec. 15, 2009	London, United Kingdom	Meeting with Czech delegation from the Ministry of Transport and Czech Technical University
Dec. 17–18, 2009	Singapore	Meeting with Ministry of Transport and Land Transport Authority
Dec. 19, 2009	Singapore	Final trip meeting to identify key findings and develop preliminary recommendations

Appendix C | Amplifying Questions

General/Background

1. What is the financial health of transportation in the country? Are there sufficient funds to meet needs? Have there been any major changes in funding/costs in the last 10 years, and what does the future look like for revenue?

2. Beyond tolling, pricing, and fare revenue sources, how are transportation in general and highways specifically funded?

3. Other than monetary fees, have other incentives/disincentives been used to change user behavior?

4. Did general/traditional tolling exist before the variable pricing concept was developed?

5. Did you experience any setbacks or outright failures during the project development process? If so, what were the causes and what would you do differently?

Concept Development and Planning

1. Where did the idea for this project come from? How long did the idea take to go from concept to operation?

2. What was the more important driver in launching this program—politics, transportation funding shortfalls, congestion levels, or environmental issues? Has the focus changed over time on why this is needed?

3. How are “pricing” and “tolling” concepts defined and distinguished—at the policy/program level and at the network application/operation level?

4. How was the pricing program developed? Did the cost estimates for such projects include operation and maintenance (O&M) costs in addition to the capital costs? Was pricing structure validated to generate theoretical revenues that guaranteed to support such functions?

5. What is the relationship between road pricing as a revenue stream and an operational strategy to reduce congestion, improve safety, or enhance the environment?

6. What are the relevance and importance of including supporting strategies such as transit enhancements, system operations strategies and technologies, and travel demand management?

7. Are there plans to expand the system or add different types of congestion pricing?

8. What is the concept of operations for tolling and pricing—at the project scoping level through operations—encompassing policy, strategic, technology, and inter-agency elements with what-if scenarios built in (if any)?

Political, Organizational, and Institutional Issues

1. What was the purpose of the pricing initiative?

2. Who is responsible for the overall program? How are the transportation responsibilities segmented (local, national, private)?

3. What are private and public relationships in the design, construction, and operations of the system? For public-private partnerships (i.e., concessions, if any) what resources were provided by the agency vis-à-vis the private partner?

4. What were the political challenges that had to be overcome to create the program?

5. Were transit improvements required as part of a package to get acceptance for the idea? If so, what were the components?

6. Were any legal changes needed to implement the system?

7. What political barriers had to be addressed to gain acceptance of the pricing initiative? What strategies were used to address political history and regulatory and legal barriers, particularly those related to public acceptance?

8. What was the level of mainstreaming pricing/tolling into the institutional planning, construction, and operations programs?

9. What institutional arrangements and interagency collaborations were needed to enable effective applications of pricing techniques? Were there institutional barriers or interagency conflicts that had to be overcome?

Pricing Policy

1. Is maximizing revenue, minimizing congestion, or a combination a goal of the pricing scheme?

2. What types of users/vehicles are exempt from paying the toll or receive a discount? How do the prices differ for local residents and nonresidents?

3. Was the pricing initiative on a new or existing transportation facility?

4. How is pricing set? What factors drive the price—day, time of day, level of congestion, distance, emissions standards, or environmental conditions?

Costs and Revenues

1. How much did it cost to implement your pricing program (capital and ongoing)?

2. How much revenue does the system generate? Does it pay for capital and operating costs?

3. Do revenues meet expectations projected before the program launched? Are revenues adequate to support targeted service levels? What's the safety cushion for unforeseen shortfalls?

4. How are net revenues (after debt and O&M cost are covered) distributed (to other transportation projects, other modes, nontransportation uses, etc.)? Is it legislatively mandated?

5. Has the program achieved economies of scale yet?

6. Does the private sector share in the revenue? If not, was this considered?

7. How are revenues incorporated into the agency budgeting and program development process?

8. How are revenues faring in the current economic climate?

Tolling Technology and Roadway Design

1. What technology is used for revenue collection and enforcement? What are the technical details of the pricing system?

2. How did the revenue collection system evolve (standardized and then implemented, independent systems, or a mixture of systems that have been cobbled together into a single back office)? Have there been any major evolutions or changes in the pricing system since the start of the program?

3. Did implementing pricing require any specific design changes for geometrics, signing, etc., or modification of the legal code? If applicable, at the termini of the pricing project/area, how are the upstream and downstream connections made (i.e., going from a priced to nonpriced facility)?

