Congestion Pricing and Investment Requirements

Requested by:

American Association of State Highway and Transportation Officials (AASHTO)

Standing Committee on Planning

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June 25, 2009

The information contained in this report was prepared as part of NCHRP Project 08-36, Task 85, National Cooperative Highway Research Program, Transportation Research Board.

Acknowledgements

This study was conducted for the American Association of State Highway and Transportation Officials (AASHTO), with funding provided through the National Cooperative Highway Research Program (NCHRP) Project 8-36. The NCHRP is supported by annual voluntary contributions from the state Departments of Transportation. Project 8-36 is intended to fund quick response studies on behalf of the AASHTO Standing Committee on Planning. The report was prepared by Jeffrey N. Buxbaum of Cambridge Systematics, Inc., with Harry Cohen, Ph.D.. Project oversight was provided by Tim Henkel, Minnesota Department of Transportation, and Dennis Slimmer, Kansas Department of Transportation.

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Executive Summary

The supply and demand for most commodities and many services is regulated by the marketplace. When supply is low and demand is high, the prices rise, and vice versa. Airplane seats, hotel rooms, and telecommunication bandwidth are sold on the basis of differential prices that vary with demand. This means that the owners of those resources can use price to spread demand from congested to noncongested periods, thereby reducing their investment in expensive fixed capital assets.

Over the last two decades, electronic tolling technology has advanced to the point where using pricing mechanisms to manage transportation demand in the same way as other products and services appears viable. In broad terms, "congestion pricing" would charge drivers for the use of crowded roads, with the price varying by the level of congestion. This price mechanism would encourage individuals to drive less, travel at different times, choose less congested (and therefore lower priced) routes, shift to "free" routes, or change modes, thereby reducing congestion, and reducing the need for capital investment (in particular, new highway capacity) to achieve congestion-reduction goals.

CONGESTION PRICING ANALYSIS IN THE 2006 CONDITIONS AND PERFORMANCE REPORT

In the *2006 Conditions and Performance Report*[1] (hereafter, the "C&P Report") the Federal Highway Administration (FHWA) evaluated the extent to which congestion pricing could reduce the need for highway infrastructure investment. In broad terms, the analysis considered "universal" congestion pricing where users of any road in the nation's highway network would be charged a fee that would enable that road to remain congestion-free. They found that congestion pricing applied in this way could reduce the amount of needed highway capital investment from 16 to 28 percent (on Federal-aid roads that were modeled), depending on the baseline investment level. It would also produce an average of $24 billion to $34 billion (2004 dollars) per year in gross revenue.

The report includes disclaimers about the shortcomings of the analysis and important caveats to the performance and revenue estimates. The most important considerations in how U.S. DOT constructed the analysis were that:

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[1] U.S. Department of Transportation, Federal Highway Administration, Federal Transit Administration, *2006 Status of the Nation's Highways, Bridges, and Tunnels: Conditions and Performance*, Publication Number FHWA-PL-07-014.

- Pricing would be implemented universally on all congested roads;
- Pricing is assumed to be at the ideal level to eliminate congestion on each link in the system;
- The effects of traffic shifting from one road to another or to other modes to avoid prices is not addressed; and
- Capital and administrative costs are not considered.

Perhaps most important is what we believe is an unstated assumption that this system of congestion pricing would be implemented immediately and all at once, and be in effect for the entire 20-year timeframe of the 2006 C&P Report: 2005 to 2024.

Using FHWA's Highway Economic Requirements System (HERS) to estimate the impact of universal congestion pricing has some issues that need to be understood so that the results can be properly interpreted. We found three main concerns.

Daily Traffic Analysis Understates the Congestion Charges

Congestion tolls were estimated using an "all-day" analysis and then just applied to the peak period. If congestion tolls were instead estimated for just the peak period, they would have been several times greater. This is because congestion tolls are set to reflect negative impacts on other highways users, which are much worse during the peak period.

FHWA factored the vehicle-miles traveled (VMT) due to congestion tolls from the "all-day" analysis downward to reflect the application of congestion tolls. However, this was applied in just the peak period, while the analysis of alternative improvements was conducted with VMT in all time periods being reduced approximately the same percentage. This resulted in a significant understatement of congestion reductions due to pricing charges.

Ignoring Network Effects Paints an Incomplete Picture

When HERS models traveler responses to changes in costs, all it can do is reduce the amount of traffic on a link-by-link basis. This means that the only traveler responses that HERS could model were those that reduce total VMT (such as fewer or shorter trips). But pricing on one highway may lead to diversion to another highway, leading to an increase in VMT, or to another mode (e.g., transit), thereby increasing costs on that element of the transportation system. The increased costs accrue both to the users of the system (through increased congestion or wear and tear on vehicles) and to the jurisdictions responsible for upkeep of these roads. Without considering network effects, we get an incomplete picture of the potential changes that would come about from congestion pricing.

Technological Barriers Cannot be Ignored

The technological barriers to implementing a comprehensive, national network of priced freeways are considerable. Even within the 20-year time period evaluated by FHWA, implementation of such a system would by necessity be phased in gradually area by area, thus diminishing the revenue impact found in the C&P Report, which assumes immediate national deployment.

THE ECONOMICS OF CONGESTION PRICING

When something is perceived as free – or at a price near free – people tend to consume as much of that good as possible. The use of public roads is often considered free or nearly free, because the current mechanisms to pay for transportation (through motor fuel taxes, vehicle taxes, and other taxes/fees) do not fully capture the value of using the roadways, and because the motor fuel tax is hidden in the purchase price of fuel. This results in what economists call "market failure," which we commonly experience as congestion. The purpose of congestion pricing is to expose drivers to the full social cost of road use through directly charging for those costs that vary with congestion.[2]

The fundamental challenge of congestion pricing is that while it results in an economically efficient solution to road congestion – making the best use of the roadway system – the entire population, on average, is worse off until we account for how the revenue is spent. This is because congestion pricing charges everyone for something for which they had not previously been charged – the benefits of travel and the impact of their travel on others.

With congestion pricing, not everyone will fare the same. The ultimate economic argument of whether society is better off and who wins or loses is dependent on the incidence of the direct and indirect benefits and costs the congestion-free travel, who pays the tolls, and how toll revenue is spent.

If the toll revenue is refunded to society through, for example, a reduction in the gas tax, a reduction in other taxes, or through transportation system investments that provide additional benefits, the losers can be compensated, perhaps to the point where no one would be worse off, and some may be better off than before.

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[2] Charging people the social cost of their activity is called charging the "marginal social cost." This is the total cost to society as a whole for producing one further unit, or taking one further action, in an economy. This total cost of producing one extra unit of something is not simply the direct cost born by the producer, but also must include the costs to the external environment and other stakeholders.

PRACTICAL CONSIDERATIONS

The analysis of universal congestion pricing in the C&P Report made the simplifying assumption that such a system could be up and running within the timeframe of the C&P report forecast. While we are confident that this cannot happen, there are much less extensive congestion pricing concepts currently being considered, planned, and implemented. It is these less extensive applications that are more likely to be proposed in the near future, and this section addresses some of the practical considerations that need to be addressed.

To begin with, policy motivations may differ from place to place, and approaches to congestion pricing may vary as well. There are also numerous ways congestion pricing can be carried out:

- **Priced lanes,** where one or more lanes on a highway are priced to afford a higher level of service than adjacent nontolled lanes;
- **Priced roads,** where an entire road or group of roads is priced;
- **Priced zones**, such as when drivers pay each time they cross the cordon, or pay for the privilege of driving within the cordon; and
- **Systemwide pricing**, where an entire system of roadways in a region, state, or nation are priced.

Where pricing is implemented, some traveler responses might be short-term – e.g., choosing different times of travel or routes – or long term – e.g., changing locations of residence or employment. Different types of travel may be more or less likely to change habits, meaning that the effects may be difficult to track.

Equity is an issue that always gets a lot of attention with respect to congestion pricing. The equity and income effects of congestion pricing are not well understood and the majority of empirical studies come from evaluations of high-occupancy toll (HOT) express-lane projects that have generally found that people of lesser means approve of and take advantage of HOT lanes (though typically not as much as wealthier people). Care should be taken when translating findings from HOT-lane projects to other types of congestion pricing projects. HOT lanes are unique in two ways. First, there is always a choice between the priced lane and the immediately adjacent free lane. Second, no options, flexibility, convenience, or received benefit has been taken away from any group of users. HOT-lanes always add capacity, either by freeing up unused capacity in an existing HOT-lane, or from building newly priced freeway lanes. These differences necessarily change the costs and benefits and potential responses for differing income groups.

Related to equity are issues of environmental justice. The solutions, or at least policy fixes, for equity problems lie in many factors, including: the design, location, time-of-day, and level-of-congestion charges; packaging of complementary alternatives and policies; and the use of revenues to provide direct or indirect support to impacted groups.

Distribution of revenue is an economic and significant political issue, without clear solutions. Under any congestion pricing scheme there will be considerable pressure to gain political and public support by using revenue to compensate those negatively affected or to recoup benefits to all groups of drivers. However, some of these uses of revenue generally contrast with public ideas of how toll revenues should be used – i.e., for the direct benefit of those paying the toll.

Regardless of the analytical outcomes, existing institutions and public opinion may oppose congestion pricing. More modest congestion pricing projects, primarily HOT lanes have moved successfully through the public process, are now accepted, and get high marks for public approval. This will not be the case for cordon pricing, freeway pricing, mileage-based pricing, or universal congestion pricing. All of these represent takeaways of existing nonpriced travel, and will face opposition from people who will perceive they are being made worse off. Unless people conclude the revenue is being used effectively (in a way that benefits them) and trust the government to carry out the program as advertised, congestion pricing programs are likely to run into stiff opposition.

CONCLUSIONS

If, at the beginning of the motor vehicle era, we had possessed the technology to allow road pricing, and we had decided to use it to capture the full marginal social cost of driving, then the fabric of our communities would be very different from what it is today. Urban areas would be more compact, and there would be more public transportation. We can see this in Europe, which has a history of charging motor fuel taxes several times higher than the levels in the United States. Because Europe has a longer tradition of trying to capture the marginal social costs of driving, it is little surprise that they have had far more success in moving contemporary congestion pricing ideas forward.

The United States is very different. We have a social and economic world built on the foundation of inexpensive automobile travel. Changing the rules at this time may be the best long term solution for society as a whole, but there will be winners and losers. Those winners and losers are not just those who would choose to pay a toll and those who would not, but also property and business owners who are counting on the continuation of those rules.

Congestion pricing needs to be approached with caution, and transparent, comprehensive, and methodologically correct analyses undertaken. The concepts are not easy to understand – even among transportation professionals – and some of the analysis methods have not yet been fully developed or tested. Analysts need to be open about where assumptions and methods may have more than the typical level of uncertainty, and test the implications of different assumptions.

