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Destination 2030 – Taking An Alternative Route

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I. INTRODUCTION

The transportation system in the Puget Sound region is in crisis. Regional transportation infrastructure and services are not keeping pace with population, employment, and travel demand growth. This gap is widening because our current transportation finance system—both statewide and within the region—is not generating enough revenue to repair and replace aging facilities, let alone add the capacity needed to meet current and projected demands.

Over the next 20 years, the state faces in the neighborhood of $80 billion in transportation needs. The Puget Sound region accounts for approximately $40 billion of that total. King County's share alone equals roughly $30 billion. Within the Puget Sound region, even if all of the proposed funding packages pass this November, we will be well short of the funds needed to meet these needs (see Figure 1).

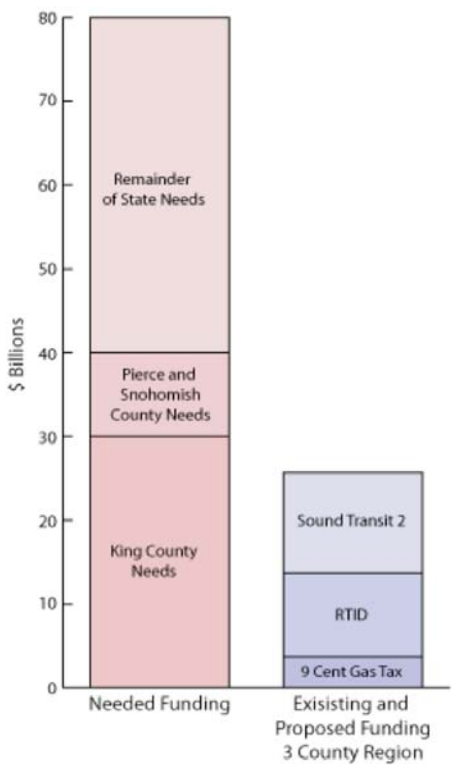

Figure 1. Transportation Needs and Proposed Funding (20 Years)

Because the available funding is small in comparison to the obvious needs, a contentious political battle is being waged over which facilities will be repaired/replaced/ expanded/built. These battles are frequently devolving into both sides arguing, "Why should we pay for YOUR facility improvements, when we need those funds to make improvements to OUR facility?"

Unfortunately, the high cost of the required regional transportation projects will make it difficult to raise the taxes we have traditionally used to pay for transportation improvements (gas tax, sales tax, motor vehicle registration tax). Large segments of the public have voted against these taxes because of their belief that they would be subsidizing projects that would primarily benefit others. What is necessary is some "out-of-the-box" thinking.

This report does just that.

Rather than asking the general public to pay for projects to benefit limited segments of the region, let us introduce market forces so that those doing the traveling pay for the costs of that travel. Using market forces and spending the revenue within the travel markets that generate those funds creates a sustainable system. Users generate the funding required to pay for the services they use. If demand warrants expansion, the use of that facility/service pays for the expansion. As use wears out a facility, the users pay for its repair or replacement.

1.1 The Transportation Improvement Fee (TIF)

This report recommends a sustainable, regional *transportation improvement fee* (TIF) concept for King County. The TIF would be able to produce $1.1 to $1.6 billion of "user fees" per year, or approximately $36 billion in net revenue over the next 20 years, without statewide contributions or regressive sales tax measures. The net present value of the TIF would be $24 billion over that same period.

The TIF concept is based on the idea that the users of the overburdened, underfunded, regional highway facilities should pay for the repair, replacement, and expansion of the transportation infrastructure they actually use. Furthermore, those payments should be in proportion to their use of, and impact on, those facilities.

The improvement fee paid by a traveler would vary according to congestion levels. To add certainty to trip making decisions and to make use of the system easy to understand, this means that the TIF would vary by time of day (and day of week) and by distance traveled.

Where congestion was highest, fees would be highest. This would generate the funds needed to expand transportation capacity, and it would encourage lower valued trips to use less expensive (and less congested) times of the day, thus reducing congestion, reducing gasoline consumption, and reducing pollutant emissions.

Where congestion was lower, fees would be lower. But fees would be present throughout the day. In this manner, all roadway users would help pay the operation, maintenance, and rehabilitation costs of these transportation facilities.

1.2 Use of the Transportation Improvement Fee

The revenue generated by the transportation improvement fee should be reserved entirely for the transportation system within the TIF region. **It is very important that the people paying the improvement fees be direct beneficiaries of the transportation system improvements and services they fund.** Transportation improvement revenues could be used to preserve and operate existing facilities, expand transportation capacity, and invest in alternative modes of travel that serve the TIF affected corridors.

"Capacity expansion" would include funding of services/infrastructure from any and all modes of travel that would increase mobility in the congested corridors. All modal capital and operations costs would be eligible for the regional transportation improvement fees.[1] It is recommended that TIF funded system improvements focus on four key elements:

- Rehabilitating existing transportation facilities
- Providing more roadway lanes where that makes economic sense
- Improving the way that roads are operated and managed
- Promoting smarter journey choices through improved public transportation.

1.3 Organization of the Report

The following chapter explores the benefit of the TIF to the Puget Sound region, articulates TIF program objectives, and recommends a general system design for the Puget Sound. Chapter 3 describes system design elements, supporting technologies, and system costs related to the recommended Closed System option. Chapter 4 presents estimates of system revenue and future net benefits. Chapter 5 provides an overview of the region's unfunded transportation needs. Chapter 6 identifies the next steps, including project definition and planning, needed to advance this program.

[1] This project has not examined the regional governance structure that would be needed to collect and allocate these funds.

2. REGIONAL TRANSPORTATION IMPROVEMENT FEES IN THE PUGET SOUND

2.1 *Why the TIF?*

There are a number of reasons why the state and the region should adopt the TIF.

The best reason is that the TIF is the fairest way to fund the transportation improvements the region wants. It may be the only way to fund these improvements. The region wants transportation system improvements. It wants less congested roads. It wants better transit service. It is willing to help pay for those improvements. However, it is true that we don't want to pay for *your* improvements. We want to pay for *our* improvements. **The great advantage of the TIF is that those who pay the TIF will gain the benefit**. If you don't use the system, you won't be required to pay for it. And that is the fairest payment system of all.

The TIF, as proposed, will also provide a large number of other benefits. A well designed "user fee" package has the potential to reduce congestion significantly. The Puget Sound region can expect to see reduced travel times, improved travel time reliability, and significant improvements in public transportation services. This will be good for all sectors of the economy, whether shoppers, workers, or businesses.

Because the TIF will rise during congested periods, travelers will have an economic incentive, as well as a travel time incentive, to travel when the road is less congested. The result will be lower volumes on the regional freeways during congested time periods, making travel faster, less stressful, and less harmful to the environment.

Because the TIF will generate sustainable revenues, transportation improvements can be made that support transportation friendly land uses, creating the "virtuous circle" of land use and transportation improvements that are the hallmark of sustainable development.

Importantly with the TIF, travel decisions will still be in the hands of the public. Travelers will choose their travel options. They can choose their route, their time of departure, and their mode. Their choices will now be effectively guided by market-based price signals that more accurately reflect the true costs of travel. Additionally, the economic behavior the TIF creates will result in improved mobility, reduced congestion, faster travel times, a financially healthier environmentally sustainable transportation system, and greater transparency in the use of revenues for the benefit of those paying the fees.

2.2 Program Objectives

The TIF program will meet several key objectives:

- **Address the regional transportation funding deficit** – The revenue generated by the transportation improvement fee would be spent to improve travel conditions for the corridors within which fees were collected. Transportation improvement revenues could be used to preserve and operate existing facilities, expand transportation capacity, and invest in alternative modes of travel. **The people paying the improvement fees would be the direct beneficiaries.**

- **Provide immediate congestion relief** – In response to a fee, travel volumes would be affected in three ways: 1) motorists would shift from single occupancy vehicles to shared ride modes (carpools and transit), 2) motorists would shift from discretionary trips to off-peak periods when the fee would be lower, and 3) some vehicle trips would be diverted or eliminated as a result of traveler sensitivity to price. By charging a fee that reflects the true costs of travel, it is possible to reduce congested conditions and improve travel times throughout the day.

- **Support alternative modes of transportation** – This program would support multi-modal transportation capacity enhancements as part of a regional transportation management package. The TIF program revenues could be used to support light rail expansion, express bus rapid transit (BRT), transit fleet expansion, park-and-ride expansion, transit-oriented joint development efforts, bicycle lane and trail facilities, and pedestrian enhancements.

- **Enhance environmental sustainability** – The TIF program would result in a substantial reduction in single-occupancy vehicle miles of travel and would encourage carpooling, transit use, and other alternative modes of transportation. Associated reductions in mobile-source emissions would improve air quality and the environment.

2.3 System Design Options

Regional user fee systems fall within one of two basic categories: a) facility-based pricing and b) area pricing systems. The purpose of this section is to describe each automated user fee application and to establish screening criteria to assess the comparative suitability of each potential application (and corresponding technological attributes) to the Puget Sound region.

Both approaches offer considerable flexibility in the use of dynamic pricing to manage traffic conditions by time of day and by location. Advanced fee collection systems are sophisticated enough to manage traffic by varying the fee rate by time of day, location, distance traveled, and other operational parameters. The following sections describe these approaches.

Facility-Based Pricing

In this approach, automated charging of fees is retrofitted to a fixed distance of a single highway segment or over a larger highway network. Motorists choosing to use the facility are charged a use fee based on total distance traveled through the network. The use fee structure may assign differential rates by time-of-day. The highway facilities included are typically major interstates, highways, or state route segments that suffer significant peak-period traffic congestion.

Central Puget Sound boundaries for a facility-based fee system would likely include Everett/Marysville to the north, Redmond and Issaquah to the east, and either Tacoma or Olympia to the south. Given current and future traffic conditions, the north-south facilities that are candidates for user fees include I-5, I-405, SR 99, SR 599, and SR 167. East-west facilities likely include I-90 and SR 520.

Facility-based systems require gantry-mounted user fee collection devices at the point of entry and at downstream locations throughout the facility. User fees may be collected on the basis of trip length. For long systems (beyond 8 miles), gantries can be placed at all entrance ramps within the facility and at entrance/exit ramps over the mainlines at the beginning and end of each freeway segment. When the vehicle enters the facility, the gantry reads the vehicle's electronic tag/license plate. When the vehicle exits the facility, the appropriate fee amount is debited from the user's account on the basis of total distance traveled and time of day.

Area Pricing

The second regional user fee system is based on an area pricing model, which is typically applied to major metropolitan cities where a dense central business district (CBD) attracts a substantial share of region's daily auto trips from outlying communities. In order to alleviate severe traffic conditions within the CBD, a boundary is drawn around the congested district. All vehicles entering the pricing 'zone' must pay a fee that may vary by time of day. Internal trips may also be charged.

Under this scheme, electronic user fee collection gantries are placed at entry points located at the edge of the pricing zone. All vehicles entering the zone are charged a time-of-day fee based on time of entry. Fees are higher during the AM and PM peak periods and lower during off-peak times of day. These area pricing systems can be structured to charge through-trips differently from trips with end points inside the zone. The intent is to charge less to those who have fewer alternative transportation options (i.e., those who are not traveling to major activity centers that are well served by transit). Trips passing through the zone (e.g., entering and exiting the zone within a specified window of time) may be exempted from paying a fee or may pay a lesser fee.

2.4 *What's the Best Fit for the Puget Sound Region?*

The Puget Sound region possesses a unique urban geography. Lake Washington and the Puget Sound waterway represent major physical barriers that orient King County's development along two major north-south axes represented by I-5 and I-405. The city of Seattle is connected to eastern King County via two floating bridges, State Route 520 and I-90, and generates many highway trips destined for locations within the central business district, eastern King County, and beyond. While Seattle continues to grow, even greater growth has been occurring in the northern, southern, and eastern suburbs. Suburban growth includes both people and jobs.

Travel Demand

The resulting travel patterns in the region suggest that while the City of Seattle is a major regional trip attractor, the highways serving Seattle (I-5, I-90, and SR 520) and major arterial roads also distribute a high volume of trips among multiple communities throughout the Puget Sound region. Seattle is the largest attractor of regional trips but represents only one among many subregional economic hubs that include Tacoma, Renton, Bellevue, Redmond, Kirkland, and Everett, among others. The polycentric nature of the Puget Sound region suggests that an area pricing scheme overlaid onto Seattle's central business district would not be effective in relieving traffic congestion in areas of King, Pierce, and Snohomish counties outside the zone.

Another key consideration is the intensity of traffic congestion on the region's highway network, which is severe because of the high share of auto trips throughout the region loaded onto the highway system. Currently, the supply of highway capacity simply cannot accommodate continued growth in regional automobile trips. Coupled with higher truck volumes, several of the region's major highways are gridlocked in the AM, midday, and PM peak periods, with recurring bottlenecks at numerous chokepoint locations throughout the regional highway network. As a system management tool, an area pricing scheme would not be as effective in addressing highway congestion as a facility-based option.

Mass Transit Capacity Requirements

The existing regional mode split, and the ability of alternative modes of transportation to absorb trip deflection caused by road pricing, is another important consideration. In cities where area-pricing schemes have been implemented, there has been a high pre-existing transit mode share. Cities such as London and Singapore have extensive mass transit assets that include subways, passenger rail, light rail, and fixed-route bus services. By comparison, the Puget Sound region's existing transit mode share is low. While this share is comparable to that of other metropolitan U.S. regions, it is much lower than the transit mode share of international cities that have implemented regional user fees.

Importantly, while much of the travel occurring in the region is in single-occupant automobiles (see Table 1), work trips made to these regional centers are twice as likely to share rides in comparison to work trips bound for destinations outside of these centers (25 percent to centers / 12 percent outside of centers). In addition, growth management legislation encourages the further development within these centers, meaning that significant potential exists for mode shift to transit as the region grows, as long as the necessary transit infrastructure can be provided.

International experience suggests that the ability of the mass transit system to absorb this mode shift is a necessary precondition to program success. This is true for both the area pricing and facility-based systems. One of the major challenges facing the Puget Sound region would be the expansion of mass transit capacity in order to adequately absorb trips deflected from the roadways on which a regional user fee system had been imposed.

Table 1. AM Peak Mode Share

Mode		% Share in AM Peak
SOV	Auto	76.4%
HOV	Transit	16.4%
	Vanpool	7.1%
	Bicycle	0.1%
	Walk	0.1%
	Truck	0.1%

Recommended System Design

To summarize, the determination of what type of automated user fee system is the most appropriate fit for a given urban geography is subject to several important considerations, including the following:

- Geography (natural barriers, waterways, peninsulas, bridges)
- Street network configuration
- Existing travel demand (temporal and spatial)
- Baseline modal capacity (auto, HOV, transit, ferry, bicycling, walking).

