

Eastside Corridor Express Toll Lanes

Concept of Operations

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Northwest Region
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**Washington State
Department of Transportation**

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ACRONYMS

ASTM V6	Time Division Multiple Access	LAN	Local Area Network
BRT	Bus Rapid Transit	LED	Light Emitting Diode
CCTV	Closed Circuit Television	MUTCD	Manual on Uniform Traffic Control Devices
CTR	Commute Trip Reduction	PIN	Personal Identification Number
CVISN	Commercial Vehicle Information Systems and Networks	PUD	Public Utility District
DMS	Dynamic Message Sign	RF	Radio Frequency
EA	Environmental Assessment	RFID	Radio Frequency Identification
EIS	Environmental Impact Statement	ROW	Right-of-Way
ETC	Electronic Toll Collection	SOV	Single Occupant Vehicle
FAQ	Frequently Asked Questions	TD	Traffic Density
FMAS	Facility Management and Administration System	TMC	Traffic Management Center
GP	General Purpose	TPA	Transportation Partnership Account
HAR	Highway Advisory Radio	TZC	Toll Zone Controller
HOT	High Occupancy Toll	UPS	Uninterruptible Power Supply
HOV	High Occupancy Vehicle	VAC	Volts Alternating Current
IRT	Incident Response Team	VDS	Vehicle Detector Station
ITS	Intelligent Transportation System	WAN	Wide Area Network
IVR	Interactive Voice Response	WSP	Washington State Patrol

EXECUTIVE SUMMARY

Intent of Concept of Operations Report

This report was developed to describe the Eastside Corridor Express Toll Lanes Project from the perspective of both WSDOT and the driving customer. It will serve as a framework for design, development, and operation of the express toll lanes system.

This document provides key design and operation elements such as ingress and egress locations, electronic toll collection (ETC) system requirements, pricing schemes, operation schedules, system enforcement options, necessary equipment, and maintenance provisions.

Chapter 1

INTRODUCTION

Why a Toll?

Across the country, major metropolitan areas face the challenge of growing populations, worsening traffic congestion, and dwindling transportation dollars. In addition, lawmakers and transportation officials in the central Puget Sound region of Washington State are struggling with an even more precarious problem -- how to fund critically-needed infrastructure preservation and improvements, while meeting rapid increases in demand on an overburdened freeway system. The Eastside Corridor, comprised of I-405 and SR 167, exemplifies this conundrum in many ways. It is one of



Looking south on I-405 approaching I-90 over Bellevue.

several busy corridors in the central Puget Sound region where WSDOT is exploring electronic tolling to improve traffic flow and efficiency. One approach to electronic tolling is already in development for the SR 520 Bridge, as a means to manage demand and help fund a vitally-needed replacement for the aging structure.

Since it first opened to traffic in the 1960s, I-405 has been transformed by strong economic growth and a surging population across the region. The Eastside Corridor is now the second busiest corridor in the state, carrying more than 800,000 people each day on I-405 alone. Strategically-targeted capacity improvements are underway, but those improvements alone will not prepare this semi-beltway around the Seattle metropolitan area for anticipated traffic increases. Dynamic tolling is one of the many tools WSDOT is considering to manage future congestion levels on this important corridor.

1.1 The SR 167 HOT Lanes Pilot Project

The state Legislature and Transportation Commission support WSDOT in implementing variably-priced tolling to improve traffic flow along our busiest corridors. Already, WSDOT is demonstrating how



The HOT lane on SR 167.

variable tolling tailored to the Eastside Corridor's unique characteristics improves traffic flow in both the tolled and general purpose (GP) lanes. After one year of operations, the high occupancy toll (HOT) lanes on SR 167 made the highway's previously underused high occupancy vehicle (HOV) lanes more efficient, while maintaining free-flow traffic speeds for transit and carpools and improving flow and travel time in the GP lanes.

WSDOT launched HOT lanes on SR 167 in May 2008. The project converted the existing HOV lanes, one in each direction, to HOT lanes. HOV vehicles with two or more (2+) people, transit, and motorcycles use the HOT lanes toll-free, while single-occupant vehicles (SOV) with a *Good To Go!* electronic tolling transponder have the option to pay a dynamically-priced toll to use the HOT lanes when space is available. There are no toll booths; the electronic tolling system automatically debits the toll amount from vehicles traveling at the current highway speed.

This four-year pilot project is an opportunity to learn how dynamic tolling could benefit other bridges and highways in Washington. Here are just a few highlights from the first-year's results for HOT lanes on SR 167:

- More than 30,000 customers paid an average toll price of \$1 to drive in the HOT lanes.
- Average daily tolled trips continue to increase monthly from 1,050 trips per weekday in May 2008 to 1,710 trips per weekday in April 2009.
- The average daily traffic volume in the GP lanes increased 4 percent, from 100,100 to 104,004.
- The average traffic speed in the GP lanes increased 10 percent, from 35 mph to 38.5 mph.
- The average daily volume in the HOT lanes increased 3 percent, from 18,400 to 19,336.
- Speeds in the HOT lanes increased 8 percent, from 55 mph to 59.4 mph on average.
- Speeds in the HOT lanes were above 45 mph during peak hours 99.2 percent of the time.

1.2 I-405 Tolling Studies

When WSDOT developed the I-405 Corridor Master Plan Environmental Impact Statement (EIS) in 2002, traffic engineers considered managing lanes to improve the flow of traffic. The EIS Record of Decision included a four-foot buffer to separate I-405's HOV lanes from its GP lanes, with the intention of studying an express toll lane system in the future. A subsequent study completed in 2004 found that a two-lane express toll lane system moves more people and vehicles than either a single lane or a non-tolled HOV system.

WSDOT is currently considering a similar express toll lane system with variable pricing on I-405 that could be integrated with SR 167's HOT lanes for a single express toll lane system throughout the Eastside Corridor.

The existing HOV lane on I-405 is well used -- so popular, in fact, that portions of the carpool lane fall short of the established HOV-lane performance speed standard of 45 mph at least 90 percent of the time during rush hour. WSDOT's HOV policy directs that toll-free occupancy requirements increase from two people or more (2+) to three people or more (3+) when the performance standard is not met. However, traffic model results indicate that an express toll lane system would be more efficient for the entire Eastside Corridor than increasing the HOV occupancy requirement alone. This is because increasing the occupancy requirement alone would increase congestion in the GP lanes and result in lower than desirable traffic volumes in the HOV lane.

1.3 Goals and Objectives

Express toll lanes along the Eastside Corridor offer more choices to commuters and make the best use of new freeway capacity and the existing HOV lanes. The project's goal is to make I-405, and eventually the entire Eastside Corridor, more efficient by operating express toll lanes at their maximum potential with reliable, free-flowing service, even when the GP lanes are congested. By maintaining this objective, the entire corridor will benefit because the corridor's GP lanes will flow better as some SOVs choose to pay a toll to use the priced lanes for a more a reliable trip. The proposed system would have two express toll lanes on I-405 connected to a single express toll lane on SR 167.

The Eastside Corridor Express Toll Lanes Project will implement the strategies of WSDOT's three-point mobility program known as **Moving Washington**:

- **Manage demand** – With more transportation choices such as transit, vanpools, and bus rapid transit (BRT)
- **Operate more efficiently** – With guaranteed reliable speeds and optimal lane performance
- **Add new capacity strategically** – With an integrated program of completed and ongoing projects along the Eastside Corridor



WSDOT is well underway with a complete corridor plan that **strategically adds new capacity** on I-405 and SR 167 where it has the greatest effect on bottlenecks and traffic flow through the corridor. Express toll lanes will allow WSDOT to **operate the freeway as efficiently as possible**, and offer commuters more travel choices to help **manage transportation demands**.

1.4 Strengthening Investments

The 2003 Nickel and 2005 Transportation Partnership Account (TPA) transportation funding packages financed projects to improve operations, add capacity, and relieve bottlenecks along the Eastside Corridor. Express toll lanes can strengthen our investments in new capacity by making the best possible use of additional lane space.