In some cases, we may not know the real answers until someone actually implements a congestion-pricing concept beyond a HOT-lane. That approach

worked in Stockholm, Sweden, where a $500 million demonstration was carried out with the government agreeing to remove the system if the people voted against it. With a skeptical public at the outset, voters in Stockholm, by a slim majority, gave their government the go ahead to turn a demonstration project into a permanent installation. As with any controversial concept, early and frequent public- and elected-official engagement will be important, leaving adequate time and funds for the difficult analyses that will have to be done to properly answer the bona fide questions of the public. Any analysis of congestion pricing should have comparisons among fully formed alternatives so that elected officials can reasonably choose among them. Complicated analyses must be boiled down such that understanding does not require advanced degrees in economics and traffic flow, but not so simplified as to eliminate the nuance and to overlook areas of uncertainty.

None of this is any different from the kind of care that should be given to any project. However, the kinds of changes that would come about as a result of congestion pricing amplify the importance of this approach.

1.0 Introduction

The supply and demand for most commodities and many services is regulated by the marketplace. When supply is low and demand is high, the prices rise, and vice versa. Airplane seats, hotel rooms, and telecommunication bandwidth are sold on the basis of differential prices that vary with demand. This means that the owners of those resources can use price to spread demand from congested to noncongested periods, thereby reducing their investment in expensive fixed capital assets.

Over the last two decades, electronic tolling technology has advanced to the point where using pricing mechanisms to manage transportation demand in the same way as other products and services appears viable. In broad terms, "congestion pricing" would charge drivers for the use of crowded roads, with the price varying by the level of congestion. This price mechanism would encourage individuals to drive less, travel at different times, choose less congested (and therefore lower priced) routes, or change modes, thereby reducing congestion, and reducing the need for capital investment (in particular, new highway capacity) to achieve congestion reduction goals.

There has been considerable experimentation and study with respect to congestion pricing for close to 20 years, much of it encouraged and funded by the FHWA's Value Pricing and Congestion Pricing Pilot Programs. Nevertheless, the actual examples of congestion pricing in the United States are limited to a few high-occupancy toll (HOT) lanes and variable pricing on existing toll bridges and toll roads. Overseas, there is more experience with congestion pricing concepts in the form of cordon or area charges in congested downtown areas, such as in Singapore, London, and Stockholm. There is no real world experience with more extensive congestion pricing on a national level.

There remain significant theoretical questions, poorly understood impacts and unintended consequences, real practical and technological barriers, and tremendous political concerns with implementing congestion pricing in the United States. That congestion pricing remains limited and controversial in the United States is evidenced by the State of New York's decision in 2008 to reject a proposal for a zone-based pricing system within Manhattan, despite significant matching funding from the U.S. Department of Transportation's Urban Partnership Program.

As conceptually elegant as congestion pricing is, it creates winners and losers incurring real economic and social consequences, many of which are not yet fully understood. While increasingly being introduced internationally, there are relatively few operational pricing programs, and those provide limited evidence of impacts on congestion mitigation, operational performance, economic and social welfare effects, and other practical considerations. Past experiences

throughout the country with developing HOT lanes, variable priced bridges, and demonstration projects for network per-mile and congestion charges continues to demonstrate that the concepts of pricing are yet to be accepted and understood by elected officials and the public. Technological advances in tolling and intelligent transportation systems have enabled functional pricing schemes to be developed, but technical hurdles remain to large-scale or complex practical implementation.

In the *2006 Conditions and Performance Report*[3] (hereafter, the "C&P Report") the Federal Highway Administration (FHWA) evaluated the extent to which congestion pricing could reduce the need for highway infrastructure investment. In broad terms, the analysis considered "universal" congestion pricing, where users of any road in the nation's highway network would be charged a fee that would enable that road to remain congestion-free. They found that congestion pricing applied in this way could reduce the amount of needed highway investment from 16 to 28 percent, depending on the baseline investment level. It would also produce an average of $24 billion to $34 billion (in 2004 dollars) per year in gross revenue.

The report includes disclaimers about the shortcomings of the analysis and important caveats to the performance and revenue estimates. The American Association of State Highway and Transportation Officials (AASHTO) and key policy-makers desired a more thorough understanding of the assumptions, procedures, limitations, and strengths of this FHWA analysis, to better understand the potential role of congestion pricing in meeting the financial needs of the nation's highway and bridge systems and reducing levels of congestions. This report addresses that question. In addition, this report provides AASHTO with basic background material on how congestion pricing works – or could work – and some of the issues involved in taking congestion pricing from academia to the real world.

Section 2.0 reviews the analysis done for the 2006 C&P Report, which addresses a nationwide system of "universal" congestion pricing. Section 3.0 provides an overview of the economics of congestion pricing, broadening the topic beyond that of "universal" pricing to other, more limited approaches that are likely to be proposed in cities, regions or states. We address practical considerations of implementation and impacts in Section 4.0, covering topics such as policy motivations; short- and long term impacts; equity issues; institutional and public acceptance issues; and implementation considerations. We summarize our conclusions with respect to the C&P report and broader implications in Section 5.0.

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[3] U.S. Department of Transportation, Federal Highway Administration, Federal Transit Administration, *2006 Status of the Nation's Highways, Bridges, and Tunnels: Conditions and Performance*, Publication Number FHWA-PL-07-014.

2.0 Congestion Pricing Analysis in the 2006 Conditions and Performance Report

In the C&P Report, FHWA has historically estimated two investment scenarios: 1) the "Cost to Maintain," representing annual investment level necessary to maintain the existing highway and bridge system condition and performance; and 2) the "Maximum Economic Investment," representing the annual investment level necessary to improve the system condition and performance assuming all projects with a benefit/cost ratio of greater than 1.0 are carried out. For the nation's highways and bridge system from 2005 to 2024, they forecast the average annual cost to maintain to be $78.8 billion, while the average annual value for maximum economic investment is projected to be $131.7 billion.[4]

In the 2006 C&P report, FHWA considered ways to reduce those investment levels through nontraditional means. They considered two levels of investment in operations and intelligent transportation system (ITS) strategies: "aggressive operations deployment" and "full operations deployment." Each of these strategies was anticipated to have relatively minimal impact on overall investment needs, with the highest level of impact realized with full operations deployment coupled with the cost-to-maintain scenario (6.6 percent reduction, or $5.2 billion per year – see Exhibit 2.1).

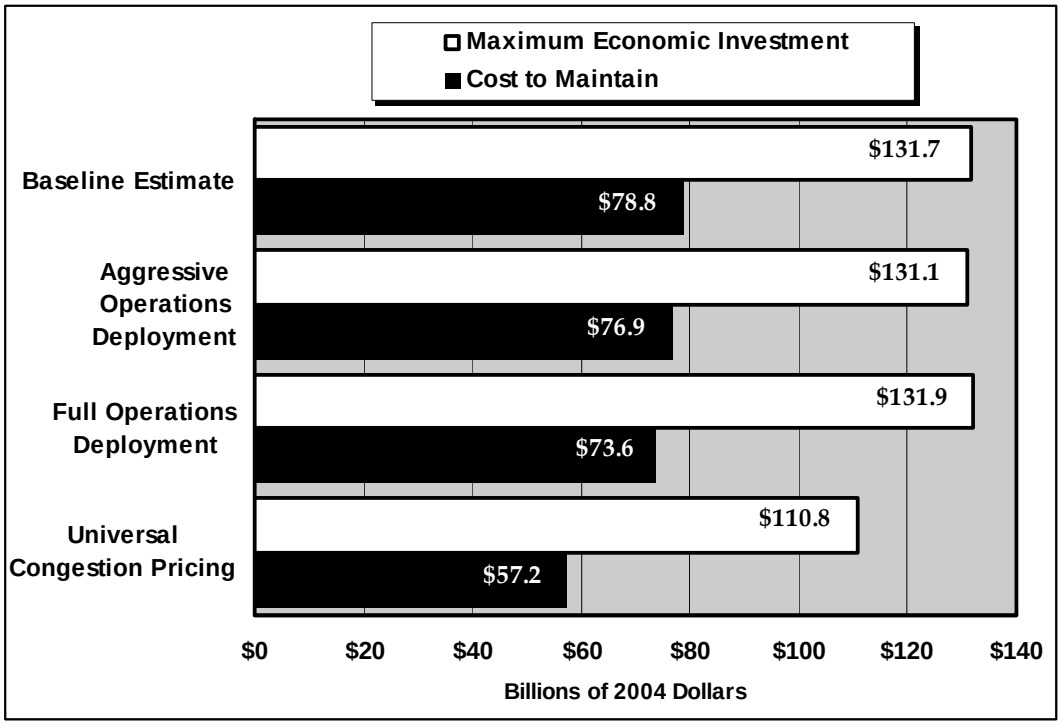
The report also considered "universal" congestion pricing, which would have a considerably greater impact:

- Cost to maintain: 27.5 percent reduction, or $21.6 billion per year; and
- Maximum economic investment: 15.9 percent reduction, or $20.9 billion per year.

Because these estimates depend on implementation of universal congestion pricing, they represent a maximum potential impact of that technique – a caution that is clearly expressed in the C&P report. Because the definition of "universal congestion pricing" is so important to understanding the results, we first explore that definition, and then summarize the methods used by FHWA to come to these conclusions.

[4] The costs for the investment scenarios and the impacts of congestion pricing in the C&P report and reported in this section are in constant 2004 dollars.

Exhibit 2.1 Impact of Congestion Reduction Strategies on Average Annual Investment Scenario Estimates



Source: U.S. Department of Transportation, Federal Highway Administration, Federal Transit Administration, 2006 Status of the Nation's Highways, Bridges, and Tunnels: Conditions and Performance.

2.1 UNIVERSAL CONGESTION PRICING

We begin by reproducing the description of how the universal congestion pricing analysis was defined in the C&P Report (page II to 10 and II to 11):

> *When highway users make decisions about whether, when, and where to travel, they consider both the implicit costs (such as travel time and safety risk) and explicit, out-of-pocket costs (such as fuel costs and tolls) of the trip. Under normal operating conditions, their use of the road will not have an appreciable effect on the costs faced by other users. As traffic volumes begin to approach the carrying capacity of the road, however, traffic congestion and delays begin to set in and travel times for all users begin to rise, with each additional vehicle making the situation progressively worse. However, individual travelers do not take into account the delays and additional costs that their use of the facility imposes on other travelers, focusing instead only on the costs that they bear themselves. Economists refer to this divergence between the costs an individual user bears and the total added costs each additional user imposes as a congestion externality. Ignoring this externality is likely to result in an inefficiently high-*

level of use of congested facilities, resulting in a loss of some of their potential benefits to users.

