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A New Public-Private Partnership Model for Road Pricing Implementation

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ABSTRACT

In a public-private partnership (PPP) arrangement providing for financing of highway investment and operations, it will be important to ensure that the public does not perceive that the private sector partner is attempting to maximize profits through excessive peak charges while the public agency does nothing to relieve congestion on free facilities. This paper presents a new PPP model to address this issue, discusses the benefits to be gained from such models, and suggests potential “corridor level” pilot demonstration projects. The paper then assesses the financial self-sufficiency of a region-wide application of the concepts without reliance on public tax support for implementation.

INTRODUCTION

Road Pricing Concepts

Road pricing includes a group of market-based strategies that all involve collecting a variable toll for highway use, with the primary intent of managing travel demand so as to reduce or eliminate congestion on a priced roadway facility, corridor or network. In the U.S., road pricing has been implemented in two types of situations. First, priced lanes have been created on existing toll-free facilities either by converting High-Occupancy Vehicle (HOV) lanes to High-Occupancy/ Toll (HOT) lanes, or by adding new lanes. Second, variable charges have been introduced on existing toll facilities that previously charged flat tolls. Eight road pricing projects are currently in operation in the U.S., four in each category (DeCorla-Souza et al. 2004b).

Proposals have been made to extend these pricing concepts to region-wide systems of priced freeways or priced freeway lanes that would maintain free-flowing traffic conditions and provide a running way that allows introduction of high quality express bus service or Bus Rapid Transit (BRT) service. A proposal by the Reason Foundation (Poole and Orski 2003) would create a network of priced lanes on existing toll-free roads, using existing HOV lanes and adding new lanes on segments where no HOV lanes exist. Free service would be provided only to authorized buses and/or vanpools. BRT would operate on the express lanes.

Another region-wide road pricing concept, called “Fast and Intertwined Regular” highways or FAIR highways, converts *all* lanes on existing freeways to priced lanes, exempts HOVs from

payment of tolls, provides discount tolls to low-income motorists, funds new express bus services, and implements major traffic flow improvements on parallel arterial facilities using Intelligent Transportation Systems (DeCorla-Souza 2003).

Synergy Between Road Pricing and Transit

Road pricing provides two key benefits for transit services. First, by managing traffic demand on a single lane or multiple lanes to ensure free flow of traffic, pricing is able to provide a fixed guideway-like running way for operation of express bus services. Second, pricing generates new revenues, which may be used to support bonds for financing the construction of new express bus or BRT stations and park-and-ride facilities, as well as for transit rolling stock and transit service operation.

Express bus services, likewise, impact the technical and political feasibility of road pricing in two key ways. First, the effectiveness of pricing strategies increases when auto travelers have the option of choosing a viable alternative mode. With new express bus services on priced highways, auto demand can be reduced without resorting to exorbitant and punitive toll rates to ensure that traffic demand does not exceed levels needed to ensure free flow. Commuters benefit from lower toll rates for those motorists who continue to drive, and better transit service for those who choose it. Second, by keeping toll rates affordable, and by providing a viable alternative for those who may not be able to afford the toll, express bus service ensures that equity is preserved for those commuters who are less able to afford tolls. Addressing equity concerns is a key factor for public and political acceptance of road pricing strategies.

Benefits of Public Private Partnerships

In an era of scarce public resources and public resistance to tax increases, tolls can bring new revenue to make Road Pricing/ express bus service projects self-financing, or nearly so. The promise of a steady stream of new revenue from tolls also makes it possible to increase private sector involvement in the financing, implementation and operation of such projects for the mutual benefit of both the public and the private sectors.

Procuring transportation facilities and services through public-private partnerships (PPPs) has many advantages over the traditional publicly financed approach (Kopp 1997):

- Projects are generally planned and constructed more quickly.
- Capital demands on the public treasury are reduced.
- Innovation in technology is encouraged.
- The private sector organization may enjoy significant economies of scale, scope and experience in the production and management of an international portfolio of projects. Risks may be spread across a diversified spectrum of projects.
- Efficiencies result from exempting private developers from traditional government procurement rules.
- Income is generated for local, state and national governments from property and income taxes paid by the private business.

The Federal government, as well as several States and local governments, have shown increasing interest in private sector involvement in the provision of transportation infrastructure and services. Given the innovative aspects of both pricing as well as BRT, advances in innovation as well as efficiency may be encouraged through greater involvement of the private sector.

Issues with Use of Public Private Partnerships with Road Pricing

Pursuit of Public-Private Partnership (PPP) arrangements for road pricing projects such as Express Toll Lanes raises some special issues. Efficient freeway operation may occasionally *require* relatively high charges in order to keep traffic free flowing during rush hours when travel demand is very high. This may be perceived by the public as “price gouging,” particularly if revenues and resulting profits go to the private sector. For example, approval of private companies operating a toll road for profit is far lower than approval of tolling itself in the SR 91 corridor in Orange County, CA (Sullivan 2000). SR 91 has Express Toll Lanes in its median.

In a PPP arrangement providing for financing of highway investment and operations, it will be important to ensure that the public does not perceive that the private sector partner is attempting to maximize profits through excessive peak charges while the public agency does nothing to relieve congestion on free facilities. This occurred in Orange County, CA where a “non-compete” clause in the PPP agreement for the Express Lanes on SR 91 prevented the public agency from making improvements on the free lanes (Sullivan 2000). Simply eliminating or limiting non-compete provisions is not a solution, because the private sector would be unwilling to invest in highway projects without adequate protection against future competition.