Dynamic pricing can maintain maximum lane capacity at free-flowing traffic speeds even at the height of rush hour. The toll acts as a flow valve that opens and closes automatically with the law of supply and demand. Toll prices adjust automatically with real-time fluctuations in traffic volume and speed. As volume increases, so does the toll. As the toll increases, fewer SOVs will choose to enter the express toll lanes, which will preserve optimal traffic flow.

Studies show that the most effective way to open express toll lanes on the Eastside Corridor is to allow certain vehicle classes, potentially HOV 3+ vehicles, to use the lanes toll-free. Other vehicles with fewer occupants would pay a dynamically-priced toll using a *Good To Go!* transponder. This is the same toll technology currently in use on the SR 167 HOT lanes and the Tacoma Narrows Bridge. Vehicles using the express toll lane system will enjoy a reliable trip that meets or exceeds a minimum level of service (LOS) requirement. On SR 167, the performance target for the HOT lanes is 45 mph or more at least 90 percent of the time in the height of rush hour.

Maximum lane capacity in the express toll lanes is based on the characteristics of the highway and the priced lanes' potential effect on the adjacent GP lanes. Since moving the most people and vehicles as rapidly and safely as possible is our primary objective, it will be critical to provide efficient access to express toll lanes and interchanges tailored to I-405's unique characteristics, accounting for traffic volume, speed, and topography.

Achieving widespread acceptance for the tolling system is an important goal and a critical step toward success. Electronic tolling works only when most drivers comply with the rules of the road. WSDOT will use lessons learned from the SR 167 HOT Lanes Pilot Project to provide community outreach and driver education about these new lanes before they are opened on I-405.

The Eastside Corridor Express Toll Lanes Project provides a unique opportunity to create a 50-mile free-flowing and reliable semi-beltway around the Seattle metropolitan

What are Express Toll Lanes?

Express toll lanes ensure reliable, toll-free commutes for buses and carpools, while offering other motorists the option to escape congestion by paying an electronic user fee.

Beginning with I-405, the Eastside Corridor could include two express toll lanes in both directions from I-5 in Lynnwood to Renton, plus a single express toll lane on SR 167 from Renton to Puyallup.

When space is available, solo drivers could choose to pay a dynamically priced toll to drive in express toll lanes, using a [Good To Go!](#) Transponder. Toll booths will not be used, so traffic speeds will not slow down.

Toll rates would automatically adjust with traffic levels to keep traffic flowing freely.

area as an efficient alternative to I-5. Since many commuters will use both tolling facilities along the Eastside Corridor, this new express toll lane system will improve efficiency by implementing a system consistent with the look and feel of the SR 167 HOT lanes. Forward compatibility of the system will guide the design, and interoperability of all state tolling technologies, both in use and purpose, will also be an essential part of the implementation.

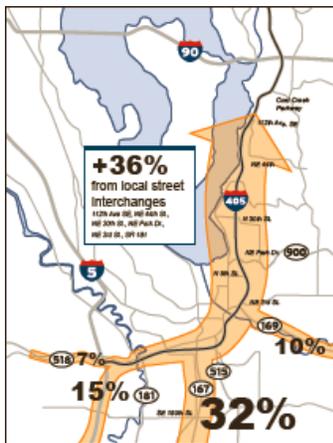
Chapter 2

EXISTING TRAFFIC CONDITIONS

Major Congestion

Today, the entire Eastside Corridor, including I-405 and SR 167, is heavily congested, and traffic congestion is expected to worsen as the region grows over the next 20 years by a projected 1 million people and 700,000 jobs.

Commuters on I-405 frequently encounter heavy traffic and congestion 10 to 12 hours a day. Morning commuters traveling from Tukwila to Bellevue experience the worst



Northbound I-405 traffic flow approaching I-90.

congestion in the state, according to WSDOT's Annual and Semi-annual Congestion Reports. During the morning rush hour, 45 percent of southbound traffic approaching Bellevue comes from the I-5, SR 527, and SR 522 interchanges. From the south, almost 60 percent of the traffic comes from I-5, SR 167, and SR 169. The greater Bellevue area, including I-90 and SR 520, is the primary destination for morning commuters.

In all lanes, I-405 experiences the highest traffic demand when it operates with the least efficiency -- at the height of rush hour. That is to say, just when we need the freeway to perform at its best, it performs at its worst.

The Eastside Corridor has not been immune to the current economic recession, which caused significant job loss in 2008 and 2009. The economic downturn somewhat reduced volumes and peak-period volumes; however, recent data indicates demand remains high and is increasing in I-405's GP and HOV lanes. Traffic speeds still remain low through much of the day.

2.1 Roadway Alignment

I-405 carries 800,000 people a day. It is heavily traveled by vehicles making both short trips and long drives across the central Puget Sound region.

Approximately 30 miles long, I-405 passes through Bothell, Kirkland, Bellevue, Renton, and Tukwila, as well as several other communities, large and small. It serves as an important connector to most of the state's busiest corridors. From its northern intersection with I-5 in Lynnwood to the southern I-5 junction in Tukwila, I-405 includes major intersections with SR 522, SR 520, I-90, SR 169, and SR 167.

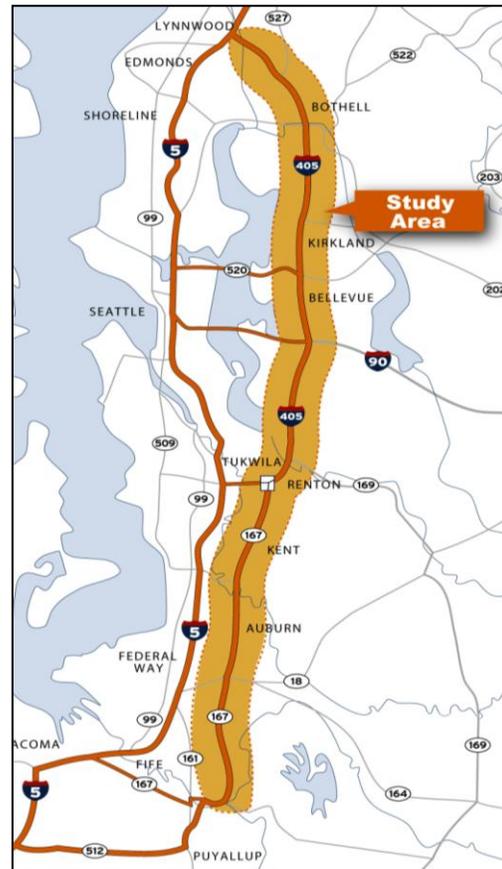
SR 167 is a primary highway connecting south King and north Pierce counties to the Seattle/Bellevue metropolitan area. The corridor serves a growing number of housing developments and lies along the largest freight distribution center in the region. On busy weekdays, SR 167 carries 120,000 vehicles. SR 167 connects with I-5 in Tacoma and I-405 in Renton, and has major intersections with SR 512, SR 410, SR 18, and SR 516.

2.2 Funded Roadway Improvements

The initial stage of the I-405 Express Toll Lanes Project is made possible by other projects in the corridor funded by the Nickel and TPA packages, as shown on the map on the next page. These funded improvements on I-405 include an additional lane in each direction between SR 520 and SR 522 in Kirkland.

This new lane from SR 520 to SR 522, together with the existing HOV lane, will be operated as express toll lanes. This will result in two tolled lanes in each direction between SR 520 and SR 522. North of SR 522, the existing HOV lane will be converted to an express toll lane, creating a single tolled lane in each direction between SR 522 and I-5.