Given the unique characteristics of the Puget Sound region, we chose to investigate a facility-based fee system, which we believe is a more appropriate fit than area pricing. Such an approach would be better able to alleviate traffic congestion relief where it occurs most, on the region's highways. An area-based system works most effectively where a very large percentage of trips are destined for a single concentrated destination. The Puget Sound region does not fit that description. In addition, a regional facility-based system would be more effective in generating the revenues needed to address the region's broader transportation needs.

The next chapter provides a more detailed discussion of the design of the regional fee collection system.

3. SYSTEM DESIGN AND COSTS

The following section describes the conceptual design for a facility-based system intended to optimally address the specific challenges presented by the Puget Sound region.

3.1 System Design Issues

A facility-based approach has been chosen to directly target congestion across the highway network. This network would include the majority of the limited access routes in the Puget Sound region, from Everett in the north to Lakewood in the south, as well as a range of multi-lane sections, reversible roadways, and the freeway ramp metering system (see Figure 2).

Some of the key issues considered in the development of the concept design include the following:

- The need to maintain acceptable operating standards that do not introduce additional capacity constraints
- The flexibility to vary charges by location, time, and distance
- Ease of understanding for the public
- The ability to implement operational strategies that minimize localized diversions to avoidance charges
- A system based on proven technologies
- Restriction of operating costs to an acceptable level
- A scheme that would be feasible for implementation by the 2010 assumed design year and, therefore, be based on currently available and affordable technologies.

Figure 2. Proposed Transportation Improvement Fee Network

3.2 System Design Options

Given the assumed design criteria described in section 3.1, two general system design options are available:

- **Closed System** – A fully closed system across the defined highway network in which all entrance and exit points across the network are monitored. Each individual trip is recorded at the entry and exit point.

- **Open System** – An "open" system is based on a series of specific revenue collection points at strategic locations across the network that charge vehicles when they pass these defined points.

If cash transactions are allowed at each tolling point, these two approaches are only appropriate for fundamentally different revenue systems (trip-based versus point-based). If electronic revenue collection systems are employed (as recommended), it is possible to use either design to calculate and apply trip-based user fees by combining the locations and times at which a given account ID is observed using the system. The primary difference between the two approaches thus becomes the cost of system deployment and operation.

The following section presents a design overview of the Closed System, which we recommend as the preferred option. We make this recommendation based on its lower cost of implementation, the ease with which the system can be expanded (if the TIF region were to be expanded to cover the cost of further roadway expansion), and the inherent "fairness" of a system that covers an entire roadway, not just "arbitrary" points on the road. More detailed information about the Open System option is described in the appendix.

3.3 Recommended TIF System – Closed System

The recommended TIF charging scheme is based on the concept of a fully closed charging system, with data collection points at every on- and off-ramp across the limited access highway network. Data collection points would be established at all entry and exit points to record each vehicle entering and leaving the strategic network. These data would be passed through a centralized facility where the respective entry and exit transactions would be matched, producing a specific trip record that would be charged a fee based on the specific parameters of the system. For example, a trip from Lynnwood to Renton during the AM peak might pass through several defined geographic zones and be charged a combined fee based on a) these zones and b) the direction of travel for that time of day.

This approach is very similar to what is used by transit systems in this region. In addition to the required entry and exit points, some mid-block toll checkpoints could also be established at key locations to provide additional trip data (such as whether the trip described in the above example actually used I-5 or I-405 for the majority of its trip) and to assist in identifying any vehicles not identified at the main ramp locations.

Charges under the Closed System would be set for a fixed period (likely three to six months) on the basis of a defined formula that would include specified zones. The charges would vary by time of day based on the congestion routinely present on those facilities (e.g., average speed). This approach would allow for the publication of a differentiated time-of-day fee structure that would apply for the next three- to six-month period. In this way user fees would rise or fall on the basis of changes in demand for the facility during peak travel. (That is, if effective transit service were available as an alternative, and sufficient individuals chose to use it, demand would drop on the roadway, congestion would ease, and the user fees on that facility would decline.)

We recommend that the TIF charges also be varied by vehicle type (e.g., passenger vehicles versus commercial trucks), with provisions made for exemptions and/or special discounts. For the purposes of this concept design, it is assumed that only buses and emergency vehicles would be exempt.

General System Issues

Figure 3 illustrates the basic operation of this type of scheme. It offers flexibility to target specific congestion locations by periodically altering zone- and time-based charging packages, without the need for any physical changes to the data collection infrastructure. Full network coverage also reduces the potential for users to bypass the system on a regular basis and provides the potential to develop charging mechanisms that can be more easily modified or shifted to future technologies as part of the ongoing USDOT-sponsored Intelligent Vehicle Initiative (IVI) and Vehicle Infrastructure Integration (VII) programs.

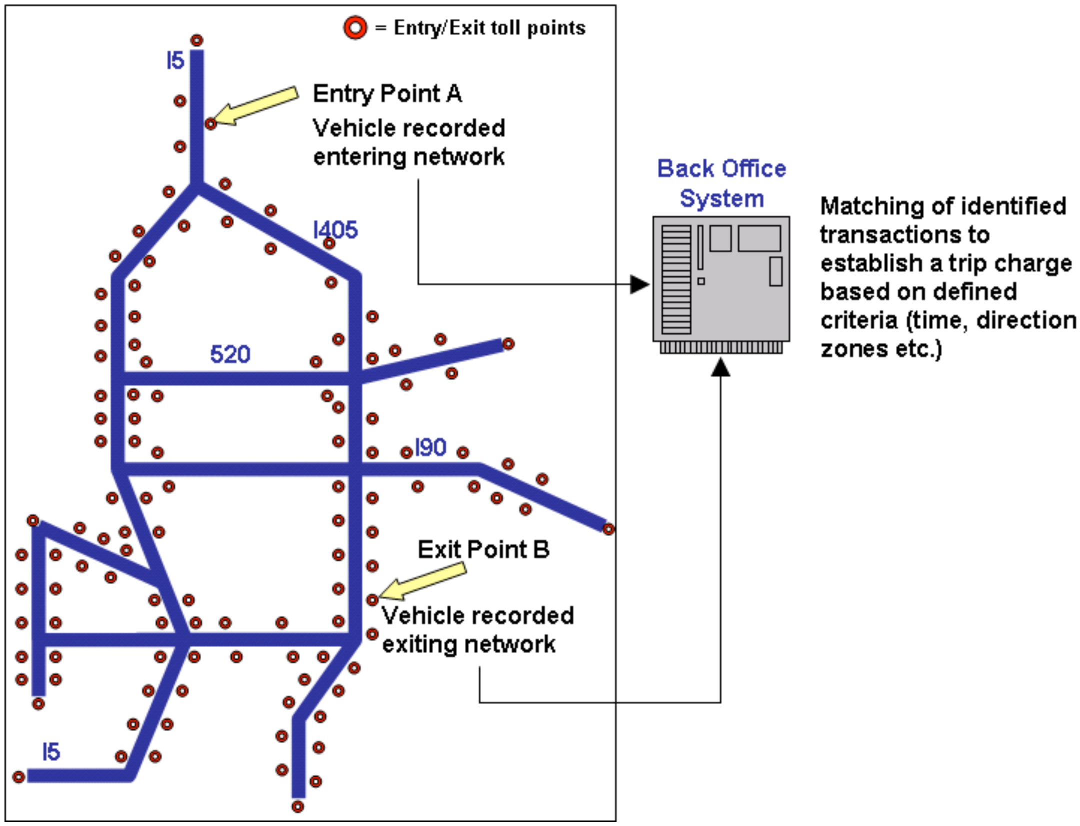

Figure 3. Closed System Design

System Design

There are two major sets of facilities required by the assumed system design: 1) roadside facilities used to record vehicle movements entering and leaving the network; and 2) back-office systems used to process this information, collect the relevant charges, and manage administrative functions. These facilities dictate how the user fee system will function and thus what operations and maintenance costs can be expected from the system. Factors that must be considered in the system design include the key scheme functions listed at right.

KEY SCHEME FUNCTIONS

- Information – providing adequate information to users and potential users on the charging regime and payment options.
- Detection – detecting, and in some cases measuring, each individual instance of use (e.g., vehicle entering and leaving the system).
- Identification – identifying the user, vehicle, or in some cases numbered account.
- Classification – measuring the vehicle to confirm its class, aligned with the classification framework for the scheme.
- Verification – cross checking processes and secondary means of detection to assist in confirming transactions, reducing processing costs, and providing a backup for potential enforcement.
- Payment – pre- and post-use collection of payment from users based on verified use.
- Enforcement – providing the means to identify and prosecute violators and/or pursue violators for payment of charges and/or fines.
- Exemptions – providing the facility to manage a range of exemptions within the context of the scheme.
- System Reliability and Accuracy – providing all of the above through cost-effective systems and technologies that can meet the required levels of reliability and accuracy, and minimize revenue leakage and fraud.

The concept design is based on the use of a combination of technologies, including vehicle-based transponders or on-board units (OBUs) that use industry standard, dedicated short range communications (DSRC) technology and cameras that incorporate licence plate recognition technology (ANPR) for enforcement. These technologies form one of the most commonly used combinations for electronic free-flow roadway charging around the world, and thus provide a well established base for the proposed scheme. (The selection of these types of technologies is addressed in more detail in Section 4).

OBUs can be supplied to system users through mail and assigned agents (e.g., post offices). They would be installed by the user. Fees would be deducted, on the basis of recorded trips, from pre-paid accounts assigned to these OBUs. (Later evolutions might be developed to include the use of OBUs with the ability to draw payments directly from smart cards currently being developed for use on the Seattle transit network, thus eliminating the need for accounts and optimizing the level of privacy for users.) Users would be able to "add value" to their OBU at their discretion through a number of different mechanisms and locations.

Casual users, those who used the network less frequently and did not have an OBU (including those who lived within or outside the state) would be identified by the system through license recognition. Chargeable trips would be identified by matching relevant entry and exit points. "Casual trips" would be subject to an additional administration charge to cover the additional costs, with payment options provided, including casual user accounts or the purchase of a "use pass" on the day of travel.

Taxis and other non-exempt "fee-for-service" vehicles that use the freeway network would be fitted (by trained technicians) with a more advanced unit integrated with the taxi meter and connected to the vehicle's main power supply. These units would be "dual mode," incorporating the ability to operate as a card payment device or as an account-based payment device linked to the taxi meter. Eligible organizations and individuals would be provided with exemption cards that could be used in place of future payment cards when appropriate. This privilege would be monitored by regular reports on the use of these cards provided to the management of the respective organizations.

Enforcement of the system would be accomplished through the secondary ANPR and image capture system. Any vehicle passing a charge point that was not recognized as a valid transaction (for reasons that could include insufficient funds or incorrect class of payment) would be recorded as a violation, and an image of the vehicle and its license plate read would be recorded. These would then be used to pursue payment from the registered owner of the vehicle.

Back-office facilities and operations would be set up to process the required level of transactions and violations and would include all of the processes required to distribute and maintain OBUs, manage contracts, and process transactions through to billing. Other required elements that have been assumed within the cost of the system include a database of registered account users linked to the back-office systems, secure access to the motor vehicle registry for violation processing, and a dedicated, secure communications system to connect these components.

Roadside Facilities

A review of the routes planned for inclusion in the network, including the number of locations and number of traffic lanes at each site, has been undertaken to provide a basis for evaluating the Closed System. Table 2 lists the routes included, summarizing the number of planned fee collection points and number of lanes, and includes provisions for five mid-block points.

Table 2. Fee Collection Points by Segment

Routes	Access/Egress Points	Lanes
I-5	167	239
I-90	32	38
SR 99 and 599	30	34
SR 509	25	33
SR 518	12	15
I-405	75	135
SR 167	34	42
SR 520	40	61
Additional mid-block sites	5	15
Total	**415**	**597**

Data collection point designs have been developed for lane configurations of from one to six lanes, and these have been assigned to each required data collection location on the basis of the number of lanes at that location. Each site would provide the ability to detect that a vehicle was passing (i.e., entering or exiting the TIF network), classify that vehicle as a car or truck, communicate with the DSRC-based OBUs to determine whether a valid OBU was present in that vehicle, collect and process license plate images from vehicles that did not have a valid OBU, and communicate these data to the central transaction processing facility. An independent verification system has also been assumed to provide a basis for checking and auditing the system.

Back-Office

The back-office systems required for a Closed System would include the following components:

- Revenue Collection Central System (RCCS) – This would be used to process the individual roadside transactions into defined trips, address transactions that had been misread or incorrectly assigned, and assign charges based on the rates table for the defined scheme. This system would also manage all relevant accounts and OBU management functions.

- Internet/Mail Center – This system would manage Internet and mail payments and enquiries, as well as the distribution of bills, notices, and OBUs.

- Customer Service Center – This facility would provide the main interface with the public, relying on many of the functions of the RCCS and the Internet/Mail center in the processing of accounts and OBU distribution and management.

- Monitoring System – This system would provide continual monitoring of the roadside and back-office systems to ensure consistent operation of all related systems and sub-systems, providing cross checks for key data streams and monitoring the operation of critical systems.

- Systems Integration – The system would ensure effective integration of the main back-office facilities with the relevant roadside systems.

Operations and Maintenance

The operations and maintenance processes would include a range of functions, including the following:

- Handling user inquiries
- Processing payment notices and debt collection
- Processing casual user transactions
- Processing incomplete transactions and failed license plate reads
- Processing system violations
- Maintaining systems and equipment.

The concept design for these elements has been based on an assessment of likely transaction volumes drawn from current traffic data at each of the entry and exit points included within the scope of the Closed System option.

3.4 System Technology

The requirements of a Closed System fee collection program constrain the potential technology choices for a cost-effective and reliable system.

Technology Options

Candidate technologies for the Closed System, based on consideration of a combination of currently operating systems, development of new technologies, and the scale of the schemes proposed, include the following:

1. **DSRC RFID Schemes** (with ANPR enforcement) — Dedicated Short Range Communication (DSRC) is the most common form of primary electronic road pricing technology in general use and is the standard on most free-flow toll facilities. The technology is based on the use of on-board vehicle units (OBUs), sometimes referred to as transponders, which communicate with gantry-mounted equipment at defined charge or check points. These units can also incorporate a smart card facility for payment. The roadside equipment identifies and verifies each vehicle's OBU and, depending on the type of system, either processes a charge from its designated account or confirms its rights of access. In most systems, the DSRC system also locates the vehicle within its detection zone by using an array of DSRC transceivers.

2. **Vehicle Positioning Systems (VPS)** — Vehicle positioning systems (e.g., GPS, Galileo) use a satellite location system (generally a global positioning system) to determine the vehicle's position and measure location and distance travelled for the purposes of charging and access control. A limitation of vehicle-based systems is that in addition to the position system itself, they require an external communications system in order to periodically report that vehicle's required

charges. Germany's truck toll system (the only adopted GPS-based system currently in operation) uses cellular telephone technology, and its associated charges, to perform this task.