This paper presents a new PPP model to address this issue, discusses the benefits to be gained from such models, and suggests potential “corridor level” pilot demonstration projects. and discusses potential for region-wide application of the concepts without reliance on public tax support for implementation. The paper then assesses the financial self-sufficiency of a region-wide application of the concepts in a prototypical large metropolitan area without reliance on public tax support for implementation.

A NEW PUBLIC-PRIVATE PARTNERSHIP MODEL FOR ROAD PRICING

Separating the Operator from the Beneficiary

To address the issues discussed above, a potential new model is suggested to separate the toll system operator from the revenue beneficiary. In this new model, the PPP agreement would employ “shadow tolls” to compensate the private partner. Shadow tolls are usage payments made by a third party. Although the private partner would *set* the toll rates (as they did for the Express Lanes on SR 91) to manage demand and ensure that traffic is free-flowing, *all toll revenue would go to the public sector*, and the public agency would reimburse the private partner with payments based on a flat shadow toll rate and the number of vehicles served at free flow speeds during the rush hours, when pro-active management of traffic flow with variable tolls is needed. The private partner would continue to set the actual user-paid toll rates. While these rates would rise as high as they need to be in order to manage demand effectively, the private

partner would not profit from the resulting increase in revenue. Potential private partners would compete on the basis of the shadow toll rate per vehicle that they are willing to accept as compensation for their infrastructure investments and highway operation and toll collection services.

Agreements with the private partner will need to include customer service standards (e.g., safety, public information, highway signage, billing, customer service centers, etc.), since the private partner may not stand to gain additional revenue if quality of service to the public is reduced. The public sector would prepare a financial plan that allocates future receipts from its normal Federal, state or local funding sources to pay for contractual obligations to the private partner. Reliance on difficult-to-predict revenues would thus be minimized, reducing costs associated with risk. Advantages of the new PPP approach are discussed below.

Public and Private Risk

Public risk will be greatly reduced. Risk will be reduced with regard to uncertainty of costs for the innovative technology and operations approaches that will be needed. The public sector would know in advance its maximum cost liability, calculated as the maximum possible vehicle throughput per hour, times the number of peak hours of pricing operations, times the shadow toll per vehicle negotiated with the private partner. The public sector could prepare a financial plan that allocates future receipts from its normal Federal, state and local funding sources to pay for contractual obligations to the private partner. Risks associated with reliance on difficult-to-predict revenues would thus be minimized.

Private sector risk would also be reduced, reducing financing costs. The private partner would be assured of an almost guaranteed stream of revenue based on the negotiated shadow toll rate. This would reduce risk-related costs for financing in the capital markets. For example, risks to bond holders would be reduced, lowering the interest rate demanded. Risk with regard to revenue receipts from user-paid tolls will be borne by the public sector. Therefore, the private partner would not need to be too concerned about the accuracy of travel growth forecasts, since priced lanes can be guaranteed to be filled to critical density threshold levels simply by lowering the user-paid toll rate.

Also, the private partner would not need to be too concerned about potential effects of competition from possible future improvements that may be made by the public agency on parallel highway facilities. Neither would there be concerns about competition resulting from efforts to improve HOV or transit services. Under normal toll road franchises, these would be of concern, since they reduce demand for vehicle use on the tolled facility and the market-clearing price that motorists could be charged. Since the private partner would receive the same monetary reimbursement (i.e., shadow toll) per vehicle no matter what type of improvements may be made to competing modes and routes, there would be no need in the PPP agreement for a non-compete clause such as the one that led to the termination of the PPP for the Express Lanes on SR 91 in Orange County, CA. To ensure full utilization of the priced lanes and guarantee its shadow toll revenues, the private partner would simply need to lower the user-paid toll rate, or even give free service, if competition from other routes or modes increases. If the public partner chooses to improve alternative routes or modes, it absorbs all the risks due to its actions through its own losses of user-paid toll revenues.

Service Delivery and Quality

Services would be more efficiently delivered. In order to maximize its profit, the private partner would strive to keep costs down through innovation, and would use efficient procurement and management practices.

Services would be more effective. The private partner would have an incentive to maximize peak period vehicle throughput while ensuring that all traffic moves at free flow speeds. Since the private partner would only be paid for vehicles that are provided with free-flowing premium service, there would be an incentive to ensure that traffic flow does not break down. Should traffic flow disruptions occur (e.g., due to accidents, incidents, or repairs), the private partner would be at risk of losing shadow toll revenue and would be likely to clear them as soon as possible. To reduce traffic flow disruptions, the private partner would also be likely to produce innovative solutions to reduce the risk of accidents and the frequency of maintenance operations during rush hours. The private operator could be required to refund tolls charged to toll-paying motorists who did not get congestion-free service.

Mobility

Mobility benefits would be maximized, rather than revenue. There would be no incentive for the private operator to keep the charges per vehicle high simply in order to maximize revenue. Higher charges than needed to manage traffic result in mobility losses, as motorists are unnecessarily dissuaded from traveling, or are unnecessarily shifted to alternative routes. This is the case with a typical toll road franchise. With a conventional franchise, tolls are charged during off-peak periods to maximize revenue, even though plenty of capacity may be available on the facility. With the new PPP model, charges would only be as high as they need to be to ensure efficient free-flowing freeway operation with maximum vehicle throughput. Also, tolls would be unnecessary in the off-peak periods if spare capacity were available, and would not be charged, preventing any inducements to divert to parallel routes.