I-405/SR 167 Eastside Corridor

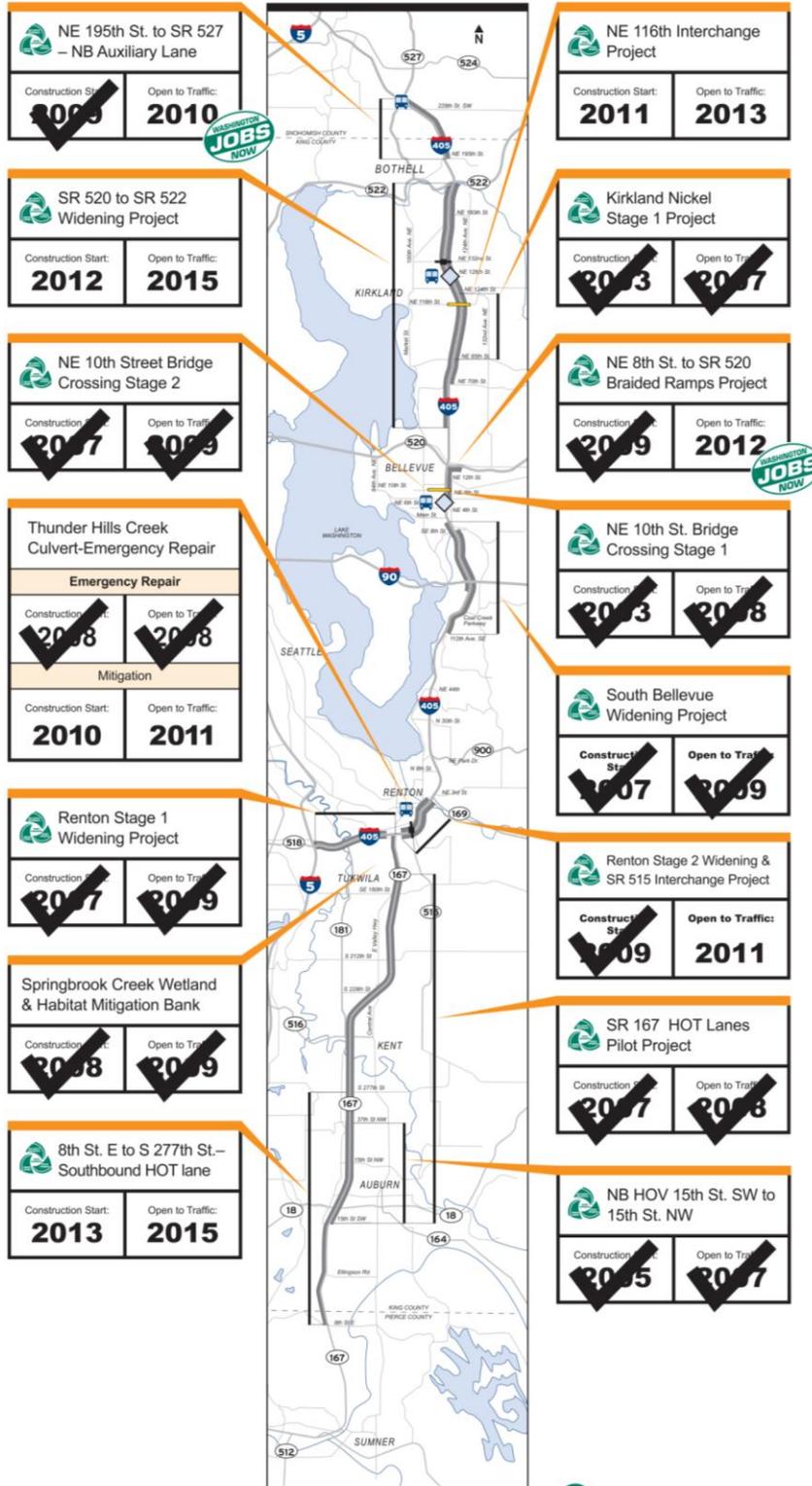


I-405 Program

Since the 2002 adoption of the [master plan for I-405 improvements](#), WSDOT has pursued a series of projects that directly address the corridor's worst chokepoints. With the 2003 Nickel and 2005 TPA funding packages, the state has invested nearly \$1.5 billion into the corridor.

Today, I-405 carries 800,000 people each day. When the program is complete, I-405 will carry approximately 1.5 million people each day.

Eastside Corridor Funded Projects



2.3 Existing HOV Lanes

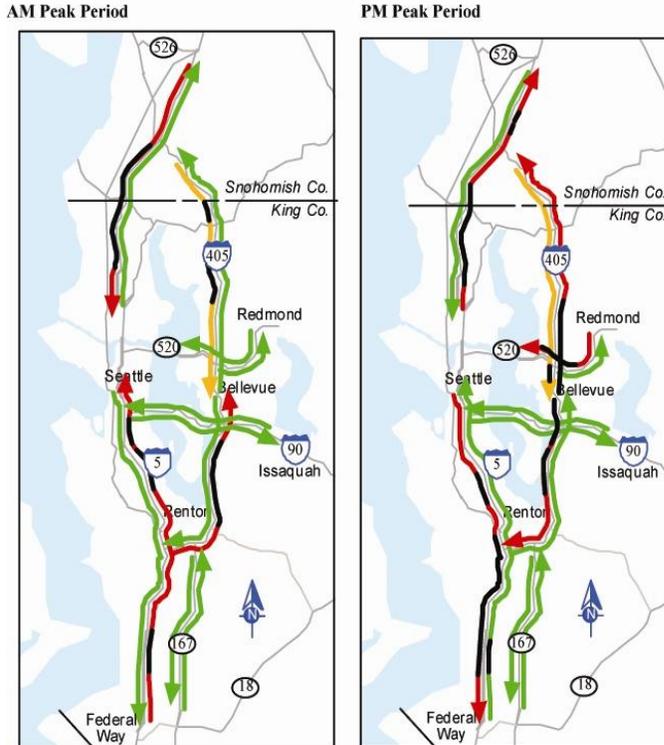
Currently I-405 includes one high-occupancy vehicle (HOV) lane in each direction with a two-person vehicle occupancy requirement. The HOV lanes operate 5 a.m. to 7 p.m. daily and are very well used. But like many HOV lanes in the Puget Sound region, increasing volume often means they no longer operate better than the adjacent GP lanes. Today, buses and carpools on I-405 are trapped in the rush hour congestion they are hoping to avoid by using HOV lanes.



Buses and carpools bypass heavy traffic using a direct access ramp at NE Sixth Street in Bellevue.

While HOV lanes still move more people than GP lanes, since there are more passengers per vehicle, the number of vehicles in HOV lanes has increased to a point where these lanes are often no faster than normal lanes. Poor HOV lane performance also presents a challenge to transit providers, commute trip reduction (CTR) efforts, and other demand management programs that depend on reliable travel in the HOV system.

Central Puget Sound HOV Lane Performance



Red and black segments on the maps above indicate segments that fail WSDOT's HOV performance standard of 45 mph or greater at least 90 percent of the time during peak hour.

Direct access ramps that allow buses and carpools to directly access the HOV lanes from park and ride lots and local streets are improving HOV lanes on I-405, but not enough. Buses and carpools now save up to six minutes by using the direct access ramps completed in 2007 on I-405 in the Totem Lake area. Bellevue's direct access ramps, completed in 2004, save drivers about two minutes, and carry more than 4,000 vehicles a day. The Totem Lake ramps carry more than 9,000 vehicles daily, the highest volume of all direct access ramps in the Puget Sound region.

Six additional direct access ramps are planned for I-405, including three in Bothell, two in Renton, and one in Kirkland. A direct access

ramp is also planned for SR 167 in Renton. All five projects currently lack funding. An additional component of the I-405 Master Plan is building direct connector ramps at major interchanges, so buses and carpools can seamlessly travel between corridors, and adding a transit flyer stop to the I-405 median in South Bellevue.

2.4 Tolling Statutes and Enforcement

Existing Washington State HOV statutes will remain the same, except solo drivers will be permitted to use the new express toll lane when they pay an electronic toll using a valid *Good To Go!* transponder. Existing statutes and legislative authorization ([RCW 47.56.403](#)) allow HOT lane operation on the SR167 facility, but any future tolling facilities in the Seattle region, including I-405, will require passage of additional legislation.

The Washington State Patrol (WSP) currently enforces HOT lanes on SR 167 and electronic tolling on the Tacoma Narrows Bridge. Much like regular HOV lane

enforcement, troopers enforce vehicle occupancy requirements on the SR 167 HOT lanes visually. When a SOV with a valid *Good to Go!* transponder enters the HOT lanes, a light flashes on the overhead sensor. That signals the WSP that the driver has entered legally. If the light doesn't flash, the trooper may stop the SOV and can issue the driver a citation. HOT lanes also accommodate violation reports by citizens through the [HERO program](#); however, such reports are not prosecutable. The HERO program will mail a warning pamphlet to the alleged violator. Toll evasion and vehicle-occupancy citations each carry fines of \$124.