3. **Image-Based or Automatic Number Plate Recognition (ANPR) Systems** — Image-Based ANPR technology is based on images taken of vehicle number plates and processed through optical character recognition software to identify the vehicle.

4. **Other Radio Frequency Identification (RFID) Systems (includng passive, pico-cell, and other technologies)** — In-vehicle RFID identifiers are read by roadside detectors to record vehicles passing defined points. These are similar to the OBUs described above but do not use the DSRC standards being developed by USDOT. Instead, they use other communications standards and have different price/performance/capabilities in comparison to the DSRC-based RFID systems.

Urban streetscape "clutter" can be a concern with any technology that requires roadside equipment, although with good design any unsightliness can be kept to a minimum, as illustrated by Figure 4. The enforcement accompanying any of the above technology choices is generally accomplished by using roadside enforcement cameras and ANPR technology, and thus to a certain extent, all of the technologies being examined must address the question of roadside clutter.

Figure 4. Examples of ANPR Equipment

Recommendation: A Combination System

The most appropriate technologies for the Closed System option would be a combination comprising DSRC OBUs as the primary payment and identification technology and ANPR technology for enforcement and casual user transactions. This combination would allow operators to benefit from the higher accuracy and lower operating costs of DSRC, while the ANPR would accomplish both the casual user management and enforcement tasks. This package would also allow interoperability with the Tacoma Narrows toll bridge operations and WSDOT SR 167 HOT lane system, as well as limiting the use of the less accurate and more costly ANPR technology to a reduced number of transactions. For more detailed information on DSRC and ANPR systems, see the appendices to this report.

The proposed system is based on current industry standard OBU communications technologies to capture the cost and security benefits these provide. Because the technologies that can be used to perform the required transaction processing are evolving rapidly, costs for system change-over to emerging national standards have been included in future year expenses for the TIF system as part of the net present value calculation for this project.

At present, CEN 278 standard units use a 5.8Ghz frequency, but they would potentially shift to a higher 5.9Ghz frequency as international standards evolve. This standard is specifically designed for multi-lane free-flow applications and differs from other passive OBUs currently used around the nation in dedicated toll lanes.

Although a DSRC/ANPR package that uses OBUs linked to account-based payments has been identified as the most suitable for this application, it is expected that this could soon be changed to a system that uses OBUs with integral smart card facilities (see Figure 5). This would reduce back-office processing, improve user convenience, and benefit from smart card payment facilities being developed for the transit system.

Figure 5. Example DSRC System OBU with Smart Card

Vehicle positioning systems (VPS) may also be attainable in the future, providing a more effective means of measuring location and distance travelled for the purposes of charging. These systems (e.g., GPS) offer greater flexibility in varying charges to influence more aspects of travel and transport choice.

Although to date the cost of VPS units has limited their use to major heavy vehicle application, their costs are decreasing. Once they have been established, VPS-based systems have the advantages of wide coverage and far fewer checkpoints than other technologies. A gradual shift from a DSRC/ANPR system to this type of system could be achieved, as the back-office systems and much of the roadside equipment would be consistent with the enforcement systems that would be required. Initially, VPS units could be added alongside the existing DSRC units and integrated with same smart card accounts and payment systems.

3.5 System Costs

Cost Estimates

Total project implementation costs are estimated at $88 million with the cost of electronic tags and smart cards (that is, if it is assumed that the base cost of electronic tags will be borne by the system, not the individual user), and $65 million without them.

Total annual operating costs are estimated to be approximately $148 million (with an 80 percent to 20 percent split of transactions between electronic tags and license plate recognition, respectively), or approximately 9 percent to 10 percent of the operating revenues.

Concept Design and Cost Model

To develop the above estimates, a cost model has been developed for both the Open and Closed concept designs. This subsection describes that cost model and the assumptions that are included in it. The same model structure is applicable to both the Open and Closed concept designs. However, the input details of these two concepts differ markedly.

The model is based on the application of similar technologies for similar systems and facilities currently in operation around the world. The technology and systems costs are based on an international market. Because of the specialist nature of these systems, it has been assumed that an experienced international supplier would provide the main system. Where available, local costs for key elements such as structures (e.g., the gantries and poles needed to hold the data collection electronics) have been incorporated into these estimates based on known pricing from other procurements of similar systems.

The cost model includes two main elements: capital costs and operating costs. Figure 6 illustrates the basic components in the cost model and shows how the transaction costs are linked to the revenue model. The basic design of the capital and operating cost components is described below.

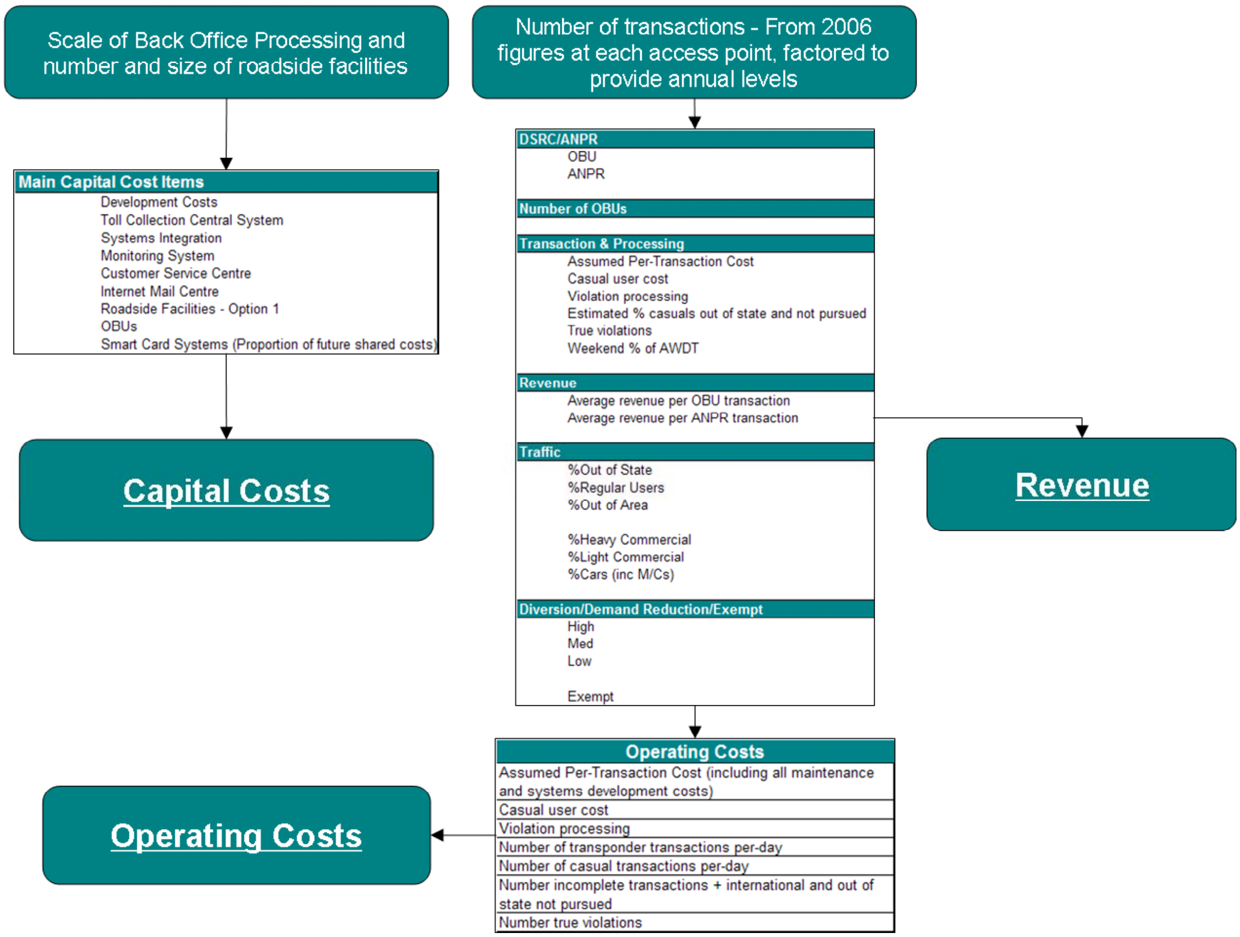

Figure 6. Cost Estimation Methodology Summary

Capital Costs

Capital costs include back-office facilities scaled to accommodate the levels of transactions expected and roadside facilities based on the number and size of revenue collection points. Elements of capital costs include the following:

- Development costs
- Revenue collection central system
- Systems integration
- Monitoring system
- Customer service center
- Internet mail center
- Roadside facilities
- Initial distribution of OBUs
- Smart card systems.

The costs of the roadside facilities for each option include all of the relevant equipment necessary to operate a DSRC/ANPR data collection point, along with an independent verification system, and the civil structures and related infrastructure (conduit, wiring, etc.) needed to mount and operate that equipment.

Generic designs and costs have been developed for sites with between one and six lanes, and the costs for each generic design have been applied to each Puget Sound site on the basis of the number of lanes present at each site. Within the model, the number of sites of each type has been summarized by route. The following routes are included in the initial cost estimate presented above: I-5, I-90, SR 99, SR 599, SR 509, SR 518, I-405, SR 167, and SR 520.

A cost has been included for the initial OBU base and for preliminary alignment of the TIF revenue collection system with planned smart card systems. At this stage it is assumed that all sites would require the construction of a new structure specifically to hold the data collection electronics, but it is expected that at least 30 percent of sites would utilize existing structures, reducing overall system costs.

Operational Costs

The estimated costs of operating the TIF are based on a per transaction cost factored up to an annual operation cost, including costs for all regular operations and maintenance. Excluded from this operational cost rate are the costs associated with revenue enforcement. The processes involved in identifying noncompliant users, issuing notices, and chasing outstanding debts are considered part of a separate system, the cost of which would be more than covered by administration charges imposed on those users. Excess revenue from these charges would assist in offsetting any losses from charges that could not be recovered. The revenue estimate presented in this report assumes that enforcement costs and losses from non-payment of debts would be canceled by these administrative fees, resulting in no net-revenue loss or gain due to required enforcement actions.

The cost model is based on a defined number of transponder transactions per day (these differ considerably between the Closed and Open system designs) and assumes a defined split of regular user and casual user transactions per day. The assumed levels of incomplete transactions[2] and violations have been developed as a proportion of this split. The number of transactions is based on an assessment of each of the identified sites, factored to provide an annual average transaction figure.

Key Assumptions

In developing the cost estimates, a range of assumptions related to system design and operations have been made:

- A cost per site has been included for the provision of communications and power. This cost assumes that the majority of sites will be located within accessible range of an existing communications network and power supply but that some additional communications infrastructure and technologies will be required.

- The OBUs that will be required at the time of commissioning have been included within the back-office capital costs. Two types of OBU have been assumed: one for general users that will be installed by the user, and the other for taxis and buses that will require trained installation. The number of units required has been based on forecast vehicle fleet figures derived from the reported number of state-registered vehicles.

- Gantry costs have been estimated on the basis of advice from local WSDOT staff.

- Other infrastructure costs have been calculated on a per installation basis for both the generic gantry types and pole-type installations.

- Back-office costs include development, design, integration of data collection points, and commissioning (e.g., system testing and verification, training).

- Where poles sites are used in place of gantry equipment, two poles will be required for front and rear images and for vehicle detectors and classifiers.

- One control box has been assumed for each site.

[2] An incomplete transaction is one in which a vehicle is observed only entering or exiting the system, but not both, because of some technical malfunction.

4. SYSTEM REVENUES

The purpose of this chapter is to describe the methodology that was used to estimate the annual revenue figures, presented earlier in this report, which could be generated from a Transportation Improvement Fee. The methodology used to estimate TIF revenues is described in Section 4.1. In Section 4.2, future modifications to the revenue model are suggested.

4.1 Revenue Estimation Methodology

The study team developed a high-level methodology for estimating the annual revenue generated from a Sustainable Transportation Program that features the system design described earlier in this report. The basic four-step revenue estimation methodology is illustrated in Figure 7.

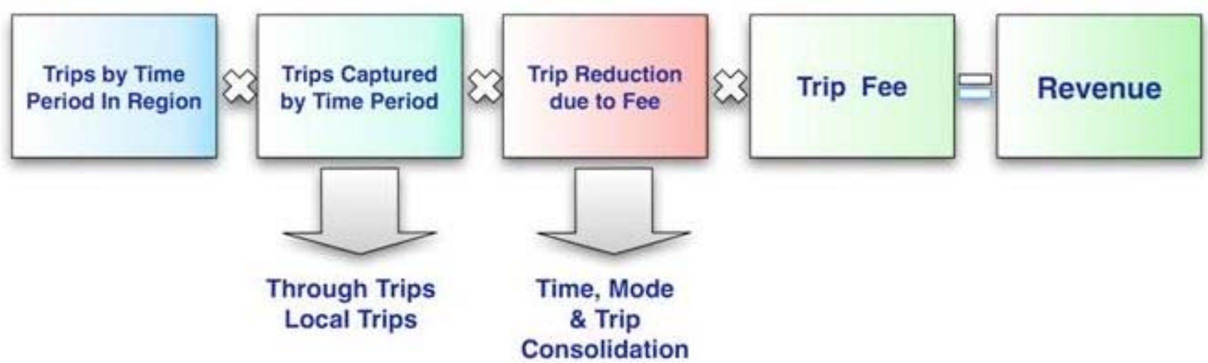

Figure 7. Revenue Estimation Methodology

The revenue model makes the following assumptions:

- Charges are applied to passenger cars and light-duty trucks accessing the network at a rate of $2 per zone during the AM and PM peak periods and $1 per zone during the midday period. (Zones correspond to the PSRC travel demand model's forecast analysis zones, illustrated in Figure 8.)

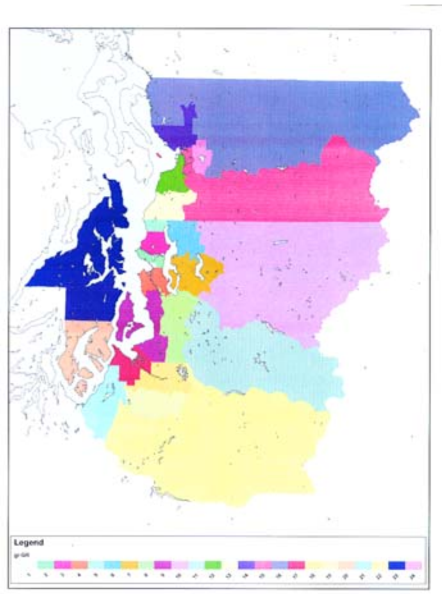

Figure 8. Analysis Zones Used for Revenue Estimation

- The fee system has a cap of $8 per trip during the AM, midday, and PM periods.

- Medium- and heavy-duty trucks are charged at twice the rate of passenger cars and light trucks.

- Vanpool and transit trips are not charged, but otherwise no exemptions or discounts have been applied for modeling purposes.

- A base charge of $1.00 per trip, regardless of trip length, is applied during late night hours and on Sundays.