A NEW PUBLIC-PRIVATE PARTNERSHIP MODEL FOR TRANSIT AND HOV SERVICES

Shadow Usage Payments

A PPP arrangement similar to the concept described above may be used to provide improved transit or HOV services. The private partner would be compensated by the public partner with a base service fee payment plus a usage payment (similar to the shadow toll) for each transit or HOV trip served above a base usage level. This usage payment per trip would make up for the difference between fares and the marginal cost per trip for providing service above the base usage level. With shadow usage payments, the private partner stands to increase its revenues (and potentially, profits) by increasing the use of transit or HOVs. This would increase its incentive to promote transit and HOV use, and to maximize transit and HOV use and resulting public benefits from reduced roadway usage during peak times.

Shadow usage payments are justified since a significant share of the benefits from shifts to transit and HOV modes accrue to the general public and not directly to the user. While transit and HOV commuters may save money over driving solo, they may experience longer travel times, including more onerous walk and wait times. They are constrained as to the time of travel, and may not be able to do things they would be free to do if they were driving solo (e.g., eat, drink, smoke, talk for long periods on their cell phones, play loud music of their choice on their car stereo systems, etc.) On the other hand, non-users benefit from lower pollutant emissions, less dependence on foreign oil, less congestion, higher development densities, and other social benefits that accrue from reduced traffic levels.

HOV shadow fee payments and transit shadow usage payments may not be cost-efficient if they exceed the estimated values of external benefits, e.g., the reduction in external costs resulting from solo driver trips eliminated. Therefore, it is important for the public agency to have the capability to estimate the value of changes in external costs resulting from mode shifts. External benefits may be estimated using the Transportation Research Board's *Guidebook to Estimate and Present Benefits and Disbenefits of Public Transit* (ECONorthwest and Parsons Brinckerhoff Quade & Douglas, Inc. 2003). If the bid price from the private partner for shadow fee payments per trip is higher than the marginal external benefit, a PPP contract option for service above the base level may not be economically justified.

Application of the Model for Transit

The PPP arrangement for transit would make over-the-road bus service commercially viable. Minimum transit performance and safety service standards (e.g., service frequency, passenger load factors and vehicle condition) could be set by the public partner to ensure quality of service. Base service payments to be made to the private transit operator could be determined on the basis of the cost of the minimum required service level set by the public agency (less expected fare revenue), with adjustments allowed for fuel prices. Shadow usage payments for riders above the specified base level of transit ridership would be based on an automatic accounting of the number of riders carried. Accounting would be facilitated by requiring use of electronic fare payment (e.g., using a smart card) for anyone wanting to get the subsidized fare.

As in the case of road pricing PPP agreements, private partners could finance transit investments by going to the capital markets and availing of credit support from the Federal government under TIFIA, backed by the projected revenue stream from fares and shadow usage payments. A special taxing district may be established by the public partner to generate additional funds to support shadow usage payments. In addition, the public partner might reduce parking requirements for new or expanded buildings served by express transit in exchange for a contribution to the corridor transportation program in lieu of the expense of expanded parking. Value capture techniques may be applied, but, in general, the auto-oriented character of most development in freeway corridors is not expected to generate many value capture opportunities for transit, although it could for highway elements.

Application of the Model for HOV Services

Carpools and vanpools are often perceived as competitors to transit, since the modes have many similar characteristics. A private partner operating transit services would therefore be concerned about the risk of competition from any efforts to increase HOV use. To address this issue, the private partner operating transit services would also be under contract to run the HOV promotion program, and would be compensated through a base service fee payment plus a shadow fee per new HOV trip above a base HOV usage level, e.g., the level of HOV use observed immediately after implementation of the road pricing program.

Protection would be provided for the public partner in the event that unexpected shifts to carpooling occur due to external factors such as a fuel shortage or significant fuel price increase. This could be done by limiting the number of new HOV trips for which it would pay a shadow fee, or by using a sliding-scale fee schedule that decreases as HOV volume increases. Keeping track of the number of HOVs would be relatively easy, because each HOV would be identified electronically (such as by passing through special lanes upon entry into the priced facilities) in order to receive a toll exemption (DeCorla-Souza 2003).

Under a conventional toll road franchise, the private operator responsible for the tolled lanes would be concerned about reduced revenues, if carpools are required to be provided free service. However, this will not be a problem with the PPP model proposed in this paper, because the private operator of the priced lanes will be compensated by a shadow toll for *every* vehicle, whether it is a single-occupant vehicle, an HOV, or a transit vehicle.

Benefits of the New Model

The new PPP approach for transit and HOV service delivery suggested above could be more economically efficient than a conventional service delivery approach, and could encourage service delivery innovation, as discussed below.

Economic efficiency and social benefits could be maximized. The private partner would have an incentive to promote transit use up to the point where the total revenue from the fare (a proxy for the transit rider's benefit) and the shadow usage payment per trip (a proxy for the external benefit) would be just equal to its marginal costs for providing service. Similarly, the private partner would have an incentive to promote HOV use up to the point where the shadow fee payment per HOV trip (a proxy for the external benefit) would be just equal to its marginal costs for promoting and providing HOV service. This would maximize economic efficiency and net social benefits.

If the shadow fee payment rates were set carefully, the private partner would be in a position to seek the most socially cost-efficient mode (i.e., transit or HOV) with which to serve the commuter. The operator would have an incentive to maximize transit ridership and HOV use in order to maximize its total revenues. Base transit service frequency requirements will ensure that the shadow fee per HOV does not provide an incentive to the private partner to increase HOV use at the cost of transit ridership to such an extent that it results in a significant reduction in transit service frequency, thus compromising the quality of express bus service.