Washington State Patrol enforces SR 167 HOT lanes.

Tolling enforcement on the Tacoma Narrows Bridge is conducted by license plate video capture. Toll operations on SR 520 likely will rely heavily on license plate photo recognition. These photo-tolling and enforcement techniques will be considered for the I-405 Express Toll Lanes Project to maintain consistency for customers across WSDOT tolling facilities.

2.5 Traffic Detection and Monitoring Equipment

WSDOT has installed a full complement of intelligent transportation system (ITS) equipment along the Eastside Corridor. The existing ITS equipment is used in part to monitor the performance of the existing facility. Electronic dynamic message signs (DMS), vehicle detector stations (VDS), roadway closed circuit television (CCTV) surveillance cameras, highway advisory radio (HAR), and ramp meters currently operate in the corridor. This equipment is connected to the existing fiber optic communications network installed along the entire length of the corridor. Some existing copper cable is still used for communications with older ITS devices. Detector stations were installed

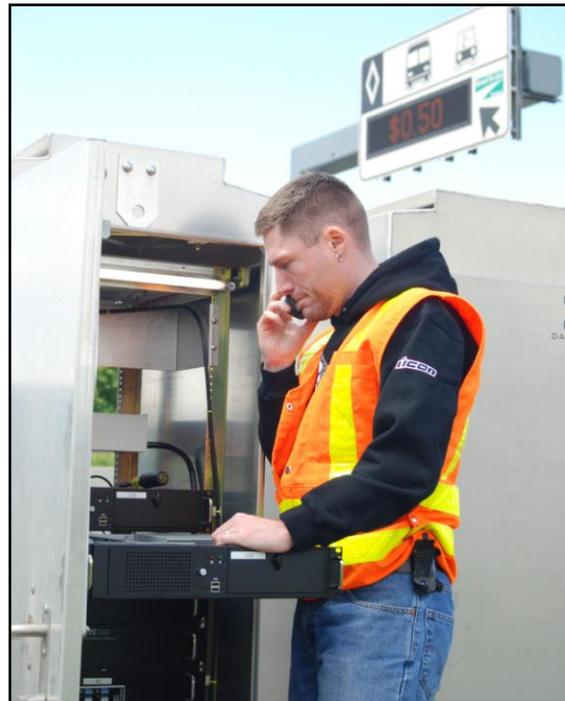
across all lanes of traffic, including ramps and interchanges, at approximately 0.5 mile intervals along the corridor. Each location provides at least one vehicle detector loop embedded in the pavement to measure traffic volume and speed.

A central computer polls loop controllers at 20-second intervals, and data is archived in five-minute aggregations. The central computer builds a rolling one-minute volume to smooth out the raw data for a number of purposes. This aggregated traffic information, including average traffic speed, will be parsed to meet the express toll lane system's data needs. Aggregated data will be collected and processed at WSDOT's traffic management center (TMC) on Dayton Avenue in Shoreline.

2.6 System Monitoring and Control

WSDOT currently monitors, analyzes, and manages the Eastside Corridor at the TMC. The center's primary freeway operational functions include traffic and alarm monitoring, management of traveler information, and incident detection. These functions rely on integrated field equipment, wide area network (WAN) and local area network (LAN) communication systems, and a data processing, reporting, and storage platform.

The system supports timely responses by emergency personnel to detected and reported incidents. A WSDOT radio system dispatches incident response and maintenance operations, and complements traffic information collected by the TMC for dissemination to the traveling public. Furthermore, WSDOT's incident response team (IRT) are on duty 24 hours a day, seven days a week to assist the WSP during major incidents and provide traffic control and re-routing, mobile communications, and the ability to clear incidents and debris. Roving IRT vehicles also provide motorist assistance to keep freeway shoulders clear and traffic moving.



WSDOT technician inspects field equipment for tolling on the SR 167 HOT lanes.

2.7 Communications Network

Communication hubs along the existing single-mode fiber optic network will serve the new express toll lanes. These hubs are located in proximity to interchanges at I-5 (Southcenter), I-90, SR 520, NE 160th Street, and I-5 (northbound) in Lynnwood.

2.8 Electrical Service

Wherever possible, the project will use existing electrical services on the corridor. However, some locations will require new service cabinets. The new cabinets will be located on WSDOT right-of-way (ROW), where access to the utility's electrical service is available and accessible for regular maintenance.

Puget Sound Energy is expected to provide electrical service for most of the Eastside Corridor express toll lanes, with Snohomish County PUD providing service north of Bothell. WSDOT has a utility services department that would work with the utility companies to develop service agreements. Coordination with the utility companies will be necessary to determine the availability of existing transformers that can service the express toll lane field equipment and to keep equipment installation costs to a minimum.

In many cases, service cabinets that operate roadway lighting also power the existing ITS equipment and devices. This typically means that 480 volts alternating current (VAC) service is delivered to a local transformer where voltage is reduced to 120/240 VAC to power the ITS equipment and devices. The expectation is that roadside cabinets to house electronic tolling equipment will be powered from the same service connection if a transformer is available within a reasonable distance. This likely will involve the installation of conduit to route electric cable from each roadside cabinet to an existing transformer.

Chapter 3

IMPLEMENTATION

Project Description

The Eastside Corridor will operate more efficiently and move more people faster with a seamless express toll lane system created by joining I-405 and SR 167 to form more than 50 miles of dynamically-priced express toll lanes. Dynamic pricing allows WSDOT to use the facility to its full potential and maintain optimal traffic volumes for faster, more reliable trips, as well as toll-free trips for carpools and transit. Express toll lanes also reduce demand in the non-tolled GP lanes by offering a new option to drivers. This will improve traffic flow for all drivers.

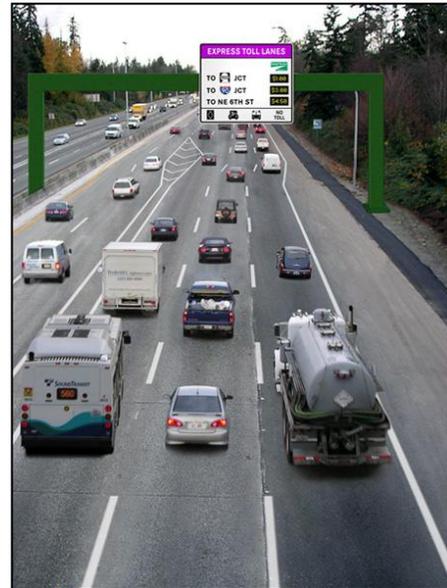
The preliminary design concepts for the Eastside Corridor express toll lanes include:

- Dynamic tolling based on current traffic speed and volume in all lanes to ensure traffic in the express toll lane flows freely, virtually all the time.
- Two express toll lanes in both directions on I-405 and a single HOT lane on SR 167.
- Direct accesses to and from express toll lanes.
- Embedded traffic sensors to collect data used in the pricing algorithm that calculates the toll rate.
- Road signs with up to three LED panels to display and update toll rates based on zone and destination.
- No toll booths. All tolls collected electronically with radio frequency identification (RFID) transponders.

Toll-Free HOV Occupancy

The minimum vehicle occupancy required for toll-free use of the Eastside Corridor express toll lanes has not yet been determined. Currently, portions of the SR 520 HOV lane are the only facility in the Puget Sound region that requires vehicle occupancy of three or more people.

Express Toll Lanes



Visualization depicts how express toll lanes on I-405 might look.

While the driving public is more accustomed to the HOV 2+ requirement, that option is not viable for efficient express toll lanes on the Eastside Corridor in the long term. Based on traffic modeling, HOV 2+ express toll lanes on I-405 would fill up and start to break down by 2020. Setting the occupancy requirement at HOV 3+ would allow the facility to operate with long-term viability and efficiency.

3.1 Phased Approach

The Eastside Corridor Express Toll Lanes Project will have a phased implementation. The preliminary phasing concept is a simple three-phase approach with *Phase 1* consisting of projects ready or near ready for construction; *Phase 2*, projects that have significant development completed, but lack full funding; and *Phase 3*, future projects with modest project development and little funding.