To maximize net societal benefits, users of congested facilities would be levied charges precisely corresponding to the economic cost of the delay they impose on one another, thereby "internalizing" the congestion externality, spreading peak traffic volumes more efficiently (but not necessarily eliminating all congestion delay), and increasing net benefits to users. In such a case, the economically efficient level of investment in highways would depend only on the cost of building, preserving, and operating highways; valuations of travel time, vehicle operating costs, and safety; and interest rates. The price signals that such an arrangement would produce would also help guide the location of future investment in capacity expansion toward those areas where it would produce the greatest benefits.

[…]

For this report, the HERS model has been adapted to provide quantitative estimates of the theoretical impact that more efficient pricing could have on the future highway investment scenario estimates. This illustrative analysis, presented in Chapter 10, assumes that congestion pricing would be implemented universally on all congested roads. Importantly, it does not account for the considerable costs that could be associated with implementing such a comprehensive pricing system, which could vary widely depending on the type of technology adopted to collect them. It also does not fully address the network effects associated with drivers diverting to other roads.

The important take aways from this definition are the assumptions that:

- Pricing would be implemented universally on all congested roads;
- Pricing is assumed to be at the ideal level to eliminate congestion on each link in the system;
- The effects of traffic shifting from one road to another or to other modes to avoid prices is not addressed, with such effects impacting jurisdictions that may have to pay for the cost of additional traffic and the potential cost to users of increased traffic;
- There is no mention of whether there would be any adjustments to existing transportation funding mechanisms; and
- Implementation costs are not considered.

Perhaps most important is what we believe is an unstated assumption that this system of congestion pricing would be implemented immediately and all at once, and be in effect for the entire 20-year timeframe of the 2006 C&P Report: 2005 to 2024.

2.2 METHODOLOGICAL OVERVIEW

To estimate future investment levels and impacts under various scenarios, FHWA uses the Highway Economic Requirements System (HERS) model, which analyzes current roadway characteristics, conditions, and performance, anticipated future travel growth levels, and benefit/cost measures to identify necessary roadway improvements and their associated costs. The HERS model analyzes these characteristics based on datasets from the Highway Performance Monitoring System (HPMS), a nationally representative sampling of road conditions. Forecasts of future conditions and performance are developed for each roadway segment for four consecutive five-year funding periods.

There are inherent deficiencies in using the HERS national transportation model to construct estimates of the revenue, performance, and travel behavior impacts of congestion pricing. FHWA modified the model to account for these limitations as best as possible and clearly laid out the assumptions embedded in the analysis.

Calculating Congestion Charges

Within the HERS model, optimal congestion charges were applied to users of congested facilities at a fee level corresponding to the additional economic cost of the delay one driver imposes on other drivers. This concept is referred to as marginal cost pricing, which is intended to capture the negative externalities of congestion and is explored in further detail in Section 3.0 of this report. To estimate marginal cost-congestion pricing user fees, the HERS model calculates average user costs (delay, operating, etc.), average user benefits (value of travel time), and predicted average travel demand and congestion volume levels. From these delay equations and value of time inputs the marginal change in congestion costs from the addition of a vehicle to a congested road segment is calculated. The marginal congestion charge represents an average over all drivers, all-day and is equal to the difference between average total user costs and average marginal costs. A congestion charge is calculated for each road segment defined as congested.

The average marginal congestion fee calculated by FHWA was 20.5 cents per mile for the "Cost to Maintain" scenario and 17.4 cents per mile for the "Maximum Investment" scenario. The charges under the Cost to Maintain scenario are higher because there is less overall investment in reducing congestion; therefore, there is more congestion to relieve. The rates reported above are average charges, as optimal congestion fees could be considerably higher on severely congested facilities and lower on less congested sections. Over the 20-year analysis period, baseline growth in traffic volumes is estimated to result in greater levels of congestion and thus produce resulting increases in average congestion fees per-mile over time.

Applying Congestion Charges

The calculated congestion charges were applied to peak period traffic volume on all roadway segments classified as "congested." To determine whether a facility is congested, a volume to service flow ratio (V/SF) was calculated. This ratio compares the number of vehicles traveling in a single lane in a single hour with the theoretical service flow capacity, or the maximum number of vehicles that could utilize the lane in an hour. The threshold for classifying highways as congested was a V/SF ratio of 0.80, while a level of 0.95 or greater was considered severely congested.

In 2009, the HERS model estimated that 42.6 percent of urban Interstate highways would be subject to congestion pricing under the Cost to Maintain scenario, and 37.5 percent in the Maximum Economic Improvement Scenario (Exhibit 2.2). Lower percentages of other roads would be impacted, with an overall total of 13.2 percent of urban roads under the Cost to Maintain Scenario and 12.1 percent under the Maximum Economic Improvement scenario. Rural mileage would have much less application of congestion pricing.

Exhibit 2.2 Percent of Highways Impacted by Congestion Pricing in 2009

Functional Classes	Interstate	Other Freeways and Expressways	Other Principal Arterials	Minor Arterials	Collectors
Percent of Mileage Subject to Congestion Pricing					
Cost to Maintain Scenario					
Urban	42.6%	30.9%	15.3%	11.0%	7.9%
Rural	6.5%	0%	1.8%	1.5%	0.3%
Maximum Economic Improvement Scenario					
Urban	37.5%	26.1%	14.5%	10.2%	7.4%
Rural	4.0%	0%	1.3%	1.3%	0.3%

Source: Federal Highway Administration.

The HERS model registers the change in the price of travel and calculates new equilibrium traffic volume for congested segments, which is generally lower than the baseline forecasts. Estimates of the revenue raised then can be produced from the congestion charges levied on the lesser volume of traffic. The annual gross revenues produced by congestion charges were estimated to be approximately $34 billion for the Cost to maintain scenario and $24 billion for the Maximum Investment scenario.

2.3 MODELING THE EFFECTS OF CONGESTION PRICING

The Highway Economic Requirements System (HERS)[5] computer model is designed to simulate highway improvement selection decisions based on the benefits and costs of improvement options. To do so, HERS first analyzes the current state of the highway system using data on pavements, geometry, traffic, and other characteristics from the Highway Performance Monitoring System (HPMS) sample dataset.[6] It then forecasts future highway conditions and performance using section-specific traffic volume growth rates. If HERS determines a highway section is deficient, it identifies potential improvements to correct deficiencies, estimates the benefits and costs of these improvements, and selects projects using incremental benefit/cost analysis. The model calculates benefits as reductions in highway user costs (including travel time, crash costs, and vehicle operating costs), agency costs such as highway maintenance costs, and societal costs such as air pollution.

Baseline Traffic Forecasts in HERS

The states provide baseline traffic forecasts for each highway section in the HPMS sample dataset reflect forecasts of anticipated growth that FHWA assumes to be based on current, constant prices. Thus these forecasts reflect what future traffic volumes would be if the cost of traveling on the highway section remains constant over time. These forecasts then are modified by applying travel demand elasticity's[7] which predict how changes in the cost of traveling on a highway section will affect future traffic volumes. Travel demand elasticity calculation procedures in HERS recognize that the predicted future volume of travel on a highway will be greater than the baseline forecast if the cost of using the highway decreases (due, for example, to a capacity improvement). Conversely, the expected future volume of travel on a highway will be less than the baseline forecast if the cost of using the highway increases (due, for example, to the growth of congestion over time).

The concept of travel demand elasticity is key to congestion pricing and can be modeled using the HERS model to account for changes in travel behavior that

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[5] Much of the material in this section is summarized from Appendix A of the 2006 Conditions and Performance report. See that appendix for a more detailed description of HERS and references to where more detailed technical information on HERS can be found.

[6] The HPMS sample dataset provides information on over 110,000 highway sections across the nation. The data are collected by State Departments of Transportation and compiled by the Federal Highway Administration. The analyses performed for the 2006 Conditions and Performance Report were done using the 2004 HPMS sample dataset.

[7] Demand elasticities are calculated as the percentage change in travel divided by the percentage change in the cost of travel. For example, an elasticity value of -0.8 implies that a 10 percent decrease in the cost of travel will result in an 8 percent increase in travel.

would alter systemwide traffic levels. Examples of such changes include impacts to the number of trips made and trip lengths, shifts to mass transit, and, over the long run, alteration of location decisions. These changes are all impacted by an increase in travel costs due to the imposition of congestion pricing, and are the foundation of the market principles and economic basis for the policy.

The calculated elasticities do not account for route diversion, which is a significant effect of pricing or changes in travel costs. HERS analyzes each highway section independently and so does not consider the network effects of improvements, or changes in travel costs. Thus, when traffic on a section is increased or decreased due to the application of the elasticity procedures, volumes on other highway sections are not affected in the model. This is one of the primary limitations of the model.

To predict speeds on freeways, signalized arterials, and other highway sections with two or more lanes in each direction, HERS first estimates the fraction of travel that will occur in the peak period. This fraction is calculated as a function of the ratio of average daily traffic to capacity (AADT/C). As AADT/C increases and the section becomes more congested, the fraction of travel occurring in the peak period decreases, reflecting the familiar phenomenon of peak spreading. Within the peak period, traffic is split between the peak- and counter-peak directions using the base year directional factor coded for each HPMS section.

In the version of HERS used for the 2006 C&P report, separate demand analyses were not performed for individual time periods. Travel costs were averaged over time periods to produce average daily travel costs. Changes in average daily travel costs (relative to the base year average daily travel costs), then were used, together with travel demand elasticities, to calculate changes in average daily traffic (relative to the baseline forecast). The fraction of travel occurring in the peak periods then was calculated as a function of the ratio of average daily traffic to capacity, as described above.

Future Investment Scenarios in HERS

In the C&P Report, estimates of future investment levels were developed for two future investment scenarios. Under the "Cost to Maintain" scenario, it was assumed that future investments would be such that the condition and performance of the highway system (as measured by average highway user costs) would be maintained at 2004 levels. Under the "Maximum Economic Investment" scenario, it was assumed that all investments for which benefits exceed costs would be made.

2.4 CONGESTION PRICING ANALYSIS USING HERS

The CS team reviewed the methodology and assumptions contained within FHWA's congestion pricing analysis using the HERS model. We obtained copies of the outputs of HERS runs used by FHWA in its analysis, along with docu-

mentation and the portions of the model code related to congestion pricing. Questions on these materials were clarified with FHWA staff through e-mail correspondence over the course of the review. This section describes our interpretation of what was done, and the implications.