Service delivery would improve and innovation would be encouraged. The incentive to maximize transit ridership, if successful, could lead to more riders and therefore more frequent service. All transit riders would gain because any increase in service frequency will reduce their waiting time.

The private partner would also have an incentive to provide additional premium services for those willing to pay a higher fare, e.g. door-to-door limousine services (similar to airport shuttles) or vanpool services, provided that the private partner would still be eligible to get the agreed upon shadow usage payment per rider from the public agency. Private operators would have an incentive to work with Transportation Management Associations to encourage employees to take transit or carpool. They might innovate with such concepts as fare agreements with employers and building owners, provision of additional services and conveniences such as station cars and park- and-ride/pool lots, and TravelSmart marketing programs (Western Australian Department of Transport 2000) that ask people to make voluntary changes in their travel choices and encourage them to use other ways of traveling rather than driving alone in a car.

POTENTIAL CORRIDOR-LEVEL DEMONSTRATION PROJECTS

Public trust, understanding and acceptance of the innovative PPP concepts discussed above may be facilitated with a pilot project. This section discusses two potential candidate pilot projects in the Washington DC metropolitan area.

Dulles Toll Road

Variable tolls to eliminate congestion may be piloted most easily in an existing travel corridor with a tolled freeway. Such an opportunity exists in the Dulles Toll Road corridor in Northern Virginia. The Dulles Toll Road Authority could enter into an arrangement with a private partner to implement open road tolling (ORT) with dynamic peak period service charges for single-occupant vehicles (SOVs) to ensure free-flowing traffic conditions, and use surplus revenues (after payment of shadow tolls to the operator) to pay other private partners or public agencies to provide new or enhanced transit and HOV services in the corridor. To encourage ridesharing, HOVs could be offered free service.

Compensation for ORT and dynamic pricing operations would be provided in the form of shadow toll payments for each vehicle provided congestion-free service in the peak period. Compensation for transit and HOV services would be in the form of usage payments based on the number of transit riders and HOV commuters above base conditions. Since availability of parking spaces at park-and-ride facilities is often the limiting factor for these services, the private partner would have an incentive to innovate with new parking arrangements to maximize transit and HOV use.

Interstate 66

Integrated road pricing/ transit strategies may also be demonstrated on I-66 inside the Capital Beltway in Northern Virginia. The facility is currently restricted to HOV2+ vehicles in peak hours. HOV occupancy requirements could be raised back to the original HOV3+ requirement, and HOV2 and SOV use could be permitted with payment of a dynamic peak service charge set high enough to ensure free flow of traffic throughout the peak period.

Revenues would go first to pay the private partner for operation of the existing facility during peak periods, using the shadow toll concept. Surplus revenues would be dedicated to improve or further subsidize transit service in the corridor, to provide additional parking for transit or HOV riders, or to make highway improvements.

Since availability of parking is currently the limiting factor at Metro transit stations, private provision of parking facilities may be encouraged through a program that offers private parking providers a subsidy payment for each transit rider that is provided with parking near a Metro station or bus stop at a below-market rate. Transit riders would be identified through use of Metro's SmarTrip card. They would need to use SmarTrip to pay for *both* parking as well as transit fares to their destination station at the park-and-ride location. This would reveal whether the driver of the parked vehicle had indeed transferred from a transit vehicle.

POTENTIAL FOR REGION-WIDE APPLICATION

Alternative Region-wide Road Pricing Scenarios

Could an entire region-wide road pricing/ express bus system be financially self-sufficient, without infusion of tax dollars, thus increasing the opportunity for PPP arrangements? Poole and Orski (2003) suggest that the type of region-wide BRT/HOT system advocated by them will not be financially self-sufficient. The main reason is the high cost of new construction for lanes to be added on segments where HOV lanes do not currently exist. Revenues generated system-wide are inadequate to cover all of the capital costs for highway construction, let alone the continuing maintenance costs and costs for operation of the toll collection system. Transit system costs, other than the "fixed guideway" costs (i.e., highway lane construction costs) would need to be supported entirely by fares and tax dollars.

The alternative scenarios evaluated in this paper attempt to overcome the financial deficit issues in Poole and Orski's region-wide road pricing/ express bus system proposals. Two alternative scenarios are developed for a prototypical metropolitan area. In both scenarios, new fare-free express bus services would be introduced on priced express lanes to benefit commuters, in exchange for introduction of congestion-based pricing on the existing highway system *in peak periods only*. No tolls would be charged in off-peak periods, because off-peak tolls may actually reduce social benefits if spare capacity is available and demand management is not necessary. The alternative scenarios are as follows:

- (1) ***A FAIR Highway network*** that converts *all* lanes on existing freeways to priced lanes *in peak periods only*, exempts two-or-more occupant HOVs from toll payments, and implements major traffic flow improvements on parallel arterial facilities using Intelligent Transportation Systems. New fare-free express bus service would provide an alternative for those single-occupant vehicle (SOV) commuters who do not value the new time savings above the going toll rate, and will compensate them for the “loss” of previously free (but inferior) highway service.
- (2) ***An Express Toll Lane network*** on existing toll-free roads that would operate *only during peak periods* daily, using existing HOV lanes and converting an existing lane to a priced lane on segments where no HOV lane exists. This concept differs from the Poole and Orski concept in that an existing lane may be taken away from general-purpose free use to create the priced network, whereas the Poole and Orski concept involves building of new lanes. The intent of using existing lanes to create the priced network is to reduce the financial deficit in the Poole and Orski proposals. Toll exemptions would be provided to authorized buses and vanpools. Three-or-more occupant HOVs would get a 50 percent toll discount. In exchange for the discounted toll charges, HOVs are provided with service on a much wider network than provided on the existing HOV system prior to road pricing. The toll discount will encourage casual carpooling (also known as “slugging”) on a much wider system.