This phasing concept will likely evolve, and both planning and funding could change.

Phase 1

- I-405 – SR 520 Bellevue to I-5 in Lynnwood
- SR 167 – Stage 4: 8th Street E to S 277th Street

Phase 2

- I-405 – SR 167 in Renton to SR 520 in Bellevue
- SR 167 – Stage 5: 8th Street E to 15th Street NW
- I-405 – SR 167 interchange HOV direct connection

Future phase(s)

- I-405 – SR 522 Bothell to I-5 in Lynnwood
- I-405 – SR 522 interchange HOV direct connection
- SR 167 – Stage 6: SR 512 to 8th Street E

Phase 1 would:

- Implement two express toll lanes from SR 520 to SR 522 and one toll lane from SR 522 to I-5
- Construct a second lane on I-405 between SR 520 and SR 522
- Be construction ready with a nearly completed environmental assessment (EA) and other necessary permits
- Open to traffic by January 2015

Phase 2 would:

- Construct a new lane on I-405 from SR 169 to SR 520 and a, I-405/SR 167 direct connector

- Complete construction by late 2017 with design-build, or sooner with nontraditional delivery methods; EA is complete for work south of I-90, although permitting and right-of-way is not

3.2 Toll Zones

The exact tolling concept for the I-405 Express Toll Lanes Project is still in development. At this time, the concept is that tolls will be priced by distance of travel based on nine toll zones. The zones will be marked by advisory signs displaying up to three current toll rates based on destination. The zones will be located along the corridor to best meet the needs of traffic and fit within the constraints of the roadway.

Roadside equipment cabinets at each tolling zone will connect to the existing fiber optic communications network to link the roadside equipment to an off-site management and administration system, possibly located at Northwest Region headquarters in Shoreline.

A driver would be charged the same price for all travel within a toll zone, regardless of the distance of the trip. This would be reflected in the toll rates shown to drivers entering the lanes.

Due to the length of the Eastside Corridor and signing limitations, it may be necessary to have decision points. At these points, drivers will be shown new toll rates for further travel within the system. These new rates will be added to the rates the driver paid upon first entering the system. Drivers will always be given the choice of returning to the toll-free GP lanes or continuing in the express toll lanes by paying an additional toll.

The current concept locates a decision point at the I-405/SR 167 interchange for drivers continuing from one freeway to the next. That is, drivers heading northbound along SR 167 will only see toll rates to reach I-405, but not for travel along I-405. Drivers heading south on I-405 will not see toll rates for

One Possible Scenario of Toll Zones for Express Toll Lanes



travel on SR 167 before reaching the SR 167 interchange.

Additionally, on I-405, a mid-corridor decision point may also be implemented. This decision point would be located in downtown Bellevue. Vehicles heading southbound from Lynnwood would see a rate sign with three destinations, the farthest of which is downtown Bellevue (NE 6th Street). Upon reaching Bellevue, a new sign would display the rates for further travel south towards Renton.

3.3 Ingress and Egress Design

Express toll lane ingress and egress designs include direct-access connections to local roads and mainline access ramps to allow merging between express toll lanes and GP lanes. Direct-access connections are possible at local roads or between freeways through a flyover ramp that routes over the GP lanes. This project includes existing direct connections at NE 128th Street and NE Sixth Street.

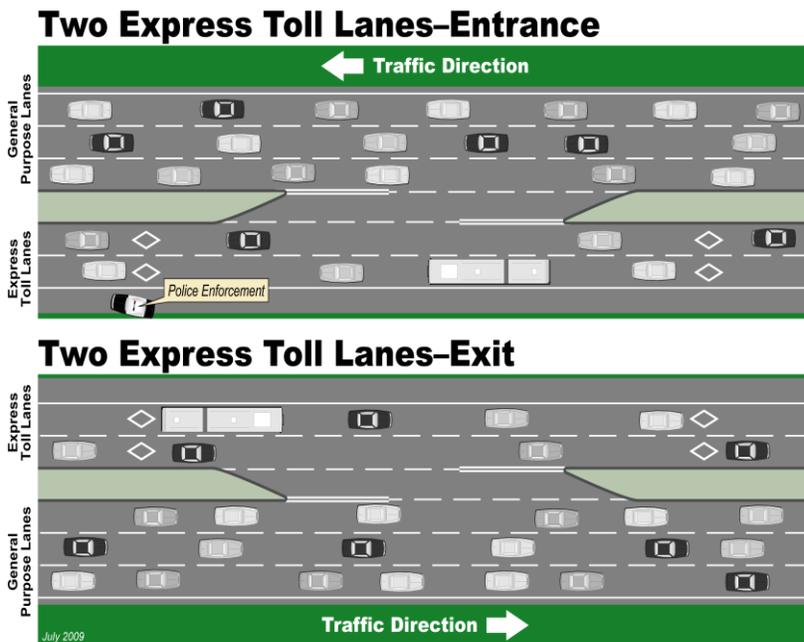
Before each access point, advisory signs will alert motorists of an approaching access zone. Immediately before reaching an access point, drivers in the GP lanes will see an electronic message sign that displays the current toll rate based on indicated destinations. Approaching an egress point, drivers in the express toll lanes will see a sign indicating which mainline exits can be reached through this egress point.

Mainline access designs to express toll lanes include at-grade access in and out of express toll lanes at both separate and shared locations. Separate, dedicated access into express toll lanes may involve an auxiliary lane that diverges from the GP lanes and

merges within the tolled lanes. The figure illustrates the design concept for an egress and ingress between a dual-lane tolled facility and GP lanes.

Another variation of mainline access ramp design being considered for this project incorporates auxiliary lanes to accommodate vehicles weaving, merging, and diverging for both toll lane ingress and egress at the same location.

Mainline Access Design Concept



The space for the auxiliary lanes would be made possible by widening the traveled way through these sections of roadway. If widening is not possible in the area of an access point, then limited shoulder-width reductions might provide a low-cost alternative for tapering the tolled lanes toward the median to form an access lane and transition zone.

In addition, merge lanes inside the tolled facility will smoothly funnel traffic through direct-connection ramps at NE Sixth and NE 128th streets. At the termini of the system, the express toll lanes will transition to/from HOV lanes. Sufficient warning will be given at the end of the system to allow drivers to merge into GP lanes.

3.4 Field Support Structure Design

Development of new electronic tolling systems typically include installation of gantries, similar to traffic signal mast arms, which span the express toll lanes and portions of the GP lanes.

For the Eastside Corridor Express Toll Lanes Project, these structures will support transponder reader antennas that transmit signals between a reader/controller housed in a roadside cabinet and the vehicle-mounted transponder. These structures also can support ETC transaction indicator beacons used by the WSP for enforcement, and cameras and lights for automated enforcement systems.



An electronic toll transponder reader gantry on SR 167 HOT lanes.

3.5 Lanes and Shoulders

Although the project intends to minimize changes to I-405's existing HOV lanes, shoulder upgrades may be necessary. Existing HOV lanes include a 2-foot inside shoulder in some locations, whereas the WSDOT *Design Manual* requires inside shoulder widths of 10 feet and up to 14 feet if law enforcement uses the shoulder.

Although the standard lane width is 12 feet, reducing tolled-lane width to a minimum of 11 feet might be necessary to facilitate construction in some areas. The exact layout of the express toll lanes will be determined during project development and is dependent on constructability, safety, and funding.

3.6 Buffer Zone

Clear, visible separation between express toll lanes and GP lanes is necessary to discourage violations, facilitate safe vehicle operations, enhance traffic capacity, and limit lane changing. A buffer zone, identified by two solid white stripes, will divide the express toll lane from the GP lanes. The standard width of the buffer will be 4 feet, with a minimum width of 2 feet.

The buffer zone will consist of pavement markings that adhere to requirements detailed in the *Manual of Uniform Traffic Control Devices* (MUTCD). No pylons or delineators are expected to be included in the buffer.

Chapter 4

OPERATING RULES and REQUIREMENTS

A critical factor in developing a successful electronic tolling system is tailoring the system to unique characteristics and attributes of the freeway and corridor. Since the SR 167 HOT lanes already have established operating rules on the Eastside Corridor, which it shares with I-405, many of the rules will carry over to the new express toll lanes with adjustments where necessary.