For the 2006 C&P Report, HERS was adapted to illustrate the maximum theoretical impact that efficient congestion pricing could have on estimates of future highway investment scenarios. Under efficient pricing, "…users of congested facilities would be levied charges precisely corresponding to the economic cost of the delay that they impose on one another, thereby reducing peak traffic volumes and increasing net benefits to all users combined."[8] The analysis assumed that congestion pricing would be implemented universally on all congested roads, with a congested road defined as one having a peak-hour volume/capacity ratio of 0.8 or greater, which is the standard definition of congestion.

The version of HERS used for the 2006 C&P report did not have the capability to conduct demand analysis for individual time periods. For this reason, FHWA first estimated efficient congestion tolls and their effects on traffic volumes on an "all-day" basis and then adjusted the results of the "all-day" analysis to represent the application of congestion tolls in just the peak period.

In describing the "all-day" analysis of congestion tolls, we use the following variables:

- AADT is *average annual daily traffic* on the highway section.
- AP is the "all-day" *average price* experienced by highway section users. It is calculated as the sum of travel time costs, vehicle operating costs, crash costs, and fuel taxes.
- MP is the "all-day" *marginal price* for the highway section, defined as AP + AADT x d(AP)/d(AADT), where d(AP)/d(AADT) is the derivative of AP with respect to AADT. Note that AADT x d(AP)/d(AADT) is the impact on other users of the section caused by a unit increase in AADT, since d(AP)/d(AADT) is the increase in the average price caused by a unit increase in AADT and AADT is the number of other users affected by the price increase.
- MSC is the "all-day" *marginal social cost* for the highway section, defined as MP plus emissions costs minus fuel taxes. Fuel taxes are subtracted because they are considered to be transfer payments, not costs.
- α and ε are parameters in the HERS short-run demand equations. Within a funding period, the effects of changes in the average price on AADT are calculated as $AADT_d = \alpha \times (AP_d)^{\varepsilon}$. The subscript "d" is used to distinguish

[8] 2006 Conditions and Performance Report, page ES-13.

quantities calculated by applying the HERS demand model from those calculated by applying its user cost models.

The steps in the "all-day" analysis were as follows:

- Step 1 – Calculate AP at the initial AADT (i.e., the AADT without congestion pricing) by applying the HERS user cost models for travel time, vehicle operating costs, and crash costs.
- Step 2 – Calculate d(AP)/d(AADT) at the initial AADT by calculating the change in AP that would result from small changes in AADT.
- Step 3 – Calculate MP at the initial AADT as AP + AADT x d(AP)/d(AADT).
- Step 4 – Calculate MSC at the initial AADT by subtracting fuel taxes and adding emission costs to MP.
- Step 5 – Calculate d(MSC)/d(AADT) at the initial AADT by calculating the change in MSC that would result from small changes in AADT.
- Step 6 – Calculate the slope of the demand curve at the initial AADT, using the following equation:

  $d(AP_d)/d(AADT_d) = (1 / (\varepsilon \times \alpha)) \times (AADT_d / \alpha)^{1/\varepsilon - 1}$

- Step 7 – Calculate the new AADT associated with the intersections of the slopes of the marginal social cost and demand curves using the following equation:

  New AADT = Initial AADT + (MSC-AP)/(d(AP_d)/d($AADT_d$) – d(MSC)/d(AADT)

This equation provides an approximation to the level of AADT at which the demand curve and marginal social cost curve intersect.

- Step 8 – Repeat Steps 1 through 7, using the new AADT determined in Step 7 instead of the initial AADT.

This second iteration provides a second (and closer) approximation to the level of AADT at which the demand curve and marginal social cost curve intersect.

- Step 9 – Calculate AP using the new AADT determined in Step 8.
- Step 10 – Calculate MSC using the new AADT determined in Step 8 by repeating Steps 1 through 4.
- Step 11 – Calculate the "all-day" congestion toll as the difference between MSC (from Step 10) and AP (from Step 9).

The 11 step procedure described above was used to model the effects of "all-day" efficient congestion pricing. The results from the "all-day" analysis then were adjusted to represent the application of congestion tolls to just the peak period. The adjustment procedure was as follows:

$$AADT_{output} = AADT_{initial} - (AADT_{initial} - AADT_{all\text{-}day})) \times PF$$

Where:

- $AADT_{initial}$ is the initial AADT (i.e., the AADT without congestion pricing).
- $AADT_{all\text{-}day}$ is the AADT calculated assuming congestion tolls are applied on an all-day basis, using the 11-step procedure described above.
- $AADT_{output}$ is the AADT output from the congestion pricing analysis adjusted to model the application of congestion tolls to just the peak period.
- PF is the *peak-factor*, or percentage of total travel occurring in the peak direction during the a.m. and p.m. peak-periods. Values of PF are typically in the 0.15 to 0.20 range.

The congestion pricing procedure described above was applied to all highway sections for which the peak-hour volume to capacity ratio (without congestion pricing) would exceed 0.8. While the effect of congestion pricing on AADT was adjusted to reflect the application of congestion tolls to just the peak-period, in calculating speeds and evaluating improvements for sections subject to congestion pricing it was assumed that traffic in all time periods would be reduced by approximately the same percentage.[9]

2.5 IMPLICATIONS FOR UNDERSTANDING THE RESULTS

In summary, using HERS to estimate the impact of universal congestion pricing has some issues that need to be understood so that the results can be properly interpreted. We found three main concerns.

Daily Traffic Analysis Understates the Congestion Charges

Congestion tolls were estimated using an "all-day" analysis and then just applied to the peak-period. If congestion tolls were instead estimated for just the peak-period, they would have been several times greater. This is because congestion tolls are set to reflect negative impacts on other highways users, which are much worse during the peak-period.

Consider, for example, a section on which an additional trip during the peak period would cost other users $0.75 and an additional trip during the off-peak period would cost other users $0.05. If 20 percent of daily traffic is in the peak-period and 80 percent is in the off-peak period, an "all-day" congestion toll would be $0.19 (calculated as $0.75 x 0.2 + $0.05 x 0.8). In this case, the peak-period toll of $0.75 is almost four times the all-day congestion toll of $0.19.

[9] Actually, the percentage reductions in traffic due to congestion pricing were slightly larger in the off-peak than in peak periods because HERS calculates the percentage of travel occurring in peak periods as a function of the ratio of AADT to capacity. As AADT is reduced, peak spreading is reduced so that more of the travel occurs in the peak period.

FHWA factored the VMT due to congestion tolls from the "all-day" analysis downward to reflect the application of congestion tolls. However, this was applied in just the peak-period, while the analysis of alternative improvements was conducted with VMT in all time periods being reduced approximately the same percentage. This resulted in a significant understatement of congestion reductions due to pricing charges.

Ignoring Network Effects Paints an Incomplete Picture

When HERS models traveler responses to changes in costs, all it can do is reduce the amount of traffic on a link-by-link basis. This means that the only traveler responses that HERS could model were those that reduce total VMT (such as fewer or shorter trips). But pricing on one highway may lead to diversion to another highway, leading to an increase in VMT, or to another mode (e.g., transit), thereby increasing costs on that element of the transportation system. Without considering network effects, we get an incomplete picture of the potential changes that would come about from congestion pricing.

Technological Barriers Cannot be Ignored

The technological barriers to implementing a comprehensive, national network of priced freeways are considerable. Even within the 20-year time period evaluated by FHWA, implementation of such a system would by necessity be phased in gradually area by area, thus diminishing the revenue impact found in the C&P Report, which assumes immediate nationwide deployment.

3.0 The Economics of Congestion Pricing

3.1 BACKGROUND AND OVERVIEW

The Federal Highway Administration document, *Congestion Pricing, A Primer*, explains congestion pricing like this:[10]

> *Congestion pricing: Sometimes called value pricing, is a way of harnessing the power of the market to reduce the waste associated with traffic congestion. Congestion pricing works by shifting purely discretionary rush-hour highway travel to other transportation modes or to off-peak periods, taking advantage of the fact that the majority of rush-hour drivers on a typical urban highway are not commuters. By removing a fraction (even as small as five percent) of the vehicles from a congested roadway, pricing enables the system to flow much more efficiently, allowing more cars to move through the same physical space. Similar variable charges have been successfully utilized in other industries; for example, airline tickets, cell phone rates, and electricity rates. There is a consensus among economists that congestion pricing represents the single most viable and sustainable approach to reducing traffic congestion.*

How have economists reached this consensus, and what is it based on? Since the emergence of modern microeconomics, theories have shown that people's demand for a good responds directly to the price of that good. As prices rise, some people choose not to purchase and when prices fall, vice versa. In the case of goods with limited supply, if prices vary and those price differentials are communicated to customers, people will make choices appropriate to their situations and supply and demand will remain in balance. Pricing of last-minute airline tickets, daytime cell phone use, and electricity rates are some examples of time-based pricing of goods. In each of these cases, customers causing peak congestion pay a premium, while those who can purchase at times when the resource is not scarce pay less. When demand remains strong even in the face of high prices, the producer receives a market signal that additional investment in expansion on a particular route or region may be profitable.

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[10] Federal Highway Administration, Office of Transportation Management, HOTM, *Congestion Pricing, A Primer,* December 2006.

The pricing of road use has not worked like this. Government has had a monopoly on road building and people have perceived roadways to be a "public good." A public good is one in which no one is excluded, everyone has equal access, and one person's use does not diminish the value to others. Public goods are those that everyone enjoys, but that are paid for by taxpayers. However, roadways may not be a true public good because under congested conditions, one additional vehicle on the road may prevent another vehicle from enjoying the same benefits of travel.

Society pays for road transportation through fixed charges; registration and license fees, excise taxes for vehicles, tires and batteries; and through variable charges such as motor fuel taxes. Although motor fuel taxes vary in proportion to use, they do not fully capture the value of roadways at different times. Some regions have other mechanisms to pay for highway improvements; local option sales taxes are particularly popular. Unlike excise taxes and motor fuel taxes that have some relationship to use, sales taxes are entirely unrelated to use and to the benefits received. All existing methods of transportation finance are regressive; that is, people of lesser means pay a higher percentage of their disposable incomes. This is an important point to keep in mind when considering some of the consequences of congestion pricing.

When something is perceived as free, or near free, people tend to consume as much of that good as possible. The use of public roads is often considered free or nearly free. This results in what economists call "market failure," which is commonly experienced as congestion. Because the theory of congestion pricing is not well understood, a common concern about congestion pricing is that it impinges on our perceived right to travel whenever or wherever we please, and that we are "double paying" for something we already pay for with taxes. In actuality, the concept of congestion pricing is to expose drivers to the full social cost of road use by directly charging for those costs that vary with congestion.

As early as 1912, the economist Arthur Pigou is credited with expressing the concept behind congestion pricing or having people pay for the cost that their presence on the road imposes on everyone else, called the "marginal social cost" of driving. When drivers must absorb that additional cost, they alter their behavior accordingly, and the fixed resource – the road – will operate more efficiently. This correction of market failure comes about by internalizing to some drivers the "negative externalities" of congestion on all of society.