The public may not be as opposed to new tolls as is commonly believed, as long as commensurate benefits are provided. For example, focus groups conducted as part of the Illinois Tollway Value Pricing Study (Resource Systems Group 2003) found that about half of all respondents indicated that they would pay at least twice as much for a free-flowing commute. Nearly all respondents felt that carpooling was a good idea and that carpools should be eligible for preferential pricing, although almost everyone indicated they would not carpool themselves.

Prototypical Freeway Network

The two alternative pricing scenarios are assessed with regard to financial self-sufficiency using a prototypical freeway network in a major metropolitan area (i.e., with a population of 3 million or more) such as Washington, DC. The metropolitan freeway network consists of approximately 1,800 lane miles, similar to the network in the Washington, DC area (Texas Transportation Institute 2004). This equates to about 300 route miles, assuming an average of 6 lanes (i.e., 3 per direction) on the network.

In 2003, the average daily congested travel period in major metropolitan areas amounted to about six and one-half hours, and percent of daily travel under congested conditions amounted to about 40 percent (Texas Transportation Institute 2004). For convenience, and to ensure a conservative estimate of toll revenue, the prototypical freeway network is assumed to be subjected to 6 hours of congestion, and 33 percent of daily freeway travel is assumed to be subjected to congested conditions in the 6-hour peak period that would warrant the use of road pricing to manage demand. These conservative estimates are used in order to ensure a conservative estimate of tolled traffic and therefore revenues.

Daily Toll Revenue for FAIR Highway Network (Scenario 1)

Table 1 provides estimates of vehicle miles of travel (VMT) that would be subjected to tolls on the FAIR highway network under Scenario 1, based on the following assumptions:

- Total daily freeway vehicle miles of travel (VMT) amounting to 36.2 million, based on 26,987 thousand VMT on Interstates and 9,213 thousand VMT on other freeways and expressways in Washington DC in 2002 (US DOT 2003, page V-43)
- 33 percent of daily freeway travel subjected to congested conditions in peak periods.
- 10 percent of peak period VMT is truck VMT.
- A reduction in peak period VMT of 10 percent on congested segments due to the effect of new tolls. With the improvement in freeway operational efficiency that results from pricing, it is possible that the elimination of congestion will *increase* freeway vehicle throughput, and therefore peak period VMT; but this is ignored in order to ensure a conservative estimate of tolled traffic and therefore revenue. (It is also likely that person throughput on the freeway network will actually increase due to mode shifts to transit, vanpools and carpools.)

Two-or-more occupant HOV traffic exempt from tolls is estimated based on the following assumptions:

- About half of highway person trips are in multi-occupant vehicles, based on single-occupant vehicle (SOV) highway person trips of 10,300 and multi-occupant vehicle trips of 10,337 in Washington, DC (Safirova et al. 2003)
- An average vehicle occupancy of 2.2 for multi-occupant vehicle trips, estimated based on the National Personal Transportation Survey data (US DOT 1997, page 24)
- Peak period traffic subjected to congestion exhibits approximately the same average vehicle occupancy characteristics as the daily average. (This is a conservative assumption, to ensure revenue “losses” from toll exemptions are not underestimated).

Average peak charges per mile to ensure free-flowing traffic conditions are conservatively estimated at about 40 cents for trucks and about 15 cents for passenger cars, based on the following estimates:

- Average peak period tolls on the SR 91 Express Lanes amount to about 40 cents per mile, based on the current toll schedule (OCTA 2004). Tolls are charged on only four out of 12 lanes (i.e., two out of six in each direction).
- If all 12 lanes of SR 91 were to be tolled in peak periods at levels to assure free flow of traffic (as are the four Express Lanes), supply of express lanes would increase threefold. Average peak period tolls per mile for passenger cars would thus likely be reduced to about one-half of the current express lane tolls, or 20 cents per mile, assuming that value of time of most SR 91 drivers is *at least* half of the value of time of those using the Express Lanes currently.

- Since a heavy truck on average consumes two to three times the lane capacity of an automobile in free-flowing traffic, tolls for trucks would be about 2.5 times the toll for passenger cars.

Revenue from the tolled traffic under Scenario 1 is estimated by multiplying traffic in peak periods that would be subjected to tolls by the respective average toll rates for passenger vehicles and trucks. Assuming an average 7.5-mile trip on the freeway is currently subjected to congestion on 5 miles (i.e., two-thirds) of its trip length, the average peak period toll per trip would be \$0.75 for passenger cars and \$2.00 for trucks.