4.1 Hours of Operation

An HOV Hours of Operations Pilot Project initiated by WSDOT in 2003 at the request of the state Transportation Commission led to the Commission's adoption of new HOV lane operating hours on SR 167 and other east King County freeways (I-405, I-90 east of Island Crest Way, and SR 520 east of I-405). Allowing all traffic to use these lanes between 7 p.m. and 5 a.m. makes better use of the lanes during off-peak hours. The Hours of Operations Pilot Project authorization expired in June 2005, but the program remains in effect.

Traffic volume is projected to increase substantially by the time the Eastside Corridor Express Toll Lanes Project launches, and likely will continue to increase for years to come. Therefore, the project team recommends a one-hour extension, operating the toll system daily from 5 a.m. to 8 p.m.

4.2 Customers

SOVs that want to use the express toll lanes must complete a *Good To Go!* electronic tolling application to open an account and order a transponder. WSDOT's [Good To Go! Web page](#) provides online registration and application. Applications may also be mailed (or faxed) to *Good To Go!* customer service. Customers may call customer service to request an application or visit a customer service storefront to complete an application and immediately receive a transponder.

Once an account is established, *Good To Go!* sends a transponder identification number and a status code to the facility management and administration system (FMAS), where the information is stored and forwarded to the tolling zone controllers. The transponder is then recognized by the roadside tolling equipment/software each time it passes through a tolling zone.

The facility will allow transit, vanpools, and carpools to travel toll-free in express toll lanes. As of this writing, it has not been determined what the toll-free occupancy requirement will be for the project, nor has it been determined if all vehicles will be required to carry transponders in express toll lanes.

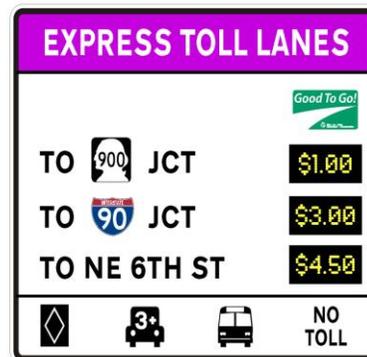
4.3 Lane Distinction

The eGo Plus transponder (currently used by the *Good To Go!* customer service vender TransCore, Inc., for tolling on the SR 167 HOT lanes and the Tacoma Narrows Bridge) can determine the lane in which a particular transponder was read at vehicle speeds of 50 to 70 mph in factory tests performed by TransCore. The primary issue related to express toll lanes systems is whether a transponder-equipped vehicle traveling in the GP lane adjacent to the priced lanes (separated by a painted buffer) will be read and charged. This is particularly a concern when the buffer, which varies from 2 to 4 feet wide, is narrowest. The system requires that no toll payments be associated with transponders inadvertently read from vehicles traveling in the GP lanes. The tolling system integrator will need to incorporate the appropriate design elements to meet this requirement, a problem not uncommon on other facilities. To date, the existing HOT lane system on SR 167 has not inadvertently charged vehicles in the adjacent GP lanes.

4.4 Toll Rate Display

Shown is a sample layout for the project's DMS. In addition to displaying the current toll rate to make that trip, the DMS will alert drivers when the facility is closed, primarily for incidents or maintenance activities. These sign layouts are for informational purposes only, since the express toll lanes signing plans have not yet been finalized.

Using the traffic data that is collected from the priced lanes and GP lanes sent from WSDOT's TMC, the management system will execute a continual dynamic pricing algorithm to calculate the toll for each of the tolling points. The GP and entry ramp lane traffic data will be used as an independent confirmation of the HOT lane input data by comparing it to average traffic volumes in the GP lanes.



Current design express toll lanes dynamic message sign (DMS).

The express toll lane system will be comprised of toll zones. Factors in determining the zones include the perceived and actual performance advantage of dual lanes, the location of major traffic movements where operations may be distinctly different compared to other facility locations, and perceived equity issues relative to toll charges being consistent with actual facility demand.

Each toll zone will be priced independently by a dynamic algorithm that continually runs on the system management server to account for the differences in performance and loss of service for single versus dual-lane directional toll areas, and to provide price control at areas with increased traffic movements.

Toll-rate signs will display one to three rates based on destination. In very general terms, pricing will be determined at each tolling zone location based on traffic data that is

collected and analyzed by the dynamic pricing server. A more detailed description of the dynamic pricing process is presented in *Chapter 5* below.

Chapter 5

TOLL RATE CALCULATIONS

The number of SOVs entering the Eastside Corridor express toll lanes must be carefully and continuously managed in order to keep the traffic flowing at a minimum of 45 mph, 90 percent of the peak-period. SOV ingress to the toll lanes will be controlled through continuous toll rate updates. Toll rates will increase as traffic increases in the express toll lanes to regulate the number of vehicles entering the priced lanes; thereby maintaining the minimum level of service. Conversely, as carpools and toll-paying customer demand decreases, so will the toll rates to encourage increased use of the express toll lanes by toll-paying drivers, and make more efficient use of available capacity.

5.1 Pricing and Lane Operations

As an SOV approaches a toll lane entry point, the message sign will display the current toll rates by destination. At each entry point, one to three specific rates will appear on the sign to inform the motorist of the current toll price for destinations within this zone. When the motorist enters, the toll rate on the sign is the amount charged regardless of subsequent rate fluctuations prior to their exiting the tolled facility. The rate displayed is “locked in” for that customer based on the point and time of entry into the express toll lanes.

Factoring both express toll lane and GP lane traffic data allows WSDOT to assess toll rates that ensure efficiency in the priced lanes. This rate-setting approach provides consistent value.

Data gathered from existing and any supplemental vehicle detector stations (VDS) will be used to calculate speeds in both the priced lanes and the GP lanes. That lane speed helps determine toll rates for each defined zone. The system’s toll calculations are described below.

With current operating assumptions, all transponder-equipped SOVs would be charged the same toll (i.e., the tolls charged are not based on vehicle class or type). Therefore, there is no need for the tolling system to determine the vehicle classification or type.

5.2 Demand Pricing Calculation

Demand-driven toll pricing is based on lane performance criteria -- minimum traffic speed of 45 mph, 90 percent of the peak-traffic period. Traffic volume is defined as the number of vehicles passing a certain point within an established time period. The traffic volume must be combined with the average vehicle speed, because a low vehicle count alone does not distinguish low traffic volume from congestion with slow traffic.

Traffic data will be collected over a defined interval (e.g., 3, 5, or 15 minutes). The interval can be modified by non-technical personnel. Traffic density (TD) will be computed from vehicle counts and speeds as explained below.

5.3 Toll System Override

The TMC is responsible for system-wide traffic monitoring and reporting and timely incident response.

To minimize response delays within the corridor and to more efficiently route emergency vehicles, the TMC will control the operating (i.e., open and closed) state of the express toll lanes. A separate and secure interface server at the TMC will provide a platform for exchange of raw traffic data and override control of the tolling system. Interfaces between system security at the TMC and the tolling facility is feasible, if appropriate security provisions such as firewalls, encryption techniques, and user authentication are incorporated into the system.

Chapter 6

MANAGEMENT and ADMINISTRATION

The FMAS and its functions are the heart of the express toll lane system. The system will collect toll transactions, messages, and traffic data from the tolling zone controllers (TZCs), and the TMC will send trip records and various messages to the customer service center.

The system will provide a means for WSDOT staff to audit toll trips. Additionally, the system will send data and messages to the message sign controllers and TZC units. The FMAS database will reconcile every express toll lane transaction collected from the toll zone controllers.