Operations

1. What technologies for operations were used, such as traditional intelligent transportation systems solutions and their expansive application to pricing and tolling applications, lane control dynamic message signs for variable pricing, active traffic management, or integrated weather and actionable roadway condition reporting systems to manage weather and other nonrecurring events?

2. How do the back-office tolling operations interface with other roadway management operations (incident clearance, freeway monitoring, dispatch, etc.)?

3. Are there cases when the tolls are waived or turned off, such as under extreme events or systemwide requirement? Who makes that decision?

4. Is there any delineation of the operations and maintenance service level for priced and nonpriced facilities?

5. How is interoperability of toll systems handled?

6. How does your enforcement system work? Who does the enforcement, what are the fines, and is it meeting your goals? What is your violation rate and who are the typical cheaters?

7. What has been the operational experience of pricing and/or tolling on freight haulers in terms of route diversion and time-of-day use? Other than the actual amount charged, are commercial freight haulers handled differently under the pricing schemes?

8. What transit alternatives are available? Were additional transit alternatives provided as a part of the project?

9. How long did it take for the pricing program to reach an operational phase that began to deliver tangible benefits?

Evaluation of Impacts and Performance Measurement

1. What performance measures do you have? How do you report them?

2. Have you been able to identify any economic impact (positive and negative) on consumption-oriented businesses (sales, delivery charges, inventory control, staffing, etc.) caused by pricing?

3. What has been your experience with quantifying projected and actual benefits (e.g., reduction of congestion, safety, and environmental) and developing performance metrics for them?

4. What has been the effect of pricing on adjacent nonpriced facilities or areas? What have been the boundary effects?

Public Acceptance and User Issues

1. How have users and nonusers reacted to your pricing program and its associated technology? What was the initial public reaction? Has it changed over time?

2. What successful or unsuccessful techniques/strategies were developed and employed to gain acceptance of pricing and tolling programs?

3. Did the public have any privacy concerns and, if so, how were they mitigated?

4. What, if any, were the socioeconomic concerns of pricing and what way, if any, did you address them?

5. Are users required to have transponders or preregister to use the facility?

6. Who were your key champions and project spokespeople?

7. What were your key messages and how did you develop them?

8. Did you do any market research or consumer studies before or after implementation?

Appendix D | Literature Review and Internet Sources

Published Literature

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Willoughby, C. *Singapore's Experience In Managing Motorization and Its Relevance To Other Countries.* World Bank, 2000.

Woodroofe, Ian. *Continental Shift: Road Tolling Across Europe is Changing.* Auto Intermediates Limited, 2006.

Web Sites

Singapore

Land Transport Authority, www.lta.gov.sg/

http://en.wikipedia.org/wiki/Electronic_Road_Pricing

http://en.wikipedia.org/wiki/Singapore_Area_Licensing_Scheme

United Kingdom

Transport for London, www.tfl.gov.uk/

http://en.wikipedia.org/wiki/London_congestion_charge

Sweden

Swedish Transport Agency, www.transportstyrelsen.se/en/

http://en.wikipedia.org/wiki/Stockholm_congestion_tax

Germany

Federal Ministry of Transport, Building, and Urban Development, www.bmvbs.de/en

http://en.wikipedia.org/wiki/Toll_Collect

http://emagazine.credit-suisse.com/app/article/index.cfm

http://www.toll-collect.de/frontend/Homepage

Czech Republic

Ministry of Transport, www.mdcr.cz/en/HomePage.htm

Appendix E | Host Country Contacts

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Appendix F | Currency Exchange Rates

The following table illustrates the exchange rates between the official currency of the host country for each scan site and the U.S. dollar. These exchange rates are certified by the Federal Reserve Bank of New York based on data collected from a sample of market participants. The exchange rates are for Dec. 12, 2009.

CURRENCY	EXCHANGE RATE	
	USD per Unit	Unit Per USD
United Kingdom Pound (GBP)	1.6234	0.6159
European Union Euro (EUR)	1.4514	0.6891
Czech Republic Koruna (CZK)	0.0566	17.6599
Swedish Krona (SEK)	0.1392	7.1829
Singapore Dollar (SGD)	0.7172	1.3943

SOURCE: Federal Reserve Statistical Release, March 17, 2010. Foreign Exchange Rates, Historic Data, www.federalreserve.gov/RELEASES/H10/Hist/.

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