In addition to congestion costs, road user charges also may be designed to recuperate costs associated with environmental and safety impacts on society or to provide revenues to finance future road and transit improvements. However, we do not need a shift to congestion pricing to recover these additional social costs because they could be recovered through changes to motor fuel tax or excise tax policy. For the purposes of this report, we focus strictly on the social

costs of congestion, but the recovery of other social costs of driving is an important concept that should not be ignored when formulating long term policy.

3.2 CONGESTION PRICING FOR SOCIAL EFFICIENCY

William Vickrey further developed the idea of congestion pricing in the 1950s and 1960s. At the time, implementing his ideas was impossible because of the primitive nature of toll collection. By the 1990s, tolls could be collected electronically without requiring drivers to stop, and there were several working examples of toll roads without tollbooths. These developments fueled a renewed interest in road congestion pricing.

Vickrey's idea was to apply market principles to achieve the highest level of economic efficiency by gaining the greatest mobility for the least expenditure. It is important to understand, however, that moving from our current system (economically inefficient) to a system based on Vickrey's concepts (economically efficient) may result in the greatest potential benefit to society, but also will result in changes – positive as well as negative – for individual members of society. That is, there will be winners and losers, and addressing the fate of the losers is an important consideration in the policy debate over congestion pricing.

The change in circumstances for individuals and particular groups is an essential point. If, when automobile travel emerged at the beginning of the 20th century, we had developed a system of road use charging based on recovering societal costs from individual drivers, the decisions made over the last century, including motor vehicle fleet composition and land use patterns, would have been very different, and well suited to that system. We can see some of these differences in Europe, which has embraced the idea of marginal social cost pricing for some time. Motor fuel taxes in Europe are many times higher than taxes in the United States. As a result, Europe has more fuel efficient fleets, less motor vehicle ownership, higher levels of investment in public transit (and transit use), and more compact land use patterns. In the United States, the process of migrating from the current system, with people making decisions based on a distorted view of the cost of travel, to one that forces full recognition of these costs has the potential to cause a significant disruption of our social fabric.

Full realization of the congestion pricing ideal would require full knowledge of congestion on the entire road network at all times, and algorithms to predict the result of price choices on each link simultaneously. Every other congestion pricing concept proposed must make compromises because of technical or political limitations. These compromises will exacerbate the winners and losers calculation.

The fundamental challenge of congestion pricing, however, is that it results in an economically efficient solution to road congestion – making the best use of the roadway system – yet the entire population, on average, may be worse off than before. This is because congestion pricing charges everyone for something they

had not previously had to pay for: the benefits of travel and the impact of travel on others. As a result, some people would be worse off than before. Consider these examples:

- **People who choose to pay the congestion charge** will continue to use the same road at the same times they always have, yet they will pay more. They may save some time, which has a value to them, but the total cost will likely be higher than it was before, even when considering the time savings. Because they are paying the congestion charge, that choice is still better than the alternative (driving at a different time-of-day, taking transit, or foregoing the trip), but they are still paying more than they would have before the congestion charge. *Some of these people* will be better off – those with very high values of time. For them, the value of the time savings exceeds the value of the congestion charge, but on average, the group that pays the congestion charge is worse off than before.
- **Those who choose an alternative mode, time, or route, or cancel their trip** will be worse off, because they will not traveling when, where, or how they want.
- **Those who were on alternative routes before** may be worse off because there may be more travelers competing for that road space. This is not an issue in universal congestion pricing, but could be an issue if only a portion of the network (e.g., all freeways) is priced. It is possible that congestion pricing might allow greater traffic throughput overall, which might relieve some traffic on nonpriced roads (rather than worsen it), but this can only be estimated through detailed analysis, or ultimately, through well done before and after studies.

In fact, the overall value of the toll that is paid may exceed the travel time saving benefits of congestion pricing. Other aspects that should factor into the calculation include savings in fuel, emissions, or other externalities. With congestion pricing, not everyone will fare the same. The ultimate economic argument of whether society is better off and who wins or loses is dependent on the incidence of the direct and indirect benefits and costs the congestion-free travel, who pays the tolls, and how toll revenue is spent.

If the toll revenue is refunded to society through, for example, a reduction in the gas tax, a reduction in other taxes, or through transportation system investments that provide additional benefits, the losers can be compensated, perhaps to the point where no one would be worse off, and some may be better off than before (a Pareto improving result, named after the economist Vilfredo Pareto who, in 1906, defined social efficiency as the optimal allocation of resources in society, achieved only when it is not possible to make anyone better off without making someone else worse off).

This discussion of who wins and who loses is necessarily done in comparison to the pricing structures and social fabric today. It does not comment on the fairness or desirability of today's conditions.

Some of the factors that influence whether congestion pricing can be a socially efficient or responsible idea are discussed in the subsections below.

3.3 PRICE SETTING

Implementing congestion pricing on a large scale would require extensive and simultaneous knowledge about congestion levels on all parts of the transportation system. It would also require the ability to anticipate how each driver's decision to leave on a trip would affect the system later on when they reach points of their route downstream. Vickrey understood that the decision to travel is made at the beginning of a trip, but the impact of travel is felt along the entire route of a trip and persists well after the trip is made due to the nature of bottlenecks.

Carrying congestion pricing to its theoretical limit would require the ability to anticipate the economically efficient prices, communicating those prices to travelers so they could decide how to respond, and then anticipating those responses so that the lower priced portions of the system could compensate – all in real time. We have seen this idea work on HOT lanes, where prices are set dynamically based on traffic level in priced lanes and prices change frequently enough to maintain optimum traffic flow. Moving beyond a single 10-mile corridor to a longer corridor introduces additional complexity, as does moving to a system of priced freeways or an entire priced roadway system.

Beyond the technical complexity of pricing different parts of the system in an economically efficient manner lies the political complexity. Economic efficiency is only one part of the equation, and the nature of our society is to strive for equity and fairness in charging. One can see this on urban transit systems. Transit systems often charge a flat rate, regardless of time-of-day or even distance traveled. Some systems like Washington, D.C.'s Metro charge higher prices during peak hours, but most have constant rates all-day. Moreover, no systems charge higher rates on more congested or more popular routes – as economically efficient as that might be. People would consider that unfair.

More practical than a custom price for each minute of the day and each road on the system would be a simplified system of user charges based on time-of-day, type of road, and perhaps general location (e.g., central business district, urban, suburban, and rural). These charges would be something less than fully economically efficient, and the degree of efficiency improvement would vary with the extent of the political compromises that needed to be made. Given the nature of political compromise, it is quite possible the resulting system would be very far from perfectly economically efficient, though it would be more so than the *status quo*, and equity issues could be addressed by redistributing the toll revenue.

3.4 THE PRICED OFF AND THOSE IMPACTED BY THE PRICED OFF

Under any congestion pricing system other than full mileage-based pricing (or "universal congestion pricing," as described in the C&P Report), there would be nonpriced parts of the system. This means that some people will not use the highway of their choosing, and would "lose" when compared to their current condition. The other losers in this situation would be those drivers previously using an alternate route or living along alternative routes that would now be faced with additional traffic and congestion from those avoiding the priced system.

An oft-quoted demonstration[11] of the value of congestion pricing is the ability of pricing to restore the full volume of a roadway by managing demand. The optimum flow on a highway occurs when vehicles travel at about 45 miles per hour. When demand exceeds a certain point, speeds drop precipitously, with the result of less throughput despite higher demand. This paradox is born out daily in stop-and-go conditions on freeways. If pricing can manage demand to the level that maintains speeds at 45 to 55 miles per hour, traffic flow can be optimal and the most value for the investment realized.

One problem, though, is what happens to drivers on roads that are not priced. If these roads become more congested as a result of shifting traffic, these users will have their condition diminished. Because freeways carry so much traffic, it is possible that the overall impact on the system would be positive. Society at large would "win," but those paying on the highway may win at the expense of those priced off and those that happen to share the other roads with priced off drivers.

3.5 MARKET SIGNALS TO IDENTIFY WHERE IMPROVEMENTS SHOULD BE MADE

Some advocates of congestion pricing emphasize the effectiveness of comprehensive pricing strategies in identifying places in the transportation system where improvements are needed. Just as an airline might raise prices on a popular route to manage the available seats; at some point, adding another flight to the route may be profitable and the airline may choose to make that investment. Constant competition for seats on that route and the high prices that can be charged signals the operator that expansion may be a good idea.

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[11] Washington State Department of Transportation, *The PRICE Is Right! A simple demonstration of how peak hour traffic flow through variable pricing can make highways more efficient and saves money and aggravation for everyone*, undated, available at: http://www.wsdot.wa.gov/NR/rdonlyres/4D0BFFF3-E59B-45EE-ABB4-1F00F762C5DE/0/MacDonaldRiceHandout.pdf.

Under a market-based system, the same market signals could be applied to roadway capacity. The problem, though, is that traffic demand is only one of many measures used to decide whether or where to make improvements. Physical constraints, environmental issues, and social equity may be equally important considerations. Again, final decisions made under full considerations would not be the most economically efficient solutions, but would reflect the reality of public decision-making in a democracy.

3.6 THE IMPORTANCE OF DEALING WITH REVENUE

Pricing seeks to recover the social costs of driving not been previously charged for, resulting in revenue gains to government. Until we consider what would be done with this revenue, it is difficult to determine whether society would be better off. Distribution of revenue is an age-old political issue, and it would be no different with congestion pricing. For the sake of fairness and gaining political support, there would be a strong temptation to use the revenue to overcompensate the losers or to spread benefits around to all groups. In all circumstances, an underlying purpose of redistributing revenue would be to make a positive contribution to society in some way. Some approaches to achieve this include:

- Investing in transit improvements in the affected area;
- Subsidizing improvements to the highways system (e.g., parallel arterials);
- Rebating motor fuel taxes;
- Reducing general taxes such as income or property;
- Awarding unspecified grants to the affected communities; and,
- Devising a system whereby users during peak times pay a price, and those who travel during off-peak get a credit. Credits might be used for travel on another day or on transit.

It is important to note, however, that these uses of revenue contrast with public ideas of how toll revenues should be used. Lessons learned from the FHWA's Value Pricing Pilot Program suggest that people support the use of tolls to benefit corridor-level improvements, including the transit system; or that toll revenue should only be spent for the benefit of those paying the toll, in particular, through investments in the highway being tolled. This is the traditional political justification for financing roads, bridges, and tunnels with tolls. These traditional public views of when tolling is justified run counter to the idea of recovering the marginal social cost of driving with tolls.