6.1 Transponder Status File

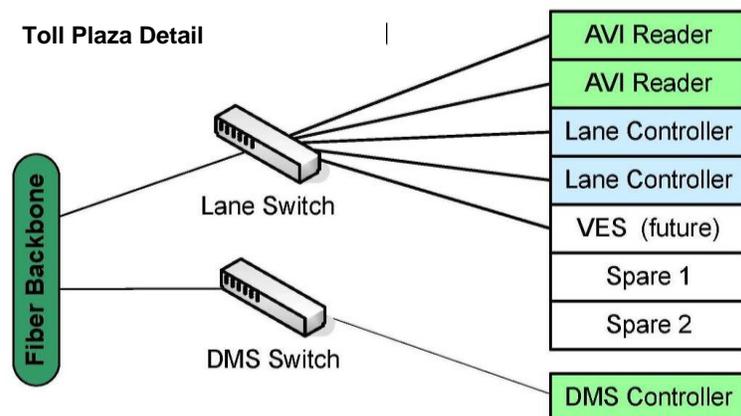
A transponder status file is a list of ETC transponder identification numbers associated with active *Good To Go!* accounts. Accounts are “active” when the balance is more than a required prepaid account minimum; when the account is properly assigned as non-revenue; or it is not delinquent on an outstanding balance.

The management system establishes and updates transponder status files sent from the customer service center. Then the system will store and forward status files to all TZCs. The TZCs use this data to validate transponder ID numbers read by roadside tolling equipment before sending a validation to overhead tolling-enforcement beacons. The TZCs also create transaction records for successful transponder reads. The controllers will have sufficient local memory and storage capacity to accommodate status files as they grow.

6.2 Time Synchronization, Controller Configuration

TZCs must be synchronized with the FMAS to audit and reconcile transactions and trace system and equipment problems. The system provides transaction time and data necessary to synchronize

clocks in the TZCs and DMS controllers, as well as any image processors integrated into the express toll lane system in the future. Consistent timing between the FMAS and roadside controllers is required to investigate, locate, and resolve anomalies and any



customer concern.

The management system will be equipped to remotely download configuration data to the TZC, DMS controllers, and any future image processors. This data provides the parameters that enable and disable certain components used to interface with ETC readers or DMS controllers.

The management system also provides the ability to enable and disable output of data to any of the roadside devices.

6.3 Transaction Generation, Transmission

Toll zone controllers will create toll transaction records using input data from the roadside equipment. Each transaction will be identified by a sequential number. Transaction records will include fields for the agency code, tolling zone location, time, date, transponder ID, and transponder status code. The controllers will send toll transaction records to the management system immediately after each record is created. If communications with the management system is interrupted, toll zone controllers will store a specified quantity of records until communication is restored. The controllers will include a portable drive for manually moving data to the management system, if needed.

6.4 Central Processing System – Trip Generation

The management and administration system will build trips from toll transaction records by sorting transactions by transponder ID number from consecutive transactions within a configurable time period. The FMAS could handle toll transactions recorded outside of the designated express toll lane operating hours by assessing a \$0.00 toll, if business rules allow.

6.5 System Maintenance Management

Toll zone controllers will include software to monitor and report the status of connected transponder readers, DMS controllers, and any future image processors. They will also include diagnostic software to monitor the status of internal components and scan memory and data storage for problems. The management system will include maintenance management software that provides alarm monitoring, automated dispatch, and a spare-parts inventory system.

Chapter 7

Good To Go! CUSTOMER SERVICE

Customer service will be critical for the success of express toll lanes. Electronic tolling will be unfamiliar to many area drivers.



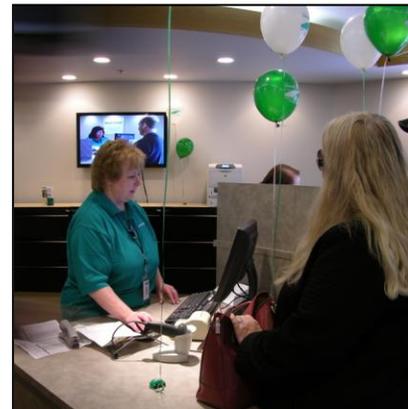
A vender (undetermined at the time of this publishing) will locate and establish a new call center, customer service headquarters (known in this document as the customer service center), and multiple new *Good To Go!* Storefronts. These efforts will provide a physical presence in the Eastside Corridor and on both sides of Lake Washington in preparation for a much larger customer base associated with new tolling on SR 520, as well as the Eastside Corridor. The storefronts provide personal contact with customers and cater to motorists who prefer not to use a computer or telephone for customer service.

Good To Go! currently operates one customer service facility in Gig Harbor. A second center opened in Tacoma a month prior to the Tacoma Narrows Bridge opening, but it was closed in June 2008. Under contract, TransCore currently provides all *Good To Go!* customer service operations and management. Before tolling begins on SR 520, WSDOT will award a new contract and close the existing Gig Harbor headquarters but maintain a storefront there.

7.1 Good To Go! Headquarters

With the closing of administrative offices in Gig Harbor, *Good To Go!* will require a new headquarters for customer service representatives, managers, supervisors, clerks, accountants, operators, and system personnel to perform customer service and account management functions and support.

Good To Go! headquarters will be designed and equipped to handle customer service and manage electronic tolling system accounts, as well as any functions related to an automated violation processing system that might be deployed. A new call center and an electronic data center might be housed separately from headquarters, as will necessary storefronts to provide adequate service options to a geographically-wide customer base.



A representative assists a customer Inside the Gig Harbor Good To Go! storefront.

7.2 Good To Go! Accounts

A customer profile established for each *Good To Go!* account will include necessary customer information such as name, address, telephone number, e-mail address, credit card information, etc. Additional information would include vehicle make, model, year, color, and license plate number for each vehicle assigned a transponder. *Good To Go!* and TransCore currently employ this account management approach.



A windshield-mounted Good To Go! electronic toll transponder.

Good To Go! customer service will be responsible for updating customer profiles. Customers will be able to update their accounts through the [Good To Go!](#) program page on WSDOT's Web site. The customer service center will support both personal and commercial accounts, as well as other account classifications. Non-revenue accounts that incur no toll charges also might require certain management operations. All revenue-based account types will be prepaid to minimize risk and costs associated with unpaid balances.

7.3 Opening a Good To Go! Account

The *Good To Go!* storefronts will accommodate walk-in account applications and customer inquiries. Customers can also access most services through the internet, mail, phone, or facsimile. The facility will also support toll account payments and deposits by cash, check, or credit card, as specified by business rules. New customers will make account inquiries at the center, online, or through the interactive voice response (IVR) system.

After submitting an application and payment of a minimum initial account balance, new customers will receive a transponder and a welcome kit that could include:

- Description of the express toll lane system and operation, and a map of the facility, pricing zones, ingress and egress locations, and tolling zones
- Welcome letter with a customer personal identification number (PIN) code for initial access to the Web site and IVR
- User's guidebook and frequently asked questions (FAQ)
- Transponder instructions
- Transponder shielding device (as applicable)
- Transponder mounting accessories

7.4 Account Replenishment

Good To Go! accounts will be replenishable, both automatically using a credit card, and manually with cash, a debit card, a check, or a one-time credit card payment. The replenishment amount will depend on WSDOT's business rules for toll operations. Customers may choose to replenish accounts automatically when their account balance drops below a predetermined threshold. Customers who choose manual account replenishment will receive a notification automatically (by e-mail or postal mail) when their balance reaches a minimum threshold. In such cases, customers will be required to call in, mail, or hand deliver payment equivalent to the necessary replenishment amount.

7.5 Account Statements

Customer service will generate and mail to customers standard *Good To Go!* electronic tolling account statements regularly. Statements will exist as electronic files for easy distribution to patrons. Upon request, customer service representatives will retrieve and view a customer's statement to hasten response to the customer's inquiry or dispute. Representatives will also have reliable access to the FMAS server for the express toll lanes to retrieve transactions listing toll trips, zone locations, and toll charges.