- Sunday travel volumes are 50 percent of weekday travel volumes.

- Violations are assumed to be revenue neutral (i.e., violators will be pursued to a level that ensures that fines recovered equate to lost revenue). This includes revenue leakage factors such as unreadable license plates and untraceable owners.

- No evaluation has been undertaken of the consequential effects on public transport system revenues.

- No evaluation has been made of trip re-timing effects.

- No evaluation has been undertaken of secondary revenue effects, such as business sector impacts

- No attempt has been made to optimize revenue streams

Step 1: Trips by time period in the region

The Puget Sound Regional Council (PSRC) provided origin-destination trip matrices according to the 24-zone scheme used in its regional travel demand model, as shown in Figure 9, for a variety of travel modes. The 24x24 zone configuration has 576 zone pairs.

Using a spreadsheet model, vehicular trips were aggregated as follows. Single-occupant autos, high-occupancy autos, and light-duty trucks each counted as one vehicle trip, while large trucks counted as two vehicles (to reflect the fact that large trucks would pay twice the fee rate of autos). Total vehicular trips were estimated for each zone pair according to the following time periods:

- 7:00 AM – 10:00 AM (AM peak)
- 10:00 AM – 4:00 pm (midday)
- 4:00 PM – 7:00 PM (PM peak)
- 7:00 PM – 7:00 AM (off-peak)

Note that the PSRC did not perform any additional or new model runs as part of this analysis.

Step 2: Trips captured

The second step in the methodology involved estimating the share of trips between zone pairs that would access the current highway network. An accessibility factor, defined as the percentage of trips assigned through any portion of the TIF network, was derived for each zone pair. An accessibility factor matrix was developed on the basis of a visual inspection of the current network and zone configuration. This factor allowed for an estimate of the number of trips captured by the network before implementation of a user fee.

Figure 9. Map of Transportation Improvement Fee Network

Step 3: Trip reduction due to fee

This step involved estimating the proportion of network trips that would be diverted away from the network after implementation of a user fee. This trip reduction factor served as a proxy for non-equilibrium trips deflected under the price conditions described in Chapter 3. These factors were developed on the basis of empirical evidence from similar user fee schemes in cities worldwide, which suggest approximately 20 percent of trips would be diverted from the network.

Step 4: Trip fee

Step 4 of the methodology involved calculating revenues on the basis of the fee structure shown in Table 3. Motorists entering the TIF network would be charged a distance-based, time-of-day fee. The total time-of-day charge paid by the motorist would increase on the basis of the total number of zones traversed. Given the short timeframe for this study, no attempt was made to predict the dynamic effect of various price conditions on travel demand per empirical travel time coefficients. Moreover, no attempt was made to optimize the fee structure by zone segment. Rather, a simple zone fee structure was derived on the basis of the general value of the travel time assumptions. By using this fee structure, together with trip matrices and the distance between zones, it was also possible to compute a rough estimate of the average fee rate per mile charged to users by time period, as reflected in Table 3.

Step 5: Calculation of total system revenues

Step 5 involved calculating revenues by time of day, and then determining total daily and annual revenues. The fee was assumed to be in effect 300 days per year. For the remaining days (Sundays and holidays), the model assumed that each vehicle would be charged a flat fee of $1.00 for access to the system and that baseline travel volumes (prior to fee implementation) would be equal to 50 percent of weekday volumes.

Table 4 provides a preliminary estimate for weekday revenues by time-of-day, average weekday revenues, and total annual revenues.

Table 3. Fee Structure by Time of Day

Time Period	Time of Day Fee	Average cost per mile
AM Peak	**$ 2.00 per zone**	**$0.43**
Midday	**$ 1.00 per zone**	**$0.24**
PM Peak	**$ 2.00 per zone**	**$0.41**
Night	**$ 1.00 systemwide**	**$0.10**

Table 4. Daily and Annual Estimated System Revenues

Time Period (2006)	Revenue
AM Peak	**$ 1.4 million**
Midday	**$ 1.6 million**
PM Peak	**$ 1.7 million**
Evening	**$0.5 million**
Total Daily Revenue	**$5.1 million**
Total Annual Revenue	**$1.6 billion**

It is estimated that the TIF system would generate $5.1 million on an average weekday, with the highest share (33 percent) of daily revenue coming from the PM peak period. By annualizing weekday revenue and adding Sunday revenues (with a $1.00 base fee), we estimate total annual revenue (in current dollars) of $1.6 billion.

In order to assess the potential return on investment of a TIF program, the stream of future net benefits was discounted to today. Annual TIF revenues were escalated at a rate of 2.5 percent per year. Project costs were likewise escalated at a rate of 2.5 percent. Costs include the following:

- One-time system implementation costs
- Annual operating costs
- Asset depreciation costs incurred at seven-year intervals.

By using a discount rate of 4.0 percent, it was estimated that the net present value of the TIF program would be approximately $24 billion. Detailed explanations of the revenue modeling assumptions and calculations are shown in the appendix.

4.2 Future Direction

Note that this analysis is a broad first-order evaluation based on existing data and is not a substitute for dynamic travel demand modeling efforts calibrated to revealed preference surveys. The figures presented here are initial estimates, consistent with the strategic investigative nature of this study.

To undertake a full analysis of the potential revenue, a comprehensive approach should be undertaken that includes the following activities:

- Construction of a transport model suitable for detailed analysis
- Data collection to support development of such a model
- Surveys to establish local values of time
- Detailed assessment of trip diversion factors, including trip re-timing and mode shift
- Establishment of the future potential network improvements
- Evaluation of future year network conditions
- Development of a detailed sustainable transport fee structure addressing issues such as vehicle classification (e.g., commercial vehicles, high occupancy vehicles), discounts, and exemptions
- Assessment of secondary economic impacts
- Assessment of social cost changes
- Assessment of environmental costs
- Sensitivity testing around key assumptions.

The PSRC has recently invested in the development of improved methodologies for analyzing the impact of regional tolling projects on traffic and revenue forecasts. The PSRC updated its regional travel demand model for use in the Congestion Relief Analysis Phase 2. The updated model is designed to reflect changes when people travel in response to congestion and pricing. It also incorporates recent research on elasticity of demand to toll prices.

In addition to addressing time of travel, it also considers changes to travel patterns and travel modes. Regional changes in vehicle miles and vehicle hours of travel can be discerned. The next phase of a more comprehensive conceptual planning effort will involve a more detailed investigation of the behavioral impacts of a regional use fee program via the regional travel demand model. The addition of these updated features will enable the regional model to incorporate the aforementioned activities.

5. ADDRESSING PUGET SOUND REGIONAL TRANSPORTATION INVESTMENT NEEDS

The transportation system in the Puget Sound region is in crisis. Infrastructure owners and service providers face major expenditures for the preservation of an aging asset portfolio. In addition, critical locations in the existing network need to be expanded to relieve traffic congestion in what has become one of the nation's most congested regions. The needs for preservation and expansion across all modes of travel far outpace the demands of users and compete for limited financial resources. This chapter summarizes what it will take for the Puget Sound to close its transportation funding deficit and improve the transportation system.

5.1 Transportation Decision Making in the Puget Sound Region

Decision making for transportation in the Puget Sound region involves multiple stakeholders at the local, regional, and state levels. Locally, counties and cities are responsible for maintaining, operating, and expanding their own highway, street, transit, pedestrian, bicycle, and other transport networks. King County, Snohomish County, Pierce County, and the city of Everett provide local and some regionally oriented bus service. Sound Transit provides regional mass transportation (commuter rail, light rail, and express bus), while airports, seaports, and railroads provide other conduits for major movements of freight and people.

The Puget Sound Regional Council (PSRC) is responsible for establishing a strategic investment framework through the long-range transportation planning process. This multi-stakeholder relationship is summarized in Figure 10.

At the state level, WSDOT distributes resources for the maintenance, preservation, operation, and expansion of state-owned highway assets and various other transportation-related needs in the region, including grants to local owners and operators of transportation infrastructure and services. WSDOT also operates one of the nation's most extensive ferry systems.

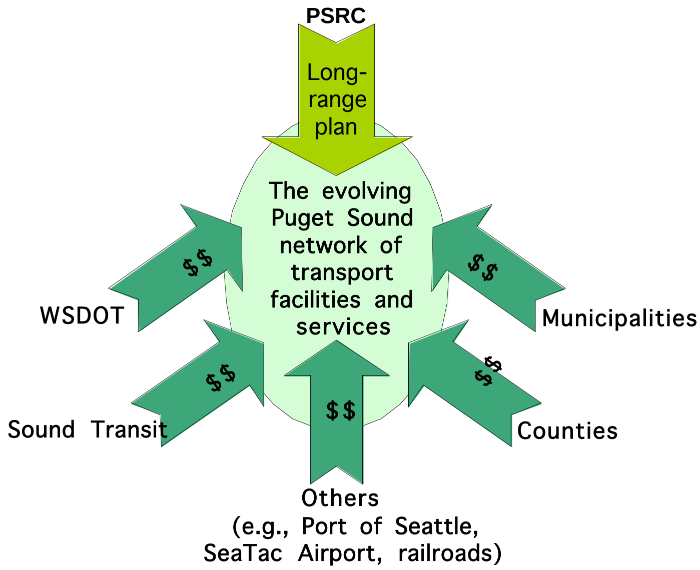

Figure 10. Puget Sound Regional Transportation Agencies

WSDOT, counties, and cities share responsibility for maintaining and operating the 15,000-mile network of highways, arterials, and local streets, as shown in Figure 11. Although the state owns a disproportionately small share of the lane-miles that make up the road network in the region, it operates all the interstates and approximately half of the principal arterial routes, while cities and counties oversee most of the minor arterials, collectors, and local roads.

5.2 Regional Investment Needs

Over the past decade, the Puget Sound region has made a substantial capital investment in developing commuter rail, light rail, and express bus service as alternatives to auto travel. Table 5 summarizes current mass transit services in the region. WSDOT's long-range plan, the Regional Transportation Investment District's Blueprint for Progress, Sound Transit's ST2, and the capital plans and needs estimates of King County, the city of Seattle, and other municipalities indicate a total statewide investment requirement over the next 25 years of approximately $80 billion.

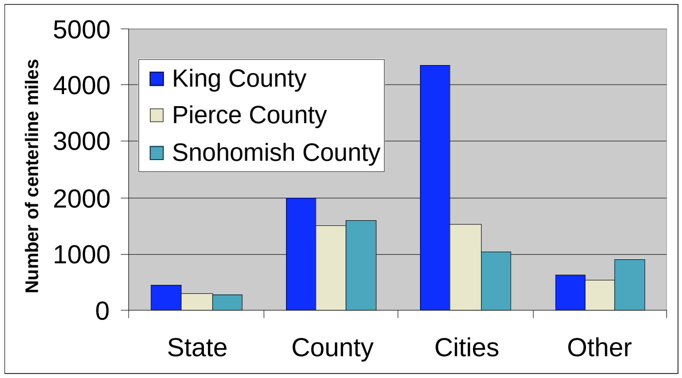

Figure 11. Ownership of Regional Roadway Network

Table 5. Summary of Regional Mass Transit Service Characteristics

Travel Mode	Route-miles served	Fleet size	Number of stations/terminals	Annual ridership (millions)
Bus	**4,000**	**2,000**	**200**	**124.1**
Light Rail	**30**	**3**	**6**	**0.8**
Commuter Rail	**200**	**10**	**9**	**1.0**
Vanpool	**n/a**	**1,750**	**n/a**	**3.0**
Paratransit	**n/a**	**600**	**n/a**	**2.3**
Ferry	**n/a**	**30**	**20**	**24.6**
Monorail	**2**	**8**	**2**	**0.8**
Total	**4,230**	**4,663**	**235**	**155.8**

Of the $80 billion need statewide, approximately half, or $40 billion, is targeted for the Puget Sound region. Of that, $30 billion ($2007) in investments has been identified over the next 25 years inside King County alone. The majority of the regional need is to provide for major investments in roadways (approximately $30 billion) and mass transportation (approximately $13 billion), with several billion dollars identified for other needs. This level of investment would address the following:

- **Surface Transportation**

  – Preservation, rehabilitation, and/or replacement of major roadway and bridge facilities (including projects such as the replacement of the SR 520 floating bridge and Alaskan Way Viaduct)

  – Preservation and maintenance of pavements, bridges, and other roadway-supporting assets such as signs, signals, striping, earthwork, drainage, maintenance facilities, support vehicles, and rest areas

  – Upgrade of existing intersections, interchanges, and arterials to accommodate more free-flowing traffic and adding lanes to existing routes such as I-405

  – Improvement and expansion of the regional HOV network

  – Upgrade and expansion of advanced technologies (intelligent transportation systems) to support roadway operations such as transportation management centers, advanced arterial signal coordination implementation, and weather information systems

  – Basic maintenance and operations of the entire network to ensure safe, efficient levels of service.

- **Mass Transit**

  – Maintenance upgrade, and regular replacement of the region's existing mass transit vehicles, guideways, stations, vessels, and terminals

  – Extension of rail infrastructure and configuration of bus priority lanes to reach new destinations, including major projects under consideration such as southward extensions of commuter rail to Lynnwood, eastward extensions of light rail to Redmond, and northward extensions of light rail to Everett

- Expansion of vehicle and vessel fleets

- Upgrade of technology to improve convenience, safety, and security of riders, including implementation of a regionally integrated farecard (One Regional Card for All, or "ORCA")

- Expansion of capacity at park-and-ride and other multi-modal transfer facilities.

* **Other Modes**

  - Maintenance, upgrade, and expansion of pedestrian facilities, including sidewalks and trails

  - Investment in bicycle facilities such as dedicated bikeways and trails

  - Provision of upgrades to facilities and services that will support travel to and from Vancouver when that city hosts the 2010 Winter Olympic Games

  - Support for the development of telecommuting infrastructure through, for example, publicly provided wide-area Wi-Fi

  - Support for local emergency responders and law enforcement where relevant to transportation.

5.3 Regional Investment Principles

Extensive consensus building efforts will be needed to establish a solid framework for prioritizing and programming capital needs funded through TIF program revenues. Some principles to consider for revenue expenditure include the following:

* Maintenance and preservation of the highway network on which user fees are charged should be one of the highest priorities. The revenue estimates presented in this report account for the capital and operations costs of maintaining the fee charging system but do not reflect the other, basic needs of the infrastructure, including such investment areas as resurfacing, striping, rehabilitation,

technology maintenance and upgrades, and safety. Users paying for a service will demand high quality of service, and the credibility of the user-pay system will be enhanced by appropriate investments in a quality network of charged highway facilities.

- Many of the trips deflected from the network after implementation of the user fee will utilize alternative modes of travel, including local and express buses, light and regional rail, and non-motorized transport (e.g., walking and biking). Consequently, regional mass transit and non-motorized facilities will require additional investments. These additional investments should focus on maintaining the comfort and convenience of transit services while expanding the capacity and extent of transit networks to reach new riders.