An interesting treatment of this topic by University of California planners King, Manville, and Shoup suggests using congestion pricing revenue to compensate

communities directly.[12] Their argument is that those people perceiving themselves as losers under congestion pricing are likely to form strong political resistance to the idea. As a result, one mechanism to gain support would be to target the distribution of revenue to create groups that perceive themselves as winners and, thus, more likely to be supportive. Actually implementing a congestion pricing project without building long term, consistent support from those affected, for better or for worse, is likely impossible.

[12] David King, Michael Manville, Donald Shoup, *The Political Calculus of Congestion Pricing*, January 2007.

4.0 Practical Considerations

The analysis of universal congestion pricing in the C&P Report made the simplifying assumption that such as system could be up and running within the timeframe of the C&P report forecast. While we are confident that this cannot happen, there are much less extensive congestion pricing concepts that are currently being considered, planned and implemented around the country. It is these less extensive applications that are more likely to be proposed in the near future, and this section addresses some of the practical considerations that need to be addressed. We start with the different policy motivations, and then consider the short- and long-term impacts of pricing; equity and social considerations; institutional and public acceptance issues; and implementation considerations.

4.1 POLICY MOTIVATIONS AND TYPES OF CONGESTION PRICING

Until recently, the idea of congestion pricing has lived in the ivory tower, where economists debated about things like recovering the difference between marginal private costs and marginal social costs, public goods and private goods, and regressive versus progressive policies. But when congestion pricing is discussed in the retail market of public policy – the legislature, governor's office, the airwaves, and blogs, there are a variety of policy motivations for congestion pricing that do not necessarily connect to the ideas of the economists, such as:

- Reducing peak period congestion, in general, or targeted to a particular highway;
- Improving travel time reliability;
- Encouraging transit use;
- Reducing air pollution, green house gas emissions, and energy use;
- Changing urban form;
- Paying for transportation projects (highway or transit); and
- Promoting economic development.

There also are numerous ways congestion pricing can be carried out:

- **Priced lanes,** where one or more lanes on a highway are priced to afford a higher-level of service than adjacent nontolled lanes;
- **Priced roads,** where an entire road or group of roads is priced;

- **Priced zones**, such as when drivers pay each time they cross the cordon, or pay for the privilege of driving within the cordon; and
- **Systemwide pricing**, where an entire system of roadways in a region, state, or nation are priced.

The rest of this section addresses various aspects of congestion pricing that relates to the policy motivations and potential ways that those policies might be carried out through specific types of congestion pricing.

4.2 POTENTIAL IMPACTS OF CONGESTION PRICING

Peoples' choices of how, when, where, and whether to travel are influenced by numerous attributes of the transportation system, land use patterns, demographics, social attitudes, and other items we may not even recognize. There are entire disciplines of research and practice devoted to understanding these relationships, and the concept of "cost" is central to all of these.

Cost can be reckoned in different ways. The most obvious are out-of-pocket costs that involve paying for fuel, parking, and tolls when driving a car, or fares when using transit. Less obvious are the wear and tear (depreciation) on a personal automobile incurred by driving. The cost is not reckoned up until the time when the car is sold. Nevertheless, this is still a monetary cost. There also is a cost of time, because time spent traveling is time that could be used for other, arguably more productive purposes.

Any change in the system can result in a reassessment of old travel patterns. If the frequency of bus service improves from once an hour to once a half-hour, I may find it a better option. Similarly, if security concerns on transit are improved, or if the stations are more comfortable, transit may become a better option. If my drive from home to work used to take 15 minutes, but now takes 30 minutes because of congestion, I may choose to leave earlier or later to avoid the congestion. Or, I may have little flexibility, or not care enough about the value of my time to change at all. If a new road is built, I may find the new road more convenient and start using it, but if that road has a toll on it, I may only use that new road when time is important to me. If the changes are significant enough, I may change basic patterns of living. A new highway or transit system might improve accessibility to land that was otherwise hard to reach, meaning people will move from one place to another, or choose different places to work as a result. This is but a small sampling of the factors affecting traveler choice.

The "price" in congestion pricing is another such change to the transportation system that will bring about a traveler response. The response due to pricing will vary considerably according to how it is applied and what the prices are, so it is impossible to generalize. We can, however, generalize the kinds of impacts that might be expected, and how those impacts might change with how the prices are applied. In addition to the importance of the details of specific pricing programs, it also is important to understand that there is very little real world

experience with pricing. Most of the pricing experience in the United States has revolved around relatively minor adjustments to toll rates on existing toll facilities, as well as HOT lanes. Lessons from these implementations may not translate well to other types of pricing, such as tolling existing freeways or cordon pricing. Other implementations, such as cordon pricing, have been tried overseas, but in environments that are very different from those in most United States communities, so these findings do not translate well either.

Short- and Long-Term Responses

Short-term responses are arguably the most obvious because they relate to day-to-day trip-making decisions. A short-term response assumes an existing pattern of behavior, places to live and work being the most influential. Adding a toll to an existing nonpriced system will bring about this range of short-term responses:

- Change of travel path from a tolled route to a nontolled route or to a lower toll route, if either of these exists under the scheme.
- Change of mode of travel, in particular if no nontolled routes are allowed for or if the nontolled routes are of poor quality. Change of mode could include ridesharing.
- Change of time of departure, if variable prices by time-of-day (or congestion levels) are used.
- Change of destination, if there is such flexibility in the short term. For example, if I want to buy groceries, and one store is reached via tolled routes and one via nontolled routes, the toll may be sufficient for me to change the store at which I choose to shop.
- Not make the trip, or combine several trips to save on the toll cost.

With more time to react and a pricing regime in place, people may respond in more far-reaching ways. The increased out-of-pocket cost to travel on a particular highway or in a particular area may lead people to sell one or more cars and, as a result, take transit more often. Some people might react to the new pricing regime by changing their place of residence or employment, or both, to avoid the new toll cost. If one or the other is changed, this would result in a shift of travel from one part of a region to another. If both are changed, it may move that travel to another region entirely.

Other travelers may respond in exactly the opposite way. They may see the additional toll cost as a small price to pay for improved travel times and reliability. Thus, if pricing is successful at bringing about improved efficiency in the transportation system, the out-of-pocket costs would be more than offset by the travel-time benefits. Some classes of travelers may see this positively and be attracted to locations with such features. This may be particularly true if toll

revenues are used to enhance transportation alternatives and bring about less congestion (and a more pleasant environment).

Impacts by Type of Trip

Pricing will have an impact on different trip purposes in different ways. The elements of the trip-making decision involved here relate to value of time and scheduling flexibility. Toll charges are likely to have the least amount of impact on business trips that are "on the clock," and these trips will likely benefit from pricing the most. Commuter travel for some people tends to be inflexible in terms of schedule, but is a recurring charge. There is considerable evidence of people changing their time of departure (earlier or later) to avoid the wasted time cost of traveling during the peak of the peak. If time-of-day pricing is used, toll charges may move people with less scheduling flexibility into the peak because they may be willing to pay for the decrease in congestion. At the same time, it may move others away because their trip type can occur at a different time. The types of trips with more flexibility might include social visits and shopping.

Shopping trips are particularly sensitive in many discussions of congestion pricing, particularly cordon or area pricing schemes. The fear is that the toll price will discourage shoppers from coming into the priced zone, thereby having an impact on retail businesses in the zone. Here again, it is the overall impact on travel that will determine whether the effect on shopping travel will be positive or negative. If the benefits received from the entire pricing program, including congestion reduction from pricing itself and capital or operating improvements brought about by toll revenue exceeding out-of-pocket costs – the effect on shopping travel can be positive. If the public does not perceive sufficient benefit from the program, then there could be negative impacts. The ultimate answers will depend on the details of the entire program.

Freight travel also is of particular concern. Freight can benefit from congestion pricing if congestion is reduced on highways and deliveries can be made more reliably, because "just-in-time" delivery regimes put a high value on schedule compliance. However, because of the emphasis on the schedules of shippers and receivers, dislodging freight trips from peak periods through the use of pricing has been shown to be particularly difficult. Studies in the New York region have shown that truckers are squeezed from both sides when faced with congestion pricing. Their time of travel is dictated by their customers, and their prices are very competitive, meaning that they have difficulty passing on the cost of the tolls to their customers.[13]

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[13] Holguín-Veras, J. *The Truth, the Myths, and the Possible in Freight Road Pricing in Congested Urban Areas.* National Urban Freight Conference, Long Beach, 2006.

4.3 EQUITY AND SOCIAL CONSEQUENCES

Congestion pricing affects population segments differently and disproportionately. The benefits received and costs borne differ significantly by driver subgroups, most often dependent on income. Real or perceived social and political concerns over inequitable impacts of congestion pricing can influence the implementation and success of any pricing project.

Assessing equity issues involves identifying winners and losers of congestion pricing policies and estimating the differential incidence of benefits and costs. One perspective on equity under congestion pricing emphasizes distributional impacts by income and socioeconomic characteristics and is concerned with perceptions of affordability across these dimensions. Another perspective focuses on the impact of people living in different areas or making differing types of trips, with the fairness perspective of which groups incur costs or receive benefits and who should pay accordingly. Despite this simple broad view, identifying winners and losers under congestion pricing, as well as the true equity impacts are exceedingly complex.

Equity Impacts by Income Group

Income is a significant variable in determining responses to congestion pricing, but not necessarily as expected. Congestion pricing concepts are often criticized as being inequitable to drivers at lower-income levels. Yet, published findings from HOT-lane demonstration projects show that all income groups use priced express lanes, although more frequent users are high-income travelers.[14] Public perception and attitude surveys also show that all income groups, including very low-income groups, are supportive of HOT-lane and variable tolling concepts.

However, a general conclusion from various studies is that congestion pricing is inherently a regressive taxation policy and low-income or less-flexible drivers (e.g., based on gender or flexibility of working schedule) are likely to be the groups worst off as a result of road pricing. If revenues are not redistributed congestion pricing generally results in gains for higher-income groups and losses for lower-income groups.

- **Lower-income drivers**, or those on fixed incomes, will have a more difficult time affording or even justifying congestion charges, thus they are more likely to be entirely "priced off" of roadways. They are disproportionately impacted and may spend a greater proportion of their income to pay to travel at preferred times or incur greater costs in travel time by choosing alternative routes.

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[14]Sullivan, Edward, *Continuation Study to Evaluate the Impacts of the SR 91 Value-Priced Express Lanes, Final Report,* December 2000.

While not universally true, lower-income drivers also tend to have less flexibility in scheduling preferences. Employees in service jobs with standardized start and end times cannot risk arriving late and will find it more difficult to travel routes priced by time-of-day. Other vulnerable groups, likely to be women, necessarily have obligations such as childcare drop-offs, adult-education classes, and other scheduled commitments that require timely travel on the most convenient routes.