TABLE 1. REGION-WIDE FAIR HIGHWAY NETWORK

Region-wide daily highway person trips ('000):

By single-occupant vehicle	10,300
By multiple-occupant vehicle	10,337
Total person trips	20,637
Percent by multi-occupant vehicles	50%

Region-wide daily highway vehicle trips ('000)

Vehicle occupancy for multi-occupant vehicles	2.2
Vehicle trips for multi-occupant vehicles	4,699
Vehicle trips for single-occupant vehicles	10,300
Total vehicle trips for personal travel	14,999
Percent vehicle trips in multi-occupant vehicles	31%

Region-wide daily highway VMT ('000):

Total daily freeway VMT (from FHWA's Highway Statistics)	36,200
Percent of freeway VMT that is subjected to congestion	33%
Daily freeway VMT subjected to congestion	11,946
Estimated percent VMT reduction due to pricing	10%
Estimated freeway VMT that will be tolled	10,751
Percent VMT by trucks in peak periods on freeways	10%
Tolled VMT by trucks in peak periods on freeways	1,075
Tolled VMT by passenger vehicles in peak periods on freeways	9,676
Tolled VMT by multi-occ. passenger vehicles in peak periods on freeways	3,031
Tolled VMT by single-occ. passenger vehicles in peak periods on freeways	6,645

Estimate of Toll Revenue ('000)

Estimate of toll rate per mile for trucks	\$0.40
Estimate of toll rate per mile for passenger cars	\$0.15
Daily toll revenue from trucks	\$430
Daily toll revenue from passenger cars	\$997
Daily toll revenue total	\$1,427
Number of days tolling is in effect	250
Annual toll revenue	\$356,700

TABLE 2. REGION-WIDE EXPRESS TOLL LANE NETWORK**Express Toll Lane Lane VMT**

Lane miles	600
VMT per lane mile per hour subject to tolls	1,350
Number of hours of toll operation	6
Total VMT subject to tolls ('000)	4,860
Percent VMT by HOV-3 or more	50%
Total VMT subject to full toll ('000)	2,430
Total VMT subject to half toll ('000)	2,430

Toll Revenue in Peak Hours on Weekdays ('000)

Estimate of toll rate per mile for non-HOV	\$0.30
Estimate of toll rate per mile for HOV	\$0.15
Daily toll revenue from non-HOVs	\$729
Daily toll revenue from HOVs	\$365
Daily toll revenue total	\$1,094
Number of days tolling is in effect	250
Annual toll revenue ('000)	\$273,375

Daily Toll Revenue for Express Toll Lane Network (Scenario 2)

Table 2 presents estimates of travel that would be subjected to tolls on the Express Toll Lanes network, based on the following assumptions:

- A network of 600 lane miles, assuming one lane in each direction of a 300-mile freeway network.
- Average tolled traffic volume of 1,350 vehicles per lane, after accounting for toll exemptions for authorized buses and vanpools (Poole and Orski 2003)

Table 2 also presents estimates of three-or-more person HOV travel that would be eligible to receive toll discounts, based on an assumption that 50 percent of the 1,350 vehicles per lane (i.e., 675 vehicles) would be eligible HOVs. This assumption is much higher than the 20 percent observed on the SR 91 Express Lanes in Orange County, where three-or-more occupant HOVs are eligible for a 50 percent discount in certain peak hours, and go free at other times. The higher percentage is assumed in order to account for the “slugging” culture in the Washington, DC area, and to ensure a conservative estimate of revenue.

Average peak charges per mile to ensure free-flowing traffic conditions in the Express Toll Lanes is conservatively estimated at about 30 cents for passenger cars, based on the peak period average of 40 cents per mile on the SR 91 Express Lanes, as discussed earlier. Trucks would not be allowed to use the lanes. Revenue from the tolled traffic is estimated by multiplying tolled VMT by the average toll rate for passenger vehicles. Assuming an average Express Toll Lane

trip uses the lane for 7.5 miles of its entire trip length, the average peak period toll per trip would be \$2.25 for non-HOV3+ passenger cars, and \$1.12 for eligible HOVs.

Costs for Operation of Tolling System

All costs presented in this paper are in 2003 dollars. It is assumed that the typical priced FAIR highway network will employ open road tolling, with toll charging points located at approximately 3 mile intervals along the 300 miles (i.e., 1,800 lane miles) of freeway resulting in the need for 600 lane charging points (i.e., 1,800 lane miles/3). For the Express Toll Lane network, there would be 200 lane charging points (i.e., 600 lane miles/3).

Estimates for toll collection and operation costs are based on cost data for open road tolling provided by Wilbur Smith & Associates (WSA) (Personal e-mail communication with the author dated October 28, 2003). Capital costs per lane charging point are estimated at \$46,000 for Electronic Toll Collection (ETC) costs and \$23,500 for Video Enforcement System (VES) costs, or a total of \$69,500 per lane charging point.

For the FAIR highway network, resulting total costs are \$41.7 million (i.e., \$69,500 X 600). For the Express Toll Lane network, total costs are estimated at one-third, or \$13.9 million. Video tolling hardware and software, ETC equipment, system software, communications system, other equipment, and miscellaneous installation, project management and training costs are estimated at a total of \$16.8 million for the FAIR highway network, and \$8.4 million for the Express Toll Lane network. Capital costs for gantries, variable message signs and traffic monitoring sensors are further estimated at \$50 million for the FAIR highway network and \$25 million for the Express Toll Lane network. Operations building costs are estimated at \$2.5 million. Thus total capital costs are estimated at \$108 million for the FAIR highway network and \$50 million for the Express Toll Lane network. Annualized at a seven percent discount rate and 20-year payback period, these costs amount to about \$10 million and \$4.7 million per year respectively.

Based on WSA data, annual operating costs for the FAIR highway network will amount to \$780,000 for administrative staff and overhead, and \$1.5 million for miscellaneous operations and maintenance expenses, for a total of \$2.28 million. For the Express Toll Lane network, these costs will be one-half of FAIR highway network costs, or \$1.14 million. In addition, annual transaction processing costs are estimated at 15 cents per trip, assuming that freeway trip lengths on priced segments will be an average of 5 miles per trip for the FAIR highway network (since only two-thirds of total peak period VMT will be on tolled segments on which demand must be managed), and 7.5 miles per trip for the Express Toll Lane network.