- Other deflected trips will utilize alternative auto travel routes. Utilization of the arterial network will increase, leading to additional investment requirements for the maintenance and operation of secondary facilities. Maintaining the local, collector, and arterial networks is essential. In addition, updating operations of those networks will become priorities for highly traveled arterial corridors in a post-fee environment. Regularly updated signal timing schemes, for instance, will play an important role in ensuring the efficient utilization of the non-highway network.

- Other priorities that maintain the integrity and improve the efficiency of the regional transportation system can also be addressed by investing the revenues generated by system users.

These principles should be considered, along with other regional priorities, to develop a credible and systematic investment plan.

6. RECOMMENDED WAY FORWARD

Internationally, several cities have pursued transportation management strategies similar to the one outlined in this report. Although a number of North American cities are exploring similar options to provide congestion relief and enhanced revenues through user fees, none has implemented a regionally scaled system. Prior to implementation of any system, however, Puget Sound's regional leaders must study alternative user fee program designs in detail, refine cost and revenue estimates, and agree to a regional governance structure and revenue distribution strategy. Overarching these steps is the need for a communication plan that explains the complete package of user fee-based travel in order to increase support from the public, regional agencies, and other stakeholder organizations.

6.1 Detailed Study of User Fee Programs and Governance

The fee scheme developed for this study is emblematic of various system designs that could be deployed in the Puget Sound region. Although relatively detailed assumptions were made, the purpose of these assumptions was to support estimation of costs and revenues, rather than to suggest a particular user fee configuration. Consequently, future efforts to develop a user fee scheme must begin with a more detailed study for Puget Sound. A more detailed study would accomplish the following:

- Examine conditions in the Puget Sound region, including existing temporal and spatial congestion profiles, existing network configuration, future growth projections, and future network expansion plans

- Examine the suitability of various corridors and facilities for inclusion in or exclusion from the user fee scheme based on the geometric configuration of the infrastructure; proximity to other portions of the network under consideration; and existing traffic flows, land uses, and projected growth rates of population, employment, and traffic

- Conduct focused stated-preference surveys to better capture price points and user behavior responses to pricing

- Model the effects of various user fee schemes on traffic flows to refine the fees to be charged and to ensure the fee rates can appropriately affect traffic levels in localized corridors and network segments

- Estimate the impacts of travel pattern changes on the greater network, including mode shifts, travel time shifts, and route changes

- Outline the specific components of the fee charging scheme needed for implementation, and refine the cost estimates presented here

- On the basis of modeling results and cost findings, design and refine a complete system, including fee rates by location, distance, and time of day

- Identify and select technologies to be used and plan the procurement and installation methods for the system

- Based on the system design, refine the revenue estimates presented here.

In addition to studying the technical elements of the system as outlined above, the region must explore the regional governance framework for implementing and operating the user fee program. Several proposals are currently being explored, and TIF governance should also be considered. Because the user fee would be a regional program, spanning municipalities and counties, it would require regional cooperation from its inception. In particular, the regional governance plan should provide mechanisms by which a regional authority could implement the fee program; manage the scheme by updating the technologies, fee structures, and network coverage over time; and distribute revenues generated by the system to various transportation needs within the region.

A major lesson learned from international experience is that the TIF program must be transparent to the public. The collection and allocation of funds requires an annual third-party audit to show the efficiency and effects of the user fees. The fund, once established, would need to be "ring fenced" or dedicated only for transport, with maintenance and upkeep of all infrastructure a priority. Improvement projects would need to be individually approved on the basis of an objective measure, such as a benefit-cost criterion. Likewise, the governing body would need to be held responsible for managing the fund in accordance with the guidelines for transparency and objectivity in allocation of its projects. Lastly, a project audit or asset management plan would need to be established in order to ensure that both old and new projects delivered the benefits promised. Funding transparency, dedication, objectivity, and asset management would be key pillars to support the implementation of a regional governance organization.

6.2 Develop a Regional Transportation Investment Plan

Regardless of the particular user fee scheme and governance plan chosen, net revenues would be substantial. Under the system design assumptions presented in this study, for example, a mid-range estimate of annual net revenues is roughly $1.6 billion, with a 20-year net total revenue of over $24 billion (NPV). However the region decides to manage the scheme, the use of revenues should be guided by principles that the region collectively determines before implementation.

Chapter 5 presented a summary of the types of projects for which revenues could be made available, given existing needs identified by Puget Sound regional stakeholders. These needs include investment in the preservation and expansion of roadway infrastructure, transit services, non-motorized modes, technology, emergency management, and the environment. The revenue generated by a user fee could cover a large portion of the region's transportation investment deficit.

Appendix A: Worldwide experience with road pricing mechanisms

Introduction

This appendix provides a description of road pricing mechanisms by addressing issues such as what they are, how they work, what they aim to do, any advantages or disadvantages.

Current experience with road pricing mechanisms

Practical experience with road pricing has been increasing worldwide. Recent developments have come a long way (both in numbers and technical efficiency) from the leading Singaporean experience with a pricing scheme in the 1970s to address traffic congestion[1]. The crucial meaning in all of these road-pricing initiatives relates to the degree of success with which the theoretical advantages of pricing are converted into practical and politically acceptable policies. Some of the basic principles governing the choices related to the road pricing mechanisms include the following:

- the concept of marginal social cost pricing (theory and measurement issues)
- a road pricing scheme should be based on sound economic theory, but needs to be technically, financially and politically practical
- an understanding of the role and significance of congestion costs
- the consideration of other external costs
- traffic considerations (e.g. commercial traffic is expected to respond more 'rationally' to road pricing than traffic associated with personal travel)
- importance of a clear policy of adopting and using these principles
- how to make these principles work in practice (it is important that people understand how the pricing works. For example, people will only act in a certain way if they have a clear understanding of the need and consequences)
    - a good example of focusing 'too much' on making a scheme theoretically appealing and 'too little' on making it practical is the Dutch 'kilometerheffing' project, which had as an aim to change current vehicle taxation to a full road pricing taxation system in the Netherlands. It was planned to charge per kilometre driven on any road, with three road types differentiated, plus three times of day (nine different tariffs). It appears that its complexity has been one of the key factors in its lack of success
    - in contrast, the Singapore ALS/ERP experience seems to have worked better. Charge rates are clearly indicated and the scheme is simple and easy to understand. Users know quickly how to plan and decide about their trips

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[1] The Area Licensing Scheme or ALS later converted into an Electronic Road Pricing or ERP.

    - similar simplicity appears to have helped the application of the London scheme. A simple pricing rule has been used for congested and uncongested periods.
- the chances of a road pricing scheme being successful (better accepted) are increased the simpler, more transparent and easily understood it is by the user
    - not too many different tariffs (keep it simple, base it on a simple message, e.g. simple per kilometre charge, peak versus non-peak period charge, driving empty charge, etc)
    - user acceptance of the need for pricing
    - not excessive variability of tariffs over time
    - predictability of tariffs over prescribed time horizons
    - consistency of tariffs over different road types or areas of the network.

Road pricing mechanisms used in urban areas

The three most common objectives driving the consideration and application of road pricing schemes in urban areas relate to the need for (i) congestion reduction, (ii) minimising the environmental impacts of transport, and (iii) revenue raising by governments. A fourth objective could be to use road-pricing mechanisms to differentiate between vehicle types (and road types) to give priority to 'high value' modes such as freight and public transport vehicles.

These objectives are either pursued independently or increasingly in combination. There are a number of approaches that can be used to characterise the pricing mechanisms employed to achieve these objectives. Small and Gomez-Ibanez (1997) divide road pricing mechanisms/schemes into four broad categories as follows[2]:

- congestion pricing applied to a city centre (notable examples are Singapore's Area License Scheme and Hong Kong's Electronic Road Pricing Trial)
- city centre toll-rings designed primarily to raise revenue (notable examples are the Scandinavian toll rings of Bergen, Oslo and Trondheim in Norway and Stockholm in Sweden)
- congestion pricing of a single facility (notable examples are Autoroute A1 in Northern France, California's Private Toll Lanes and the I-15 Express Lanes in San Diego)
- comprehensive area-wide congestion pricing (notable examples are the Netherlands' Randstad Region scheme and the London CC scheme).

Urban road pricing provides an efficient mechanism for charging for the use of roads over a certain area and/or during a particular time period. Depending on the local conditions and the purpose of the respective road pricing, different systems of charging can be applied. From this perspective, road-pricing schemes can be categorised into two broad forms using trip length and trip duration as key attributes in the user's decisions to travel. These two forms can be described as follows:

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[2] Some of these schemes and their characteristics are described in more detail in Section 4.

- Travel dependent area pricing which is based on the amount of kilometres driven within a certain perimeter/cordoned area (e.g. the Switzerland scheme), or on a network of interdependent motorways (e.g. schemes used in France, Spain, Italy, Portugal and Germany or CityLink in Melbourne), or based on a zone principle (similar to the zones in a public transport fare collection system). In this form, trips can be charged according to the time of the day they are made, road category used, peak traffic lanes, and vehicle category.
- Time dependent area pricing that requires a driving permit/licence to travel within a certain perimeter for a limited time period (Germany before Toll Collect project, Benelux, Denmark).

However, a finer specification of pricing mechanisms fitting the two broad principles of travel demand decisions (i.e. trip length and trip duration) is likely to be required in order to aid the practicality and applicability of the pricing regime. These are discussed in more detail below and are based on the notion of ***cordon pricing***, where each trip in and/or out the priced area is charged in distinct step charges rather than by increments (e.g. congestion pricing flat fee in London or pricing in peak hours such as the Stockholm ERP trial); and the notion of ***distance or zonal related pricing***, where vehicles are charged in increments according to the travelled distance within a defined area or to zones which are crossed during the trip. In addition, there can be ***pricing for the use of specific parts of infrastructure*** such as freeways/highways, tunnels, bridges etc. and ***value pricing***, where charging is applied for the use of dedicated lanes (e.g. HOT (high occupancy toll) lanes in the USA).

A more recent account of basic pricing mechanisms/schemes that can potentially be used for urban road pricing is presented in Europe's Progress Project (2004) or in the Auckland Road Pricing Evaluation Study (2006). The main options described in this report include the following:

Area licensing schemes

These types of schemes apply to trips made within a defined area during a defined time period. Users who wish to use (or keep) their vehicles within a defined area during a defined time period need to purchase and display a special permit, or to register the vehicle registration number in a computer database (e.g. the London congestion charging scheme). A variant of this scheme represents the case of requiring a permit for users (vehicles) who wish to enter a defined area (the restricted zone). In this case, users are charged when entering a defined area at designated entry points on a defined boundary (e.g. Singapore's Area Licensing Scheme that operated from 1975 until 1998). Area licensing and entry permit schemes are set up and operate by applying charges to either moving vehicles or to moving and parked vehicles.

A key advantage for these types of pricing mechanisms is that for a small, simple scheme it can be relatively easy for the public to understand and relatively straightforward to implement. However, a significant disadvantage is that charges are applied on a daily basis for access to the defined area (a relatively blunt instrument), rather than on a per trip basis. Trip making decisions are therefore correspondingly taken on a daily basis, and there is no incentive to restrict the number of daily trips made once the daily licence has been purchased. These schemes are also not very flexible. There are practical limits on the number of combinations of licence variants (e.g. charging zones, time periods, vehicle types) that could be accommodated within a scheme, before the range of licence types required becomes complicated and confusing to the user.

Cordon charging schemes

Cordon type pricing mechanisms are perhaps the most commonly proposed form of electronic road pricing (e.g. Singapore ERP scheme). These involve setting up a cordon of road pricing points around a defined area of a city. Road users are then charged (usually electronically) each time they cross the cordon. A key improvement of cordon pricing in comparison with licensing and permit schemes mentioned above, is that each individual trip made into the defined area during the time of operation is subject to a road user charge. Each trip is therefore the subject of a choice decision influenced by the level of the applied charge. Pricing of individual trips can also be relatively sophisticated with variations by time-of-day and a range of vehicle types.

Simple cordon charging schemes are, however, likely to have boundary effects. These may include increased parking just outside the boundary, local difficulties related to trip origins or destinations located just inside or outside the cordon, and trip diversion on to roads outside the cordon.

Multi-cordon and zone-based charging schemes

These types of pricing mechanisms are conceptually similar to simple cordon charging, as road users are charged each time they cross defined boundaries. Multi-cordon charging schemes typically have two or more concentric cordons, while zone-based schemes levy charges for travelling across defined zone boundaries that may intercept orbital movements as well as radial ones. (e.g. Trondheim expansion scheme)

Use of multiple cordons or zone-based charges can give a finer level of influence over travel patterns since the charging points can more closely reflect the problem traffic movements that the scheme is seeking to address. Boundary problems can also be reduced if lower charges are levied at more points, rather than concentrating the road user charge at a single cordon. However, multi-cordon and zone-based charging schemes are more expensive to implement and more complex for the public to understand than simple cordon charging.

Distance-based charging schemes

Charges under these schemes are applied directly on the basis of distance travelled. Such schemes can be used on toll roads (where distance travelled between toll plazas is simple to calculate) but have not yet been implemented in urban areas. A distance-based charging scheme was proposed for heavy goods vehicles in the UK from 2007-08 (an initiative that is now diverted into a wider process for a more comprehensive road pricing regime design for UK cities/regions). Another notable example is the Swiss heavy vehicle, distance-based, charging system (LSVA).

Distance–based charging is attractive in that it charges directly for travel in the problem areas. It is therefore the logical end-point in a process of creating denser and denser networks of charging zones, and correspondingly should theoretically be even better at influencing demand than multi-cordon or zone-based charging schemes. However, the technology required is more complex and costly to implement.

Distance–based charging is even more efficient than cordon charging because it is specifically targeted to the demand/use of the road (distance travelled) rather than just for access to a part of the network such as a CBD. It is well suited to urban travel where only trips actually embarked upon are charged for. Congestion would therefore be reduced, depending on what trip choices and lengths are charged.

Access control schemes

Access control schemes are also known as 'Electronic Gateways' in Italy where they are currently found. These schemes differ from other charging schemes in that the local businesses and residents (organic traffic) are allowed free access, but charges are applied to all other traffic (non-organic traffic) wanting to enter the designated areas. Charges under these schemes are applied directly on the basis of daily access into the designated areas of the urban centre. In larger cities, your access is only free into your designated area whilst access into other areas of the city are denied or charged. In Florence and Bologna, for example, there are several areas designated and each has its own entry and exit routes without crossing into adjacent areas. Vehicles not organic to the area are charged an entry fee on a daily basis for up to a maximum of a three-day limit. These charges and fines generate revenues from non-organic vehicles and violators respectively. The only exceptions are free day passes for authorized customers of doctors, hospitals and specified businesses such as automotive diagnostic centres. These agents can register their clients on an Internet portal into the system's administrative database. Audits are performed by the local Police for any abuse of the 'privilege' to be a designated agent and any repeat instances of abuse by an agent could result in the loss of the privileged agent's status.