These vulnerable groups may also benefit in other economic ways as a result of significant revenue redistribution that is either targeted to compensate economic losses or that provides for substantial investments in public transit system, which are more likely to be used.

- **Higher-income drivers** are natural consumers of congestion pricing and will find it easier to afford congestion charges as a function of total income. Even these drivers with standard and scheduled travel obligations tend to be more time-sensitive than price-sensitive and stand to benefit from reduced travel times.

  While there is little empirical evidence, congestion pricing may encourage wealth stratification in the United States, by accruing travel-time benefits to those who are able to pay, thus enabling greater productivity and performance. While high-income drivers are the perceived winners in congestion pricing, they also are losers in a purely economic sense, as they must also pay direct costs for a good that was previously free.

The equity and income effects of congestion pricing are not well understood and the majority of empirical studies come from evaluations of HOT-express-lane projects. Care should be taken when translating findings from HOT-lane projects to other types of congestion pricing projects. HOT lanes are unique in two ways. First, there is always a choice between the priced lane and the immediately adjacent free lane. Second, no options, flexibility, convenience, or received benefit has been taken away from any group of users. HOT lanes always add capacity, either by freeing up unused capacity in an existing HOV-lane, or from building newly priced freeway lanes. These differences necessarily change the costs and benefits and potential responses for differing income groups.

Community Livability and Environmental Justice[15]

We may be concerned about equity when it comes to introducing changes to the existing system because of perceptions of fairness and government's role in increasing, or at least not diminishing, social welfare. However, there are also legal considerations of equity that have collectively come to be known as the transportation-related field of Environmental Justice, defined as follows:[16]

- To avoid, minimize, or mitigate disproportionately high and adverse human health or environmental effects, including social and economic effects, on minority populations and low-income populations;
- To ensure the full and fair participation by all potentially affected communities in the transportation decision-making process; and
- To prevent the denial of, reduction in, or significant delay in the receipt of benefits by minority populations and low-income populations.

As articulated by a publication from the Institute for Transportation Studies at the University of California at Berkeley, equity and fairness issues most frequently arise when:[17]

- Some communities get the benefits of improved accessibility, faster trips, and congestion relief, while others experience fewer benefits;
- Some communities suffer disproportionately from transportation programs' negative impacts, like air pollution;
- Some communities have to pay higher transportation taxes or higher fares than others in relation to the services that they receive; or
- Some communities are less represented than others when policy-making bodies debate and decide what should be done with transportation resources.

All of these issues come into play in congestion pricing, and the direct cost of the congestion charge is simply the beginning. The solutions, or at least policy fixes,

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[15] This section is a very brief summary of a much more extensive report on Equity and Fairness in tolling prepared by the Texas Transportation Institute in collaboration with Cambridge Systematics for the Washington State Transportation Commission, contained in *Washington State Comprehensive Tolling Study, Volume 2, Background Paper 4*. Available online at: http://wstc.wa.gov/Tolling/FR1_WS_TollStudy_Vol2_Paper04.pdf.

[16] Federal Highway Administration. *Questions and Answers on Environmental Justice and Title VI*. April 2008. Available on-line at: www.fhwa.dot.gov/environment/ejustice/facts/index.htm.

[17] Cairns, Shannon; Greig, Jessica; and Wachs, Martin. *Environmental Justice and Transportation: A Citizen's Handbook*, Institute of Transportation Studies, University of California at Berkeley, January 2003, http://www.its.berkeley.edu/publications/ejhandbook/ejhandbook.html, accessed October 9, 2005.

for equity problems lie in many factors, including: the design, location, time-of-day, and level-of-congestion charges; packaging of complementary alternatives and policies; and the use of revenues to provide direct or indirect support to impacted groups.

The ultimate impact on different income groups, however, is heavily influenced by how the revenue from congestion pricing is spent. Revenue reinvestment is widely acknowledged by economists and policy-makers to be a solution to inequitable income effects, by redistributing benefits to specifically targeted recipients, through tax policy changes, or to the public in general, through infrastructure and transit investments. Equity issues and revenue redistribution options are explored further in the following section.

Revenue Investment Implications

Congestion pricing makes explicit the full costs of driving to the individual. As a result, costs incurred to society in general and not previously charged for through the transportation finance system may be recovered through charges, resulting in revenue gains to government. As demonstrated in FHWA's analysis, there are considerable revenue implications associated with congestion pricing. In its sixth year of operation the London Congestion Charge brought in a total of £278 million ($422 million). Nearly half of total revenue financed the program's administrative costs, leaving £137 million in net revenue for transportation infrastructure improvements in the City.[18]

Distribution of revenue is an economic and significant political issue, without clear solutions. Under any congestion pricing scheme there will be considerable pressure to gain political and public support by using revenue to compensate those negatively affected or to recoup benefits to all groups of drivers. Approaches to achieve redistribution to a broad group of highway users could include:

- General investments in transportation infrastructure priorities;
- Reductions in or credits for general taxes, such as income or property;
- Rebates for motor fuel taxes paid for all drivers;
- Allocation of toll credits to drivers, which may be utilized wholly by some or any surplus retained by others; and
- Subsidizing improvements to alternative highways system (e.g., parallel arterials).

[18] Transport for London, *Central London Congestion Charge: Impacts Monitoring*. Sixth annual report. July 2008. Available online at: www.tfl.gov.uk/assets/downloads/sixth-annual-impacts-monitoring-report-2008-07.pdf.

Approaches to achieve targeted redistribution to certain groups of highway users could include:

- General investments in transit improvements in the affected area;
- Rebates, with income limits, for motor fuel taxes or transit fares paid;
- Awards of unspecified grants to affected communities; and
- Direct income tax credits for average charges paid by low-income users.

It is important to note, however, that these uses of revenue generally contrast with public ideas of how toll revenues should be used. Lessons learned from the FHWA's Value Pricing Pilot Program suggest that people support the use of tolls to benefit corridor-level improvements, including transit systems, or that toll revenue should only be spent for the benefit of those paying the toll, in particular through investments in the highway being tolled. This is the traditional political justification for financing roads, bridges, and tunnels with tolls. These traditional public views of when it is acceptable to toll run counter to the idea of recovering the marginal social cost of driving through congestion pricing charges.

As mentioned in Section 3.6, King et al. suggests using congestion pricing revenue to compensate communities directly.[19] Since the "losers" of congestion pricing are likely to form strong political resistance to the idea, decision-makers could develop a revenue distribution system targeted to ultimately change the perception of opposition groups from "losers" to "winners" of the system, thus increasing the likelihood of political support.

4.4 INSTITUTIONAL AND PUBLIC ACCEPTANCE ISSUES

Regardless of the analytical outcomes, existing institutions and public opinion may oppose congestion pricing. This can arise from the uncertainty associated with a change from the status quo, and realities or perceptions relating to winners and losers. The public and/or institutions may find that the policy rationale for pricing is not compelling, do not believe it is an effective solution, or are particularly concerned it will negatively impact them personally or as an organization. Regardless of the policy merits, however, there also may be concerns about the ability of existing public institutions to manage a pricing program.

There is little actual experience with congestion pricing, and the public acceptance challenges in each area will depend on the population served, the

[19] David King, Michael Manville, Donald Shoup, *The Political Calculus of Congestion Pricing*, January 2007.

historical record of trust in public officials, the specifics of the pricing proposal, including the existing and anticipated transportation system.

A recent report compiled public opinion data related to tolls and road pricing,[20] and found that the public:

- Wants value; that is, they want to see a benefit for the price that they pay;
- Learns from experience; as tolling and pricing options are actually implemented, the fear of the unknown recedes and approval increases;
- Cares about the use of revenues and wants tangible projects;
- Believes in equity and wants fairness; and
- Wants simplicity and prefers tolls to taxes.

The one example of a community trying to undertake extensive congestion pricing in the United States occurred in New York City in 2007. There, Mayor Bloomberg rolled out a comprehensive program of reforms for the City called PlaNYC, one element of which was a cordon toll below 86th Street in Manhattan.[21] It was a bold plan, but was ultimately defeated as the Mayor barely managed to get the support of his own City Council and failed to get the support of the state Legislature. At the risk of oversimplification, the issues came down to many of the things discussed in this report: who pays, who wins, who loses, and what would be done with the revenue. It was a complicated project that the general public did not fully understand. The project proponents also failed to build consensus and to negotiate elements of the project, which ultimately led to its defeat.

More modest congestion pricing projects, primarily HOT lanes have moved successfully through the public process, are now accepted, and get high marks for public approval. With HOT lanes, unlike the congestion pricing concepts discussed in this paper, there are no "takeaways." They all price unused capacity. So, despite the popular moniker of "Lexus Lanes," surveys have shown that people across the income spectrum favor these facilities because they offer an opportunity for reliable travel if and when someone really needs that service.

This will not be the case for cordon pricing, freeway pricing, mileage-based pricing, or universal congestion pricing. All of these represent takeaways of existing nonpriced travel, and will face opposition from people who will perceive they are being made worse off. Unless people conclude the revenue is being used effectively (in a way that benefits them) and trust the government to

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[20] National Cooperative Highway Research Program, *Synthesis Compilation of Public Opinion Data on Tolls and Road Pricing, A Synthesis of Highway Practice*, 2008.

[21] Details can be found on the program's web site: http://www.nyc.gov/html/planyc2030/.

carry out the program as advertised, congestion pricing programs are likely to run into stiff opposition, as in New York City.

Successful implementations of congestion pricing will go a long way toward demonstrating the potential value of these concepts. London's area pricing scheme and Stockholm's cordon toll both had opposition, both were adjusted along the way, but both generally can be called successful and even popular. This is not to say that both do not still generate their share of opposition. Attempts to expand the London scheme to incorporate emissions charges proved too aggressive and were defeated.

4.5 IMPLEMENTATION CONSIDERATIONS

Technological Barriers

Technological advances in tolling and intelligent transportation systems have enabled functional pricing schemes to be developed around the world, but technical hurdles remain to large-scale or complex practical implementations of the practice. Practical implementations of congestion pricing schemes have developed substantially since Singapore's introduction of a downtown cordon pricing zone in 1975. Currently, operating major congestion pricing initiatives implemented on a broad scale are based on a similar strategy of cordon area or zone-based pricing, including the 2008 proposal in New York City. To date, there is no global experience with a national network congestion pricing system similar to the scenario envisioned and analyzed by FHWA.

In the United States, Oregon's Road User Fee Pilot Program has come closest to evaluating the requirements and advancing the technology necessary for wide adoption of a network-based congestion pricing scenario. This program requires on-board devices with Global Positioning Service (GPS) and wireless communication capabilities to track the position and total movements of vehicles. Significant technological issues were identified in the implementation of this pilot program, including the cost, maintenance, and operation of on-board devices, and capabilities of wireless data encryption and data transfer with service and payment stations.