Construction Costs

Poole and Orski (2003) have estimated construction costs for direct connector ramps to provide Express Toll Lane access in Washington, DC at about \$1,040 million. This amounts to an annualized cost of about \$100 million assuming a seven percent discount rate and a 20-year payback period. The Express Toll Lane network will need such direct access ramps for safe access and egress, and to ensure that congestion on adjacent lanes is not exacerbated by new weaving movements as vehicles attempt to access or leave the Express Toll Lanes.

Costs for Express Bus Service

Costs for new express bus service are estimated to be the same for both scenarios, since the same level of service will be provided. It is assumed that new express bus service would be introduced during peak periods, from 6 am to 9 am and from 4 pm to 7 pm, i.e., about six hours a day. It is estimated that this service would operate on 300 miles of freeway, i.e., about 600 freeway route miles, at an average frequency of one bus every three minutes, i.e., 20 buses an hour throughout the peak periods. It is assumed that each bus would travel an additional 20 percent of route miles off the freeway network to pick up and drop off passengers. Thus, total revenue miles of service each day would be 720 route miles X 20 buses per hour X 6 hours, or 86,400 route miles.

Assuming an average bus speed (including intermediate stops for pick ups and drop offs) of 20 mph, total revenue hours per day would be 4,320. Based on cost data for Seattle, WA (MacDonald 2003), operating costs for a typical large metropolitan area may be estimated at \$90 per revenue hour. Based on the higher labor costs for split shifts and use of part-time labor for peak period service, costs for peak service are estimated to be from 1 to 10 percent higher than for conventional operations (Charles River Associates 2001), or a maximum of about \$100 per revenue hour. Operating costs would thus be \$432,000 per day or about \$108 million per year assuming weekday operations only, i.e., 250 days per year excluding holidays.

At an average bus speed of 20 mph, each bus would serve 60 revenue miles during each three-hour peak period. Thus, to operate 43,200 revenue miles in each peak period would require 720 buses (i.e., 43,200/60). At a cost of about \$300,000 per bus (based on data on the web site of the American Public Transit Association, see <http://www.apta.com/research/stats/bus/buscost.cfm>), capital costs for buses would be \$216 million, or an annualized cost of about \$30 million assuming a seven percent discount rate and 10-year bus life. Total annualized costs for capital and operation of new express service are thus estimated at about \$138 million.

At 43,200 revenue miles per peak period, a total of 86,400 revenue miles would be served each day. Assuming average bus occupancy of 20 passengers, 1.728 million passenger miles would be served per day. For an average commute trip length of 11.6 miles (US DOT 1997, page 13), about 150,000 passenger trips would be served per day, or 37.5 million per year. Thus, the average cost per passenger trip is estimated at \$3.70, i.e., \$138 million/ 37.5 million. Of course, if bus ridership were only half of the above estimate (i.e., an occupancy of 10 passengers per bus), these costs would double.

In any case, it will be important for the public partner to weigh these potential costs for accommodating a bus commute trip against costs for accommodating a solo-driver or HOV trip in peak periods. For example, average construction costs for adding a lane on a freeway in urban areas amount to \$10 million per mile (US DOT 2000); this equates to 32 cents per mile driven on it during peak periods (DeCorla-Souza 2004a), or \$3.20 for a 10-mile trip. As discussed below, costs for construction and maintenance of a parking space can range from \$1.40 to \$5.80 per day; these are often borne entirely by the employer, and amount to 70 cents to \$2.90 per one-way

commute trip. Thus, the total costs for a new (i.e., “marginal”) peak period commute trip not borne directly by a solo-driver may range from \$3.90 to \$6.10.

Costs for Park-and-Ride Facilities and Shuttle Services

The cost for construction of a surface parking lot is about \$2,300 per space (US DOT 1992). This amounts to an annualized cost of \$220 per space assuming a seven percent discount rate and 20-year life. Annualized maintenance costs are \$130 per space (US DOT 1992). Thus total annualized costs per space are \$350. This amounts to \$1.40 per space per day. This cost would need to be recovered from parking fees.

For a parking garage with three levels or more, construction costs are estimated at \$12,300 per space (US DOT 1992). This amounts to an annualized cost of \$1,200 per space assuming a seven percent discount rate and 20-year life. Annualized maintenance costs are \$250 per space (US DOT 1992). Thus total annualized costs per space are \$1,450. This amounts to \$5.80 per space per day that would need to be recovered from parking fees.

Most new park-and-ride spaces will be needed in exurban or suburban locations. At these locations, it is more likely that the State transportation agency will own land within existing rights-of-way near interchanges or along the freeway. It may therefore be possible to build new park-and-ride facilities on surface lots, adjacent to express bus stations.

The private provider of express bus service may possibly find that it can increase its total profits by subsidizing the cost of parking in order to increase total transit ridership and benefit from larger usage payments. In addition, the private partner may elect to provide subsidized shuttle services to employment sites in the vicinity of the express bus stations, in order to increase transit ridership and its usage payments.

Costs for HOV Identification

Both pricing scenarios will need to provide for some type of HOV self-identification. For the FAIR highway network, this will be needed for vehicles with two or more occupants, so that the system will not bill these vehicles when their transponders are identified on the tolled freeway segments. For the Express Toll Lane network, self-identification of three-or-more occupant HOVs will be needed, so that they can qualify for the 50 percent toll discount. It is estimated that ETC equipment for this purpose will be provided at HOV identification zones. Based on WSA estimates, each such zone will involve a capital cost of about \$46,000.