Access control schemes are currently deployed in eight cities in Italy. Most notable are Rome, Florence, Bologna and Sienna. The system is a combine DSRC electronic read of wind screen mounted transponders and electronic image capture of number plates. The DSRC transponder is identical to the DSRC transponder used on the Italian Autostrade with a special access coding for the driver's home city area. The scheme's technology provides added value for the user to have only one transponder and one billing account to pay motorway tolls, while also providing his electronic gateway access into his own city centre or payment of fees into other city centres.

Access control schemes are attractive in providing more user acceptance in the local urban centre. Unlike the blunt area schemes such as London, these access control schemes provide flexibility for occasional users who are forced into the designated area for appointments beyond their control. The electronic gateway scheme also provides, in its design, the necessary by-passes to allow non-organic vehicles to circumnavigate the designated access areas. In effectiveness, the Florence scheme and the Bologna scheme provide a suppression of 20% and 24% respectively. This compares favourably with London's 18% suppression of trips.

Unit Charge

Pricing of roads is a product of two key elements that make up the value charged to the user. These are the amount of the service demanded/consumed (e.g. duration of stay, distance travelled, number of zones, etc.) and the price (unit charge or unit fee) for each unit of this consumption. The value of the charge (user cost) is a product of the quantity (consumption) and the price (unit fee). Both of these are important and may depend on different characteristics/ features of a road pricing scheme. Most of the discussion above has focussed on the former. Unit charges add another dimension to the development of a road pricing policy. They are often dependent on the different types of vehicles and their characteristics such as number of axles, gross vehicle mass, presence of trailers, emission values, number of passengers, etc. Thus the unit charge structure becomes a very important policy parameter in designing a road pricing scheme as it influences user behaviour and trip choice.

Road pricing mechanisms - some implications

Road pricing solutions are likely to become more acceptable to users and communities as the benefits and efficiencies of real-world pricing applications are better understood. However, public acceptance will continue to depend on a number of key factors including:

- a clear need for their consideration (e.g. severe congestion problems)
- a clear understanding of their effectiveness as proposed solutions over alternative approaches (e.g. paying for the *true* cost of each trip rather than via non-transparent lumpy payments such as registration, insurance and petrol taxes)
- transparent and uncomplicated solutions which are easily understood and not perceived as additional charges by the public (i.e. pricing not perceived as primarily an additional revenue source)
- perceived equity of application
- *favourable* economic climate (e.g. no major economic shocks like high unemployment, high petrol prices and the like)[3].

[3] This is often the case as no matter how elegant pricing mechanisms can be, experience in many countries shows that political/public resistance has always been a major impediment to implementation. For example, attempting the introduction of road pricing when economic conditions are not favorable or fuel prices are high is likely to increase public resistance, as perceptions of increased transport costs also increase opposition to

The table below presents an example of a summary account of travel impacts and their intensity as a result of introducing road pricing to raise funds or to manage traffic congestion.

A summary of travel impacts due to pricing/tolling

Travel impact	Toll road funding	Congestion pricing	Comments
Reduces total traffic	1	2	Impacts on total travel depend on the price structure and the quality of alternatives.
Reduces peak period traffic	2	3	Fixed tolls cause moderate peak reductions.
Shifts peak traffic to off-peak periods	0	3	Fixed tolls provide no incentive to shift.
Shifts car travel to alternative modes	2	3	Congestion pricing supports use of travel alternatives, toll roads do not.
Improves access, reduces the need for travel	-1	0	Additional roadway capacity can encourage low-density urban expansion.
Increased ride sharing	2	3	Encourages ridesharing and may fund rideshare programs.
Increased public transport	2	3	Encourages transit use and may fund transit improvements.
Increased cycling	1	2	Encourages cycling and may fund cycling improvements.
Increased walking	1	2	Encourages walking and may fund pedestrian improvements.
Increased telework	1	2	Encourages telework.
Reduced freight traffic	1	1	May have some effect.

Note: Rating from 3 (very beneficial) to –3 (very harmful). A 0 indicates no impact or mixed impacts

Source: TDM Encyclopedia - http://www.vtpi.org/tdm/tdm35.htm

Road pricing benefits

Road pricing impacts vary depending on factors including the type of pricing, how it is structured, and the transportation and geographic conditions in which it is implemented. For example, a fixed road toll may do little to reduce congestion if alternative routes and modes are poor. However, it may provide significant congestion reductions if transportation alternatives (such as increased vehicle occupancy, public transport and telecommuting) are relatively attractive, and so a modest charge will cause a relatively large mode shift. In some situations, pricing will shift traffic and congestion problems to other routes or areas. Actual impacts will vary depending on circumstances. For example, in some situations, pricing applications will have greater congestion reduction impacts

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additional charges. However, high petrol prices and as a result pressure on governments not to increase fuel taxes may lead to a search for alternatives such as use of more direct pricing mechanisms.

than others, which means that these differences should be considered when evaluating and selecting pricing options.

The examples from world-wide experience reveal the that in terms of scale the prime benefits of improved travel times and reliability accrue to road-based public transport users and continuing motorists, whilst second tier benefits are reductions in accidents and pollution and overall improved ambience in urban streets.

BANK PAYMENTS IN TRANSPORTATION

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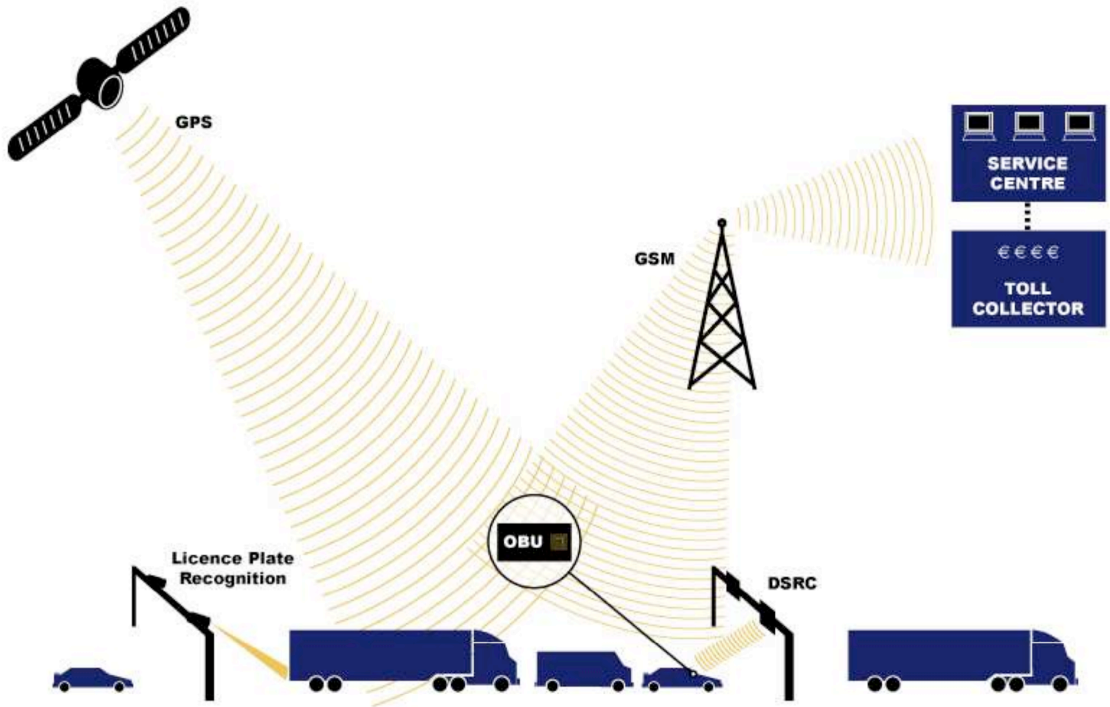

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1.0 Introduction and Purpose

Today national, federal, state and local transportation agencies are concerned with increased needs for road infrastructure and congestion. Financing the construction and maintenance of road networks is an ongoing problem with traditional funding sources no longer adequate. The opportunities to reduce operational costs, ability to change user behavior and increase revenue are many. This paper will discuss the benefits and challenges of using an open system payment mechanism that will effectively increase customer acceptance, drive revenue, produce new partnerships and reduce the maintenance and operational costs for transportation.

The proprietary nature of the collection and payment technology inherently bring with it additional costs and operational inefficiencies in the entire payment ecosystem. To date, transportation authorities have not had the ability to utilize bank sponsored open payment facilities (such as MasterCard and Visa) that are afforded to consumers and merchants world wide. But now is the time for a convergence of bank sponsored cards and transport payments. The card associations are now aggressively targeting the small payments market to convert the $1.4T in annual small cash transactions (<$25) to card transactions and transportation is a target market for them.

The opportunity now exists for transportation authorities to partner with the banking industry to transition from an issuer to payment acceptor and concentrate on their core competencies of operating and maintaining road infrastructure.

2.0 Trends in Electronic Payments

The evolution of electronic payments continues to take place at great speed with an ever-changing landscape of business models and technology. Electronic payments are changing how we interact with the world as new services demand new forms of payment. Convenience and flexibility is the key to success in today's world that allow people to buy and sell anywhere, anytime and in any way using a growing range of devices for a growing range of product and services. Electronic payment industry is improving their functionality and usability providing users and merchants with time saving solutions and increased benefits. The convergence of various types and modes of payment systems in the marketplace are fostering new business relationships. Consumer and merchant demands and the economies of scale are making the electronic payment industry re-think their business models and creating an atmosphere for partnership amongst the many desperate payment systems worldwide.

The bank electronic payment industry has seen enormous growth has become ubiquitous as illustrated in Figure 1.

Figure 1

Visa	MasterCard
1.3 billion cards in circulation	749 million cards in circulation
$4 trillion volume	$1.74 trillion volume
24 million merchants	24 million merchants
160 countries	19.1 billion transactions
20,000 member financial institutions	25,000 member financial institutions

Growth is expected at 15% annually for the next 10 years doubling transaction volumes by 2010.

There are two accepted types of electronic payment card systems. An open loop system that has a broad international merchant base accepting cards from multiple financial institution card issuers and a world wide processing infrastructure as in Visa, MasterCard and Amex. A closed loop system that is limited to a single merchant or a small group of merchants and single or small group of non-financial card issuers generally within a limited geographic region. The closed loop system is self contained giving it the ability to create their own set of rules and standards. A closed system is primarily used by mass transit, road, bridge and tunnel agencies. Some of the most successful in the transportation industry are:

- *Octopus Card*—a contactless smart card launched in 1997 for use at Hong Kong mass transit with over 10 million cards issued and over 7 million transaction per day totaling over $6.5 M US in volume. This closed system includes over 100 retail merchants, parking and transit operators. Consumer acceptance has been widespread and 25% of the transactions occur for non transit purchases.

- *Oyster Card*—a contactless smart card for electronic ticketing mass transit for the Transport for London and National Rail services within the Greater London area. Launched in 2003 and as of January 2007 over 10 million people have used the card. There are no immediate plans to extend the Oyster card to the national railway network outside the Greater London area. A new contactless credit card combined with a London transport Oyster card, is to be launched by Barclays Bank. It will combine the standard technology for bank issued debit/credit card payments alongside that of the Oyster card to target small payments such as those incurred in on and off street parking.

- *E-ZPass*—implemented in northeastern United States and uses high frequency RFID transponders to pay tolls. It is accepted at over 60 highways, tunnels, bridges and bridges with over 9 million On Board Unit transponders issued. E-ZPass has made efforts to expand acceptance at merchants but to date has had limited success.

Financial institutions are beginning to realize the revenue potential/benefit that can be brought by these closed systems and are making radical changes to their rules/policies and infrastructure to gain a market share.

The use of technological advances in communications, cards, terminals and backend processing systems has revolutionized their approach to the market. Financial institutions are considering how these changes will impact their payment businesses, and determine how to build out alternative payment services as extensions of existing products in order to adapt to these existing closed loop markets.

Today one of the main thrust of the card associations and financial institutions is to capture one of the last payment domains -- small payments. The conversion of cash to card transactions is proving to be an enormous success. Cash transactions under $25 account for well over $1.4 trillion dollars and more consumers are using their cards for small payments. Tower Group says micro (under $5) and small payments (under $25) span several different markets across mobile, Internet and point-of-sale channels. Speed and costs are the driving factors for the consumers and merchants and transaction volumes for the card associations in the small payments segment. As a result new rules and regulations are being created to facilitate the small payment usage by the consumer and merchant communities.

As a result of merchant and consumer demand for speed and consumer through put at the register, the financial industry has adopted and is now implementing a contactless card solution for small payments that can be utilized in both an online or offline environment. Visa, MasterCard, Amex and Discover have made radical changes to their rules to accommodate the need for speed and a fee structure that makes sense for these transactions. Rule changes for transactions under $25 have been approved to allow for consumers to purchase goods and services. Some of the rule changes and highlights are listed below:

- Contactless card acceptance based on common specification using contactless interface ISO 14443B with Mastercard *PayPass*, Visa Contactless and Amex ExpressPay.
- No Signature required for transactions under $25
- No receipt required for transactions under $25
- Some merchant categories permit off-line transactions
- Additional new merchant categories that transact small payments
- Reduced fees for merchant
- Transaction looks very much like a traditional transaction
- Does not require mutual authentication (EMV requires this)
- Requires minimal infrastructure change by current card association acquirer or network

These cards have had a successful launch allowing for issuance of 38M cards to be used at 44,000 available locations. This technology is based on ISO/IEC 14443 and is supported by various card manufacturers, chip manufacturers, terminal venders and other closed loop payment systems worldwide.

3.0 Transportation – A Prime Market for the Bank Card Associations

Transportation covers a wide range of techniques to charge the public for transportation related costs by employing electronic systems of various kinds to identify vehicles traveling on particular roads based on pre-set pricing schemes on any single or combination of time, distance and location (TDL). Automatic number plate recognition (ANPR), Global Navigation Satellite System (GNSS), Global Positioning Systems (GPS), Tag and Beacon and Toll Gantries are the vehicle usage and detection technologies used by transportation authorities to assure the proper collection of fees. On and off street parking is also changing with greater use of the above technologies and "demand management" variable charging. With congestion charging and demand management, cities and municipalities are charging for the road and parking spaces based on the demand for those spaces, and not simply a fixed fee. Given the explosion of the number of vehicles on the road causing ever increasing congestion, demand management is being implemented by transportation authorities around the world to push drivers to make their journey at less congested times by the charging of a user fee. The potential of increasing electronic payment transactions in the industry is substantial. Examples of successful implementations and trial are:

- In Singapore where Road User Charging has been operating successfully since 1975 (with Electronic RUC introduced in 1999). The scheme reduced traffic in the area by around 28% and increased average speeds by up to 40%;
- In London, where the Central London Congestion Charging scheme has been successful by reducing traffic in the central London charging zone by up to 18% and congestion by up to 30%. A western extension to the existing charging zone is to be introduced in early 2007;
- In Stockholm where a six month trial of Road Pricing ended in July 2006 with a referendum on the potential implementation of a permanent scheme held in September 2006. Overall, 52% of residents of the Stockholm area voted in favour of a permanent Road Pricing scheme, though the level of support varied between city and suburban areas;
- Orange County, CA where 300,000 vehicles per day with 600,000 OBUs have been issued is a successful US implementation of road use charging.
- In San Francisco and Seattle, various experiments in road user charging and parking fees based on demand management.