Other HOT-express-lane systems in states have successfully implemented booth or barrier-controlled pricing of specific lanes or limited-access highway segments. Entirely new highway corridor and expressways have been completed with advanced automated electronic tolling systems, including technological innovations such as vehicle license plate recognition and on-line registration and payment systems. The basics of all modern, successful congestion pricing schemes generally include the following components: on-board vehicle transmitters, radio frequency identification (RFID) vehicle tags and on-road reader platforms, and a customer service and enforcement department.

It would be possible to leverage existing systems for electronic toll collection in some major metropolitan areas, but controlling access and responding to the demands of the fully priced network system in FHWA's scenario would require a technological system far beyond any that have been implemented or evaluated in the world to date. To control access and collect fees from specific congested highway segments throughout the nation would require substantial information systems architecture and physical infrastructure. Such a system would have to include sophisticated electronic tolling systems that would calculate and communicate real-time congestion charges, as well as complete on-board vehicle monitoring, enforcement, and collection capabilities. Another possibility would be dependent on new physical infrastructure to develop a system of controlled access points to known major congested freeways, similar to today's system of toll booths and barriers on highway facilities.

Also, the expense of the capital improvements necessary to create the physical and electronic infrastructure necessary for this scenario would likely be significant and was not estimated in FHWA's 2006 C&P Report. The Report did, however, estimate implementation costs for the two nonpricing operations strategies.[22] FHWA notes that while estimates of capital costs for pricing are not well known and some of the revenue generated from pricing may also be reinvested into the necessary infrastructure and technology; the annual capital costs of infrastructure necessary to support nationwide congestion pricing would be considerable and offset some gains from pricing. In addition, FHWA typically limits its scenario analysis to capital costs, as annual operating and maintenance costs for operations strategies are not included in the cost performance analysis.

Administrative Costs

Collecting tolls is considerably more expensive than collecting motor fuel taxes and excise taxes. There is little experience with congestion pricing beyond several HOT lanes in the United States and a few cordon pricing implementations overseas. We do know that collecting tolls from traditional toll facilities can cost anywhere from $0.10 to $0.60 per transaction or more. Although electronic tolling holds promise for bringing costs down, many places have not yet realized those cost declines. This comes as a surprise to many people, but electronic toll collection usually involves considerable labor in the back office, verifying license plate reads, sending collection statements, and so on. Some have described electronic tolling as simply moving the toll collectors from the traffic lanes to the back office.

All electronic tolling would likely involve some combination of transponder-based toll collection, GPS-based toll collection, and video. All systems would

[22]See Part II, Chapter 10, *Sensitivity Analysis* in the 2006 Conditions and Performance Report.

require a video element to ensure compliance with the system, which contributes significantly to the cost, because it requires human interaction.

The area pricing scheme in London is known to have more than 50 percent of its toll revenue used to support the cost of toll collection. Other evidence from Trondheim, Norway's cordon area scheme suggested operations and maintenance overhead of 10 percent of gross toll revenue.

Privacy Concerns

Congestion pricing relies on all electronic tolling. By its nature, all electronic tolling needs to identify a customer at a particular time and place in order to collect revenue, or at least to enforce a revenue system. Some argue that privacy concerns are a nonissue, because of experience from when existing toll facilities converted from cash to electronic systems. Most toll agencies offered anonymous accounts, so that people could use the electronic systems without personal information being recorded. Virtually all electronic tolling systems operate on an opt-in concept. If you choose to pay electronically, you agree to have certain information about you recorded. If you do not want that information recorded, you can continue to pay cash, if a cash option is allowed.

The congestion pricing concepts we are talking about go beyond an optional system, because they put prices on roads that were previously free. So, if someone "opts out," they are denied access to the road. This means that any congestion pricing system will have to wrestle with how to ensure revenue collection while guaranteeing the privacy of citizens.

Addressing privacy concerns can be done through a combination of business rules and technology, including:

- Offering anonymous transponders or accounts;
- Providing options for single use payments;
- Making sure that there are proper data encryption and protection policies, and that data is purged after it is no longer needed to validate transactions; and
- Having clear policies relating to access and use of customer data.

5.0 Conclusions

This report had a twofold mission. One was to evaluate the analysis done by FHWA in the 2006 C&P report, the other was to provide an overview of some of the broader opportunities and implications for congestion pricing.

5.1 UNDERSTANDING THE C&P REPORT FINDINGS ON CONGESTION PRICING

FHWA applied economic principles in conjunction with updates to the HERS model, to illustrate the "maximum, theoretical impact that efficient pricing could have on the estimates of future highway investment scenarios." These maximum, theoretical impacts were considerable – a savings approaching 30 percent of annual investment needs under the Cost to Maintain scenario. It is important, however, to view these findings in the context of the stated and unstated assumptions, which would significantly diminish the real world potential of congestion pricing over the 20-year life of the C&P estimate, the most important of which are:

- The immediate, universal implementation of pricing on all congested roads;
- The capital and administrative costs for pricing infrastructure are not accounted for; and
- The network effects of pricing on travel demand and shifts in cost responsibility to other jurisdictions are not accounted for.

The C&P report was explicit about the assumptions used, and clearly stated that the infrastructure cost savings represented a "maximum potential impact" of universal congestion pricing. However, the assumptions are so far beyond what might be considered reasonable within the timeframe of the C&P analysis, that the value of those estimates for anything other than an academic exercise could lead policy makers to the wrong conclusions. We summarize each of our major concerns below.

The Immediate, Universal Implementation of Pricing on All Congested Roads

The analysis assumes that efficient congestion fees could be charged universally (on all functional classes of roadways across the nation) beginning in the first year of analysis and continuing over the entire 20-year period. There are significant theoretical and practical barriers exist to implementing an effective congestion pricing system in the real world.

There are congestion pricing applications in use today, but they are limited to single points or single corridors. The level of sophistication of the technology needed to implement universal congestion pricing does not exist today, and will take years to research and develop before it can be implemented in the field.

Beyond the technical difficulties are the political. There is by no means a consensus that congestion pricing is acceptable. The difficulties of understanding the winners and losers and addressing how to spend the revenue will likely take extensive debate. Even if policy-makers were to make an immediate decision to implement universal congestion pricing, it would take years of research and development to put it into place. Whether it was rolled out region by region or state by state, or turned on all at once in one big transition moment, the benefits of universal congestion pricing might optimistically be expected to be realized sometime toward the end of the 20-year analysis period, rather than from day one.

The value of the C&P's estimate, therefore, is in showing the ultimate potential of a perfect system at some time in the future, rather than a realistic assessment of the magnitude of changes that could be achieved within the C&P forecast period.

The Capital and Administrative Costs for Pricing Infrastructure are Not Accounted For

The universal congestion pricing analysis in the 2006 C&P Report describes the lower-level of investment that would be brought about by the concept and the toll revenue that would result, but does not address the costs of implementation – which would be substantial. By contrast, FHWA's analysis of full deployment of transportation operations strategies and ITS technologies does consider these costs. A sample of some of the costs that would need to be incurred to implement universal congestion pricing includes:

- Initial capital Expenses:
  - Research and development;
  - In-vehicle technology for the entire auto and truck fleet;
  - Sensor technology to detect vehicle movement by place and time, and calculate the correct fee;
  - Price-setting technology that detects current traffic conditions, anticipates future traffic conditions, and calculates the economically efficient price;
  - Data harvesting technology to transfer vehicle-specific data to a billing entity; and
  - Back office systems.
- Recurring capital expenses:
  - Periodic replacement of all technology components.

- Operating expenses:
  - Personnel and equipment to operate billing systems, maintain the technology, and handle customer interaction.

The Network Effects of Pricing on Travel Demand are Not Accounted For

The HERS model uses inputs of individual links, or highway segments, and analyses the effects of each link independently. As a result, the current modeling framework to evaluate the effects of congestion pricing does not account for the full impacts of pricing on alternate interconnected roadways, or shifts in travel demand between time periods or modes of travel.

HERS treats changes in the costs of travel on a link-by-link basis, and applies elasticity values to change the expected future volume. Therefore, for example, if one link is congested, HERS will estimate a price for that link to reduce the level of congestion to a more acceptable level. It will not, however, allocate that traffic to another road, or to another route. Therefore, HERS is only calculating cost savings from reduction of traffic due to pricing, but it does not calculate cost increases from higher traffic on other parts of the network or on the transit system. The C&P Report addresses transit needs in another section, but does not account for increases in transit needs that result from congestion pricing.

5.2 BROADER OPPORTUNITIES AND IMPLICATIONS FOR CONGESTION PRICING

If, at the beginning of the motor vehicle era, we had possessed the technology to allow road pricing, and we had decided to use it to capture the full marginal social cost of driving, then the fabric of our communities would be very different from what it is today. Urban areas would be more compact, and there would be more public transportation. We can see this in Europe, which has a history of charging motor fuel taxes several times higher than the levels in the United States. Because Europe has a longer tradition of trying to capture the marginal social costs of driving, it is little surprise that they have had far more success in moving contemporary congestion pricing ideas forward.

The United States is very different. We have a social and economic world built on the foundation of inexpensive automobile travel. Changing the rules at this time may be the best long term solution for society as a whole, but there will be winners and losers. Those winners and losers are not just those who would choose to pay a toll and those who would not, but also property and business owners who are counting on the continuation of those rules.

Congestion pricing needs to be approached with caution, and transparent, comprehensive, and methodologically correct analyses undertaken. The concepts are not easy to understand – even among transportation professionals –

and some of the analysis methods have not yet been fully developed or tested. Analysts need to be open about where assumptions and methods may have more than the typical level of uncertainty, and test the implications of different assumptions.

In some cases, we may not know the real answers until someone actually implements a congestion-pricing concept beyond a HOT lane. That approach worked in Stockholm, Sweden, where a $500 million demonstration was carried out with the government agreeing to remove the system if the people voted against it. With a skeptical public at the outset, voters in Stockholm, by a slim majority, gave their government the go-ahead to turn a demonstration project into a permanent installation. As with any controversial concept, early and frequent public and elected-official engagement will be important, leaving adequate time and funds for the difficult analyses that will have to be done to properly answer the bona fide questions of the public. Any analysis of congestion pricing should have comparisons among fully formed alternatives so that elected officials can reasonably choose among them. Complicated analyses must be boiled down such that understanding does not require advanced degrees in economics and traffic flow, but not so simplified as to eliminate the nuance and to overlook areas of uncertainty.

None of this is any different from the kind of care that should be given to any project. However, the kinds of changes that would come about as a result of congestion pricing amplify the importance of this approach.

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