For the FAIR highway network, approximately 600 HOV self-identification zones will be needed at freeway entrance ramps throughout the 300-mile priced network. Based on the total of 600 zones, costs will be \$27.6 million or an annualized cost of \$2.7 million. For the Express Toll Lane network, approximately 200 HOV self-identification zones will be needed at freeway entrance ramps throughout the network. Based on the total of 200 zones, costs will be \$9.2 million or an annualized cost of \$0.9 million.

Access ramps will need to be re-stripped and/or widened to accommodate the HOV self-identification zones at freeway entrance ramps. It is assumed that the number of new “lane miles” to be constructed at entrance ramps will be approximately 0.05 mile per zone. For the FAIR highway network, 30 lane miles will be needed for the total of 600 zones. For the Express Toll Lane network, 10 lane miles will be needed for the total of 200 zones. At an estimated cost of \$3 million per lane mile for construction of normal cost urban freeway lanes (US DOT 2000), total capital costs will be about \$90 million for the FAIR highway network and \$30 million for the Express Toll Lane network. This amounts to annualized costs of \$9 million and \$3 million respectively, assuming a seven percent discount rate and 20-year life. Total annualized costs (for both lane construction and equipment) would thus amount to \$11.7 million and \$3.9 million respectively.

Costs for Arterial Network Management and Operations Improvements

Mitretek Systems (2003) reports that system capital cost for an adaptive traffic signal control system for 65 signals (expandable to 235 signals) in Arlington County, VA, amounted to \$2.43 million. Mitretek also reports that the system capital cost for an advanced traffic signal control system in downtown Indianapolis (including upgrading 220 intersections and connecting them to a central computer system) amounted to \$5.1 million. Based on these estimates, it is estimated that installing adaptive signal control with advanced signal systems region wide will involve a capital cost of about \$75 million (i.e., 10 times the total costs for the two types of arterial system improvements), or an annualized cost of \$7.5 million. Including annual operations and maintenance costs estimated at \$2.5 million, management and operations of the arterial network to maximize its efficiency will involve an annual cost of \$10 million for the FAIR highway network scenario.

Total Annualized Costs and Self-Financing Potential for Region-wide Priced Network Scenarios

Based on costs estimated above for the components of FAIR highway and Express Toll Lane networks, total region-wide annualized costs for the two scenarios are estimated as shown in Table 3. Annual net toll revenue (i.e., after adjusting for toll exemptions and discounts) for both scenarios is also presented. The revenues were estimated based on daily revenue estimates, assuming that the pricing schemes would operate on 250 working weekdays each year. A comparison of system wide revenues to system wide costs suggests that, for both scenarios, annual toll revenues will be adequate to pay for annualized costs, suggesting that self-financing PPP arrangements may be feasible. For FAIR highway networks, the analysis suggests that there will be a surplus of revenue. This would provide a cushion that could reduce financing costs in the capital markets. It would also provide a source of revenue for new investments to address critical transportation needs.

TABLE 3. ANNUALIZED COSTS VS. ANNUAL REVENUES (million \$)

	<u>FAIR Highways</u>	<u>Express Lanes</u>
Capital costs for toll collection/credit systems	\$10.0	\$4.7
Operations cost at 15 cents per trip	\$80.6	\$24.3
Highway lane construction costs	\$0.0	\$100.0
Express bus service	\$138.0	\$138.0
Parking for bus stations (user-paid)	\$0.0	\$0.0
HOV identification zones/ramps	\$11.7	\$3.9
Management and operations of arterial network	\$10.0	\$0.0
Total annual costs	\$250.3	\$270.9
Revenues	\$356.7	\$273.4

CONCLUSIONS

Potential new models for public-private partnerships (PPP) for the delivery of road pricing/ express bus systems, as presented in this paper, would employ outcome-based contracting systems and incorporate financial incentives to maximize public mobility goals, with clear performance standards to ensure service quality. The models would address public concerns relating to private sector monopoly power as well as private sector concerns about competition, while at the same time facilitating efficient provision of new multimodal transportation services and maximizing mobility and freeway efficiency.

The potential new model suggested for road pricing separates the system operator from the revenue beneficiary. The PPP agreement would employ “shadow tolls” to compensate the private partner. The public agency would pay the private partner based *only* on a flat shadow toll rate and the number of vehicles served at free flow speeds during the rush hours, when pro-active management of traffic flow with variable tolls is needed. In addition, road users would be charged variable tolls directly. The private partner would set the user-paid variable toll rates to manage demand and ensure that traffic is free-flowing. However, *all user-paid toll revenues would go to the public sector*. User-paid toll rates would rise as high as they need to be in order to manage demand effectively, but the private partner would not profit from the resulting increase in user-paid toll revenue relative to shadow toll revenue. Potential private partners would compete to build and operate the road project on the basis of the quality of their proposals and the shadow toll rates that they are willing to accept as compensation for their infrastructure investments and freeway operation and toll collection services. PPP arrangements could also encourage efficient and effective provision of transit and park-and-ride services, by compensating private partners for provision of transit services and high-occupancy vehicle (HOV) services based on the number of commuters attracted to these modes.

Pilot demonstrations of these models would help considerably in gaining public understanding, trust and acceptance of these innovative concepts. Two potential corridor-level demonstration pilots are suggested in this paper. In addition, two alternative region-wide concepts are

presented and financial self-sufficiency of the concepts are assessed. The results of the analysis suggest that both would generate sufficient new revenues to pay for toll collection operations as well as mobility improvements, including new fare-free express bus service, and arterial network and freeway network management and operations. Surpluses may also be available to address new transportation capacity needs in growing areas.

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