Implementations and pilots in places like Bristol(UK), Manchester(UK) and Birmingham (UK), Germany, Switzerland and Austria are coming online and are a model for the future. Over half of the states in the US have or are planning toll roads and RUC to respond to what officials describe as shortfalls in transportation funding and to manage urban and road congestion. With the increase in political will being "pushed " by substantial short fall of transportation funding, crumbling infrastructure and ever increasing congestion, the financial needs of the transportation authorities are expanding the need for charging of road and parking. This market is seen by the bank card payment associations as the small payment "Killer Application" and is a prime market for transaction growth. In the US alone toll operator members of IBTTA generate more than $8 billion in annual revenues with growth rates exceeding all estimates. It has all the attributes that are in the small payment target market:

- Low value transactions
- Large number of users
- High transaction volumes

The transportation and financial industry is now implementing strategies for the use of new available technologies to capture these market opportunities. The old payment technologies of coins and cash are giving way to the new "digital cash" paradigm. This is being driven not only because of efficiency and efficacy of digital cash, but also due to the need for larger payments that exceed coin capabilities and the handling of variable rates over time periods. These two factors drive the need for greater use of easier, faster and more convenient payment mechanism than have been employed in the past.

The micro-payment opportunity and the acceptance of the contactless technologies allow for expanded business opportunities between open and closed payment systems where speed and costs are a factor. The transportation market is now seeing, what were once independent payment systems such as mass transit, toll road collection, parking and mobile phone coming together to better serve their respective goals. Transportation agencies see this as a way to off set the operational cost of issuing cards/tags and the overhead of managing the back office processes and concentrate on their core competencies. Retailers and financial institutions now have an opportunity to partner with toll collection operators so consumers can use a single hands free card to purchase snacks, parking and restaurants as well as payment of toll road, bridges, tunnel and mass transit.

4.0 Benefits for Transportation Authorities

4.1 Driving Customer Acceptance

Universal payment acceptance through bank card payment system can enhance the service offering of the toll collection agencies. Consumers demand the ability to pay anywhere, anytime and through multiple form factors including toll tags, fobs, and mobile phones. An open payment mechanism used by authorities allowing for the purchase of goods and services from a widest variety of merchants in both a hands free drive up or tag in hand mode will facilitate tag acceptance. Bank payment systems offer a consolidated bill and a single authoritative customer service source for all payment transactions providing additional enhancements to capture consumer acceptance. The apparent failure of E-ZPass and other toll collection accounting methods to extend its franchise much outside the toll market points to a critical limitation of closed-loop approaches that do not offer the wide choice to consumers and ease of acceptance by the merchant.

4.2 Co-Branding and Promotions

Enhancing the transportation authority's brand through partnerships and co-branding opportunities with merchants and financial institutions further enhances the toll collection marketing efforts. Co-branding provides a way for toll authorities to combine forces with national and local companies to enhance the marketing of new products and services while making consumers aware of automated tolling benefits. New merchant partnerships provide opportunities to reach out to consumers in the local region with special discounts, offers and other promotions to entice consumers to use the respective products. Of course the major card associations will actively promote their brand usage for toll payment and will be a powerful tool to enhance customer awareness and usage.

4.3 Integrated Solutions

Integrated travel data and the chaining of parking, rail and bus rides allows the transportation authority the ability to effect driver habits through variable pricing throughout the value chain. Little attentions has been paid to the interaction that needs to occur when implementing various means to redirect vehicle flows. The bank payment system can merge these requirements with their operating and business infrastructure of the financial payments industry. .

4.4 More Ways to Pay

The flexibility afforded consumers through an open electronic payment system is changing the paradigm from a push oriented model to a pull oriented model. No longer is the consumer needs driving new technologies. The new paradigm is technology is driving customer demands they previously did not know they have.

For example RUC payments can now be made via a mobile phone. The card associations and banks are actively working with mobile phone manufacturers and mobile carriers to facilitate these payments for on-street parking. The use of card based mobile payments is now being piloted at break neck speed. The bank card industry is currently implementing various mobile payments technologies. HSBC and Mastercard are performing over-the-air (OTA) provisioning of mobile phones allowing consumers to download their personal HSBC credit cards securely into mobile phones. Taking this one step further, the OBU can be personalized over-the-air with the account of by the vehicle owner's choice enrollment costs and increasing customer satisfaction. Currently the Transport of London is using Single Message Service (SMS) text messaging payment service for Central London congestion charging. This ultimately brings additional ways to the consumer to pay variable and time sensitive tolls such as congestion charging without building costly road infrastructure.

4.5 Operational Cost Savings

An effective and efficient collection mechanism for roads charging result in cost savings. A shift in back office operations to a banking payment processor would provide a reliable and tested source. An electronic transportation authority using an open payment system would provide savings in operating, maintaining and handling infrastructure and virtually eliminate individual account services. The efficiency of these operations is highly desirous because it would reduce collection costs, enhance audit and fiscal control and allow for a transition from OBU issuer to payment acceptor.

Bank/Financial Institution bears the cost of:

- Back Office Management
- Customer Statements
- Card/Tag issuance and Life Cycle
- Reports
- Data Retention
- Customer Service
- Security
- Extensive research and development expenditures in new technologies
- Relieve customer service operational costs

The delegation of non-core payment collection operations to a bank payment processor who specializing in the management of payment operation and Customer Relationship Management will impact costs and direct the agency's competencies to what they do best and make more efficient use of their capital, technology, labor and resources.

5.0 Comparison of Payment Architectures

The similarities of the toll and road user collection and bank payment systems augur well with the opportunity to form a partnership.

5.1 Account Based

In many ways the financial payment and road collection systems are similar. Both the US card associations and the road collection authorities primarily utilize an account based payment system. Cards issued by the card associations are linked directly to bank checking, savings or credit account. Banks also offer a pre paid based account for those who do not currently have or desire a relationship with a bank. These prepaid accounts can be anonymous. The road collection system accounts are linked to a central prepaid account and are debited periodically based on the back office account updating scheme.

5.2 OBU/Smart card

The road collection systems utilize various technologies for the communication between the vehicle tags or On Board Units (OBU) and the reader. The OBUs are primarily read-only and contain permanent identifier information that is encoded at the time a tag is issued to a user. Other available tags are capable of write-once-read-many (WORM), read-write functions and also permits new, updated information to be encoded each time the tag is interrogated and others can perform read-write capability and has an intelligent, on-board processor capable of performing calculations, executing simple programs, and carrying account balances. Tags can be either passive (no battery) or active (battery on board) depending on their capabilities. The bank card payment system utilizes three types of cards; mag stripe, contact and contactless. In the US the primary cards issued is magstripe and contactless smart cards. The US issued contactless smart card uses a wireless short range RFID technology (ISO 14443) and the card data is read-only and typically contain a permanent identifying information such as the cardholder's card number, expiration date, service code and other information required by the banking systems. In the international markets banks issue contact and contactless smart cards with read write and crypto capabilities. All bank issued cards are passive and do not require a battery.

5.3 Back Office

There are many similarities of the back office systems. Both provide general payment administration capabilities and support the electronic transfer of authenticated funds from the customer to the merchant/transportation operator. They both support an enrollment for new customers, issue card/tag, manage card/tag life cycle, process collections for post pay and prepay schemes, post transactions to a customer account. They also are capable of generating a bill, support a sophisticated customer service center (CSC) and use cryptographic techniques to ensure security.

There are many attributes of each system and they are compared in Figure 2 below:

Figure 2: High Level Comparison of ETC and Bank Payment System

	CURRENT COLLECTION SYSTEM	BANK PAYMENT SYSTEM
Enrollment	‣ Standardized process for enrollment	‣ Standardized process for enrollment
Payment Cycle	‣ Prepay ‣ Post Pay	‣ Pre Pay ‣ Post Pay ‣ Pay As You Go
Financial Account	‣ Account in central database ‣ On card but not generally implemented ‣ Offline payment processing	‣ Bank and prepaid account in central database ‣ On card but used in Europe and Asia ‣ Offline e-purse payment processing and specific account based merchant categories
Settlement	‣ 1 day	‣ 1-2 days
Regulations	‣ Reg E ‣ Reg Z ‣ Various Government Agencies	‣ Self Regulated
Communications	‣ Various forms of long range RFID	‣ Short Range ISO 14443 just implemented ‣ Open to new comms for target market
Dynamic Fee Calculation	‣ In account based system Fee calculations performed in back office	‣ Performed by third party financial processors
Card Management System	‣ Developing	‣ Mature and process driven
Customer Service Operations	‣ For toll tag holders for specific agency	‣ International customer service facilities
Standards	‣ Proprietary but follows industry best practices ‣ Incremental acceptance for interoperability	‣ Follows international standards ‣ Driver for new standards ‣ Strict oversight
Transaction Security	‣ Proprietary crypto and data storage	‣ Follows international standards for entire payment ecosystem
Activation Device (Tag/Card)	‣ Passive or Active ‣ Read only primary use ‣ Read-write	‣ Passive ‣ Read only primary use in US ‣ Read-Write

5.4 Transaction Processing

The transaction processing/authorization systems are similar in that they both can process transactions offline for batch transmission at pre-determined intervals for settlement and funds movement and distribute a hot list for bad cards to the local acceptance device or server. Both have billing systems and customer service staff with access to the needed transaction data to serve customer inquiries and needs. The diagrams below show a high level transaction processing flow for each as illustrated in Figures 3 and 4.

Figure 3: Conceptual Architecture Breakdown of Credit/Debit Transaction

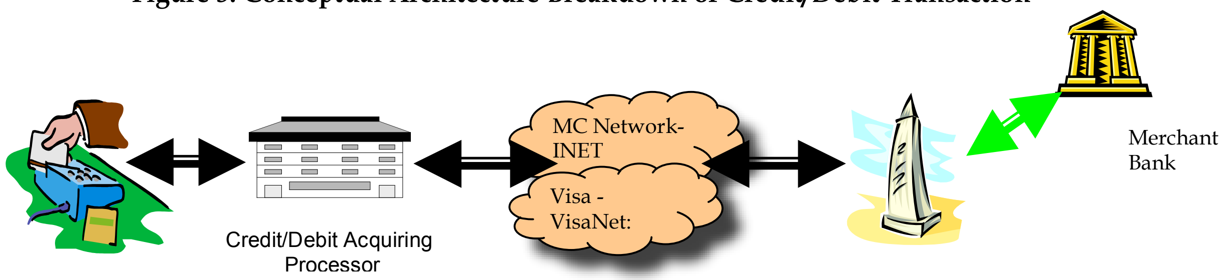
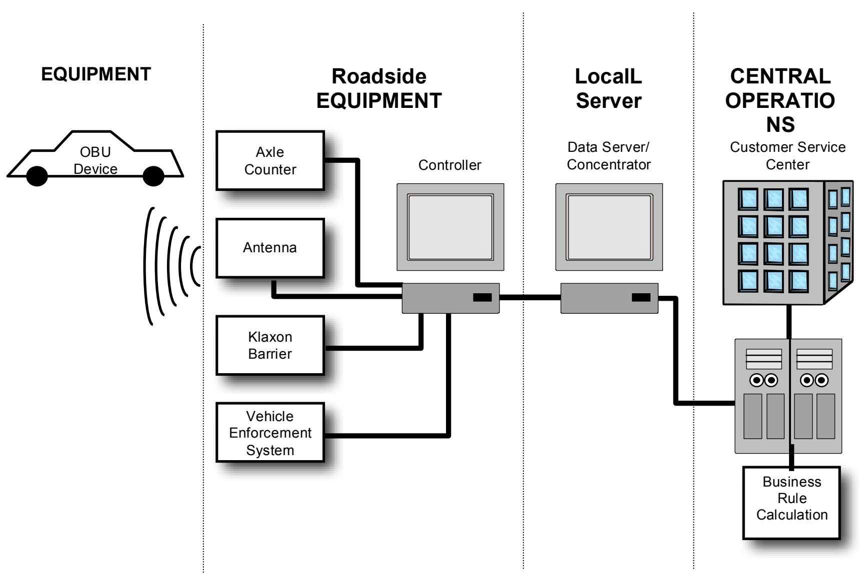


Figure 4: Conceptual Architecture Breakdown of ETC Transaction



For variable charging scenarios the payment processing can become more complex and there is a divergence in processing a transaction. In these instances a separate process to apply the business rules for fee calculation is required. The bank sponsored payment transaction processes a fixed amount.

6.0 RUC Components

There are three scenarios in which the bank sponsored payments can be applied to toll collection.

6.1 OBU/Antenna—Tag and Beacon

For fixed-toll limited-access roads, toll payment will function very much like the current bank sponsored system works today when a consumer with a Visa or MasterCard make a purchase at a merchant. As the vehicle approaches the toll location it will authorize a transaction for a fixed amount in an offline or online environment and is then processed and settled with the bank and merchant.

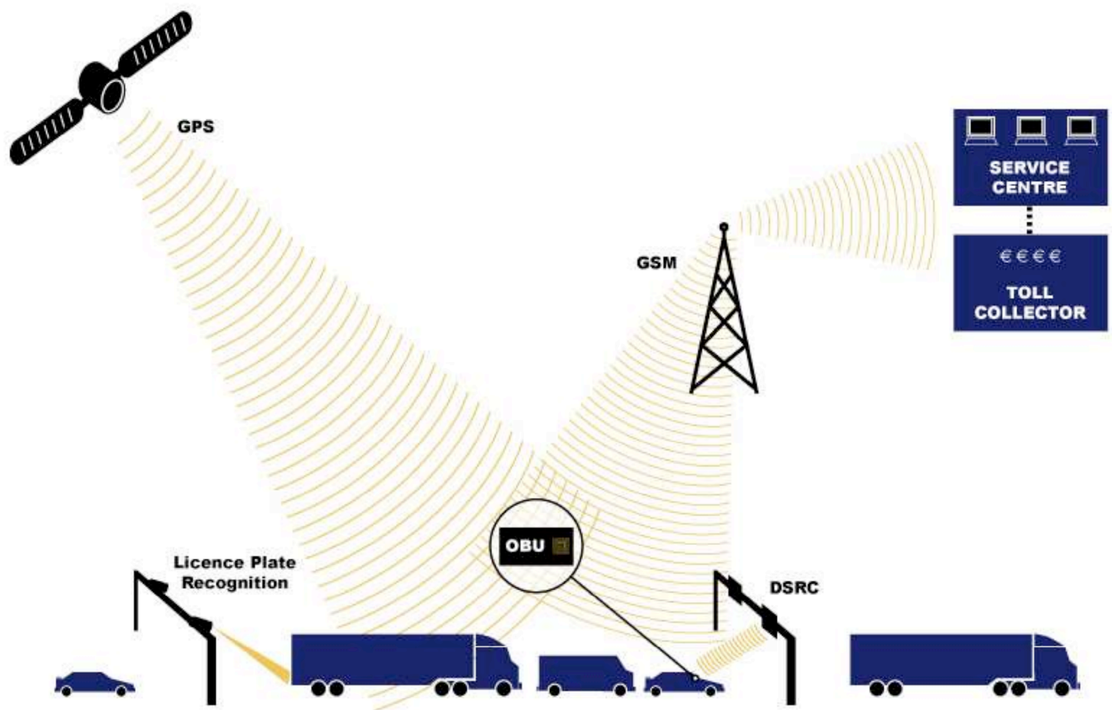
For distance/time based variable toll charging scenarios it becomes more complex. These transactions would need to be separated from the operation of the toll collection system for the application of the business rules for the generation of the fees. Whereas in a typical Visa/MasterCard retail purchase, for example, the price for an item is relatively fixed and constant from one customer to the next but in a distance based tolling scenario the fees paid by a vehicle can vary from one passenger to the next based on fees calculated by origin and destination.

6.2 Automatic Number Plate Recognition (ANPR)

Camera based systems with image processing to identify and read vehicle number plates and uses [optical character recognition] on images to read the [license plates] on vehicles. The key advantages are there is no OBU required and the ANPR has dual responsibilities of detection for charging and enforcement and can support DLT. The disadvantages are the need for roadside infrastructure and not 100% accurate. In either case, the need to pre or post pay requires kiosks, cell phone, internet or an agent network to receive and process payments. Bank debit cards can be used to pre or post pay for an ANPR transaction. In London, the majority, over 30% of thetransactions are done through a traditional call center where an operator receives the information directly from the driver. Data indicates, however, that kiosks, internet and SMS transactions are now over 50%.

6.3 Global Navigation Satellite System (GNSS)

In vehicle equipment uses satellite signals to calculate position and vector of travel information then is matched to map information to identify the route traveled. Key advantages are no roadside equipment for each payment point as there is with a tag and beacon approach. The OBU is more expensive, but typically is equipped with a cellular modem for digital communications of transactions. GNSS better supports card payments due to the transaction processing time. In effect, the OBU is a retail terminal to interface with the controlling transportation authority. The disadvantages are expense of the individual OBUs and the need for a geographical information system (GIS) to record the boundaries of the road, facility or the parking space to be charged.



7.0 Technology Integration Challenges

Currently companies at all levels of the ETC market (i.e. component, back office and subsystems) are working to achieve technical compatibility between toll collection systems. Their efforts have paved the way for the bank payment system to integrate their general purpose payment system. Although the toll collection and bank payment systems are similar in many respects there are various technical issues that need to be addressed for integrating the systems. The most challenging technical issues concern the On Board Unit (OBU) and the payment pre processing requirements for distance/time based variable charging.

7.1 On Board Unit (OBU)

For the integration of a bank payment system, the OBU must have the ability to store the proper banking information securely and allow the reader to access this data. There are numerous options for the OBU to handle bank and vehicle data. The bank card data can be imbedded into OBU or the OBU can be a relay device into which a bank "smart card" is inserted (contact smart card) or tapped (contactless smart card) for the reader to query.

- OBUs designed for bank payments with imbedded data specifications
- OBUs with a card slot for accepting contacted smart cards (ISO7816) or acceptance of proximity contactless smart cards (ISO14443)

The technology is rapidly advancing in support of the increasing needs of the toll industry. The government of Singapore for example has implemented a system that can communicate with cars and charge their smart cards. An OBU device is affixed on the lower front windscreen within sight of the driver, in which a stored-value card, the Cash Card ,is inserted. In Singapore the OBU units were supplied by Siemans Plessey and EFKON AG of Germany offers smart card accepting OBUs.

7.2 Security

Security is of paramount importance for the bank card industry. The commercial and technical integration of the two industries can only be achieved when the highest level of security is attained. The ability of the technology to operate wirelessly at long ranges raises the issues of malicious fraud i.e. "hackers" changing account numbers or changing valuations. Proprietary channel encryption and device authentication techniques are evolving but there are no global standards that currently exist for this technology that meet bank payment standards. For the bank payments industry to adopt the various wireless technologies, the communications channel needs to be secure and a standard security approach for hardware components and data storage throughout the system tiers must be defined, agreed and certified. There is a new focus on introducing and evaluating emerging secure wireless technologies that enhance the prospects of open electronic payment usage in the toll collection industry. The current aggressive approach by the bank card industry to capture the small payments market augurs well for building a partnership and finding ways to overcome the financial industry's security concerns.

7.3 Privacy

User privacy issues are a frequently voiced concern. The consumer concerns over privacy has the industry concerned that there is a high level of rejection rate by the consumer based the fear of government's use of any data accumulated and the security of the personal data from theft. The data security standards and the use of the personal data are highly regulated in the banking and credit card industry and there exists a trusted relationship with the consumer. This goes a long way in mitigating these fears. Any new relationship must have a privacy and security policy that clearly defines what personal information is to be collected, how the information will be used, who can access the information, how the information will be protected, and how the individual will control its use.

8.0 Conclusion

Customer and market demands are driving the bank card payment industry into the wireless payment arena. A number of new contactless payment applications and technologies being implemented world wide are having enormous success. Increased convenience for the consumer and lower costs for the merchants has resulted in one of the most successful new product launches for the bank card industry. The Transportation authorities can benefit from an open bank card payment system by driving greater customer acceptance and operational cost savings. With large volumes, low value transactions and large number of users toll collection agencies fit the criteria of the bank payment industry and augur well for a relationship with the bank payment industry.

Migrating to an open bank payment system is a significant undertaking. The toll collection agencies need to consider the changes required in their systems and processes and how it will impact their user base and current operations. Understanding the business and financial benefits of conversion is only the start. The technical characteristics of the wireless technology, product availability, integration, risks and security and required investment are only some of the key considerations to take into consideration.

New long range wireless technologies and smart card accepting on board units are emerging as a secure means for payment. Cooperation of all the stakeholders needs to be organized and it will require collaboration and agreement on business, security, technical and consumer issues. Certainly this is the time for the integration of the transportation industry with the bank card payment organizations. This will range from parking, tolling and new road user charging applications in the near and present future.

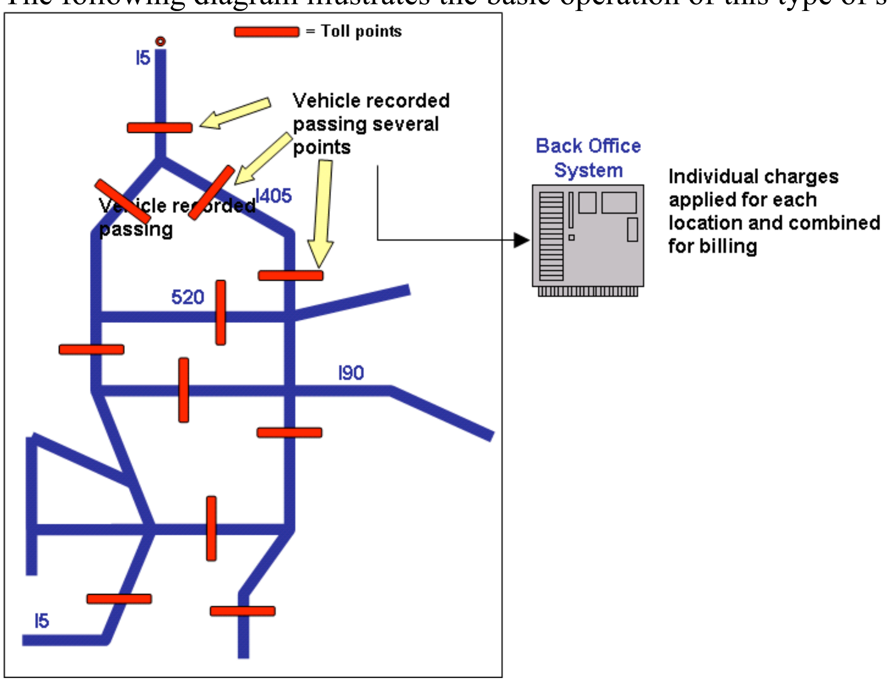
Appendix C: Open System Concept Design Details (Option 2)

General scheme function

Option 2, is based on the concept of an open charging system with toll points located at key mid block sites across the network.

Toll points would be established at key locations to record each vehicle passing through that section. This data would be passed through a similar centralised back office facility to Option 1, where the charges would be combined for billing. In this case an example trip from Lynnwood to Renton during the morning peak may pass several charge points and be charged a combine fee based on these sections, with charges potentially varied by direction of travel for that time of day. As with Option 1, charges could be set for a fixed period (likely 6 months) based on a defined formula that would include specified sections, and charges varying by time of day linked directly to some form of congestion measurement.

The following diagram illustrates the basic operation of this type of scheme.



General scheme issues

This type of scheme has advantages in terms of its reduced infrastructure requirements, but limits the flexibility of the scheme to target specific congestion through varying zone and time based packages. The partial coverage of the network may also encourage users to bypass the system on a regular basis, and limits the potential to design charging structures that are seen as fair and responsive.

Scheme design

A with Option 1 there are three major components to the system design; road side facilities used to record vehicle movement entering an leaving the network; back office systems used to process this information and collect the relevant charges; and the operation of the system.
These combined systems are designed around the same nine functional requirements, including the need to check vehicles passing defined points, and charging the driver or vehicle owner the appropriate fees.

The concept design for this option has therefore been based on the same combination of technologies as Option 1 (DSRC vehicle units and ANPR enforcement), and will apply the same or similar processes to the management of:

- Normal users – DSRC based OBUs,
- Casual users – License recognition with an additional administration charge
- Taxis – integrated units linked to the taxi meter.
- Exempt Vehicles – Dual mode OBUs and cards
- Enforcement – ANPR and image capture system
- Back office facilities and operations – Developed to address the required levels
- Roadside facilities

A key area of difference with Option 1 would be in the scale of roadside facilities. Although the basic designs would be the same, the number of locations wild be significantly lower, and all would be multi lane two way installations. The following table sets out the assumed locations of the planned toll points and number of lanes by direction.

Image based tolling/automatic number plate recognition (ANPR) technology

ANPR technology is used on most electronic tolling facilities around the world, both in free-flow and toll-lane based situations, although most often as an enforcement back up to DSRC technologies.

ANPR systems are based on images taken of vehicle number plates and processed through recognition software to identify the vehicle. Some systems can use front and/or rear located cameras to capture the images and so improve identification rates. Once identified the required charge or permit checking processes are undertaken in a similar way to other systems.
A key issue with ANPR facilities is the level of reliability of the plate reads. Even the best systems in current use are capable of read rates of around 98% in good conditions, but this can reduce as a result of problems such as light reflections in the image, dirty or damaged plates. This leads to the need for manual checking of those that cannot be automatically read and can add significantly to processing costs.

Street based equipment required for an ANPR system would include pole and/or gantry mounted cameras and illumination devices. In some cases these are combined into one unit and depending on the overall system design there may be a requirement for additional cameras (front and rear), classification devices, and independent verification counters.

Typical ANPR camera & illumination device   Combined unit

Vehicle positioning systems (e.g., GPS)

Internationally, road authorities have been exploring and implementing Vehicle Positioning Systems (VPS) which do not require on-road infrastructure to assign a position to a vehicle. Instead, these systems use a satellite location systems (generally GPS) to determine the vehicle's position and measure location and distance travelled for the purposes of charging and access control. These systems offer greater flexibility for authorities to vary charges to influence more aspects of travel and transport choice.

Although VPS technologies are an effective means of tracking vehicle position, the information they gather and store needs to be communicated to central systems on a regular basis, and as such VPS units are generally combined with other technologies (digital maps, wide area communications, and short range GPRS communications) to charge and enforce the system. Other additional features required for this type of system include enforcement check points (fixed and mobile) and depending on the focus of the system these can be extensive.

The current cost of units has been a major factor in these systems only being used for major heavy vehicle application to date, but these are reducing and, once established, VPS based systems have the advantages of wide coverage and far fewer check points than other technologies. It is expected that on-board VPS units will become standard features in new vehicles within 10 years, and this migration is a specifically identified strategy for the European Union.

VPS based system require far less on-street equipment than other systems, with the primary function of the street based facilities being backup enforcement at selected check points. Fixed on street checkpoints are most likely to use similar DSRC and ANPR technologies described in the previous section, and require a series of pole or gantry mounted devices.

The check points are similar to ANPR and DSRC facilities, with the functions depending on the structure of the system. Devices required may include DSRC transceivers, ANPR cameras and vehicle classifiers, with similar controller requirements to the systems already described.

Passive RFID systems

Passive RFID toll systems rely on small devices positioned in the vehicle windscreen and read by roadside reading equipment. This type of technology is generally used in toll-lane based systems as these units are unable to be used effectively for accurate positioning, and therefore effective identification of paying vehicles in a multi-lane free-flow environment.

Option 2 - Limited Open Tolling Scheme			
Toll Location	Route/Highway	Number of lanes	Direction
NE Swamp Creek	I-5	5/5	SB/NB
NE 145th	I-5	4/5	SB/NB
Ship Canal Bridge	I-5	4/4	SB/NB
South Boeing Field	I-5	5/5	SB/NB
South Center Hill	I-5	5/5	SB/NB
Midspan Bridge	I-90	4/5	WB/EB
Eastgate	I-90	4/4	EB/WB
Mill Creek (South)	I-405	3/3	SB/NB
70th	I-405	4/5	SB/NB
Kennydale Hill	I-405	3/3	SB/NB
Ikea Exit/ SW 43rd St	SR-167	3/3	SB/NB
140th St	SR-520	3/3	WB/EB
Midspan Bridge	SR-520	2/2	WB/EB
TOTAL LANES		101	
TOTAL SITES		26	

As for Option 1, for each of the toll points identified a generic design has been assigned. based on the number of lanes at that site.

Back office

The back office systems required or this scheme will comprise the same basic facilities as those for Option 1, including:

- Toll Collection Central System (TCCS)
- Internet/Mail Centre
- Customer Service Centre
- Monitoring System
- Systems Integration
- Operations and Maintenance
- The operational and maintenance processes will also include the same basic functions including:

- Dealing with user enquiries
- Processing payment notices and debt collection
- Processing of casual user transactions
- Processing incomplete transactions and failed license plate reads
- Processing system violations
- Maintenance of systems and equipment

Likely transaction volumes for this option have been developed from current traffic data at the defined mid-block locations included within the scope of Option 2.