7.6 Call Center

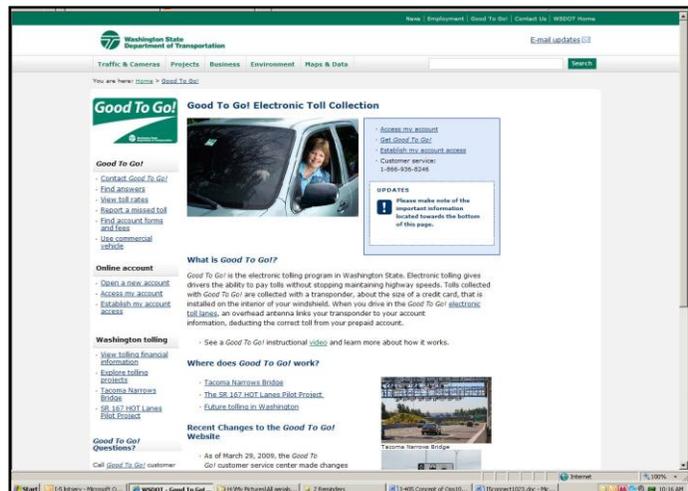
The call center telephone system will process incoming customer calls. It will include an automated IVR system that routes calls through menu selections and provides appropriate services. The system will provide general information and allow customers to review account balances, make credit card or check payments, obtain a list of recent trips and transactions, and report a lost or stolen transponder. Automated call center services will operate 24 hours a day, 7 days a week.

During hours of business operation, callers will be able to transfer to a representative. Call center staff will field customer calls pertaining to the Eastside Corridor express toll lane system, as well as other Washington State toll facilities.

7.7 Web Page Functions

An existing WSDOT [Good To Go!](#) Web page will provide general information about the Eastside Corridor Express Toll Lanes Project for the public. The information will include:

- Project description and operation details
- Contact information



A screenshot from the [Good To Go!](#) Web page.

- Maps of pricing zones, and ingress and egress points
- Facility locations and operating hours of the storefronts
- Links to the WSDOT traffic conditions page, live traffic cams, roadway construction updates, and related lane closures
- FAQs
- News and announcements

The Web page will provide both prospective and existing customers with online capabilities including:

- New account applications
- Historical trip transactions reports
- Current account balance
- Account replenishment with credit card
- Customer profile information updating, including payment method, account type, credit card information, vehicle information, etc.
- Contact information and complaint submittal
- Additional transponder request
- Lost/stolen/found transponder notification

Access to all *Good To Go!* account management functions will be completed over a secure log in. The secure connection will protect and encrypt data transmissions to and from the customer's browser.

Chapter 8

ENFORCEMENT

Enforcement is critical to the system's operational performance and driver-perceived integrity, particularly among toll-paying drivers. The project design elements affect the extent and efficiency of enforcement. Signing will be clear and situated effectively for customers to quickly assess the cost and value of choosing the express toll lanes.

As described above, the express toll lanes will be separated from the GP lanes by a painted, double, solid-white line buffer to facilitate enforcement. This buffer will support safe traffic operations between the express toll lanes and the GP lanes.



The Washington State Patrol will conduct enforcement of the Express Toll Lanes.

8.1 System Enforcement

The WSP will exclusively perform on-site enforcement of express toll lanes. Troopers will visually identify violators and direct them to a safe pullover location for further investigation and, if appropriate, issue a violation citation. In order for troopers to provide efficient enforcement, they will use special electronic-tolling enforcement tools including ETC enforcement beacons.

8.2 Enforcement Beacon

LED light powered by a toll zone controller will serve as a toll transaction indicator or enforcement beacon. The beacon will be mounted on a gantry over the toll zone, making it visible to troopers in a nearby enforcement area.

The duration of illumination is determined by the time the vehicle is in the toll zone. Troopers will use the light to determine potential violators, pending confirmation and further investigation of factors such as vehicle occupancy.

Depending on occupancy and transponder requirements, the beacon may illuminate for toll-free carpools or valid toll transactions. If video tolling is implemented, WSP officers will observe vehicles that declare as carpools to ensure they meet the



Two enforcement beacons, one for each direction, are located over the "Illegal to Cross the Double White Line" sign on this reader gantry for SR 167 HOT lanes.

occupancy requirement. A beacon that flashes for vehicles declaring toll-free status might best assist troopers.

Without video tolling, it may be more advantageous to troopers for the beacon to illuminate for valid toll transactions. Vehicles that do not trigger the beacon would be checked for the minimum occupancy requirement.

8.3 Enforcement Operations

Currently, WSDOT intends to financially support the WSP through the annual operations and maintenance budget. The cost to enforce the express toll lanes will be deducted from the gross toll revenue. This will allow WSP to spend more hours monitoring the express toll lanes. WSDOT will consider implementing enforcement areas along the express toll lane facility to allow officers safe and sufficient areas to monitor vehicles and safely stop drivers for further investigation.

8.4 Optional Video Tolling

The option of video tolling, as described in Chapter 2 above, is favorable as a form of enforcement or payment. Video tolling equipment would include lighting and video cameras at each transponder reader location. Such a system would assist the WSP enforcement operations by identifying vehicles that do not carry a transponder. These vehicles could then be mailed a bill, citation, or warning, depending on WSDOT policy.

WSDOT and WSP currently use video enforcement on the tolled Tacoma Narrows Bridge. The system uses video to capture license plates of vehicles that bypass toll booths and pass under transponder readers without a valid transponder. Using the license plate number, WSP identifies the vehicle's registered owner and mails the owner a violation notice.

For the SR 520 project, WSDOT is considering a similar system that would bill vehicles without a transponder, rather than issue a citation. For I-405, a video system likely would require transponders that could be registered for use as carpools or be switched (able to self-declare) between toll-free and toll-paying status. With this technology, WSP would monitor passing vehicles for minimum occupancy requirements.

A down side to this option is that it places a burden on HOV vehicles, especially casual carpools that do not routinely use the corridor. Carpools without a transponder would not have toll-free access to the express toll lanes, as they currently do in the SR 167 HOT lanes. Video tolling cannot determine the occupancy of a vehicle or differentiate a valid carpool from a violator. Despite their qualification for toll-free use, HOV vehicle owners without a transponder would receive a bill or citation.

A video tolling system would be accurate enough to determine the cumulative toll price from multiple reads of a vehicle's license plate along the corridor, similar to the process used to determine the toll of a vehicle with a transponder. However, another policy yet to be determined is what to do when the system records a license plate that matches a

Good To Go! account in the system. In such a case, the system cannot determine if the vehicle's transponder had declared toll-free occupancy status. For other Washington toll facilities, the customer is simply charged the normal toll. After repeated video charges, the customer service center may contact the customer to verify the transponder is correctly installed.

Chapter 9

HARDWARE and EQUIPMENT

A major advantage provided by modern, electronic tolling systems is functionality without toll booths that otherwise cost money to build and slow down traffic. The trade off appears, in part, in the complexity of required technology and the amount of necessary hardware and equipment. From reader antennas and electronic message signs to roadside equipment, loop detectors, and transponders, the system for all electronic tolling is hardware-heavy and requires installation and operation of the specialized equipment.

9.1 Toll Zone Controllers, Communications

TZCs are industrial-type, rack, or back-panel mountable computers. They will collect electronic toll transaction records, monitor connected devices, report status changes of peripheral devices, and communicate with readers and the management system. They will include a redundant backup system housed in a roadside cabinet. Each controller will be capable of storing toll transactions and equipment status messages for extended time periods, in case communication with the management system fails on the first transmission.

The TZCs will also include a hot-swappable hard drive to allow continued operation of the tolled lanes if the equipment fails. The system will support manual downloading and moving of transactions from the toll zone controller to the management system.

9.2 Toll Debiting Equipment

The transponder-reading and tolling equipment consists of vehicle-mounted transponders with a radio frequency module, overhead antennas, and readers.

The transponder sends and receives signals from the reader. The radio frequency module can be integrated into or mounted on the antenna. Alternatively, the module can be located with the reader, but within a maximum allowable distance based on the thickness of the antenna cable. This is the case for *Good To Go!*'s eGo Plus, with the radio frequency module housed in a roadside cabinet.



Reader antennas allow electronic tolling on SR 167 HOT lanes.

As a vehicle with a valid transponder enters a toll zone, an antenna transmits modulated signals between the vehicle's transponder and the roadside tolling equipment. The antenna also receives modulated signals from the transponder, then encodes and

transmits signals back to the antenna. The received signals are sent to a connected radio frequency module for demodulation.

A reader receives demodulated signals, decodes the transponder ID information, validates the transponder ID code, and transmits the code to the toll zone controller with any appended information such as time and date, input status, or receiving antenna ID. The reader can also perform specified control operations through commands from a terminal connected to an auxiliary port. For this facility, readers will be installed in a roadside cabinet located at each tolling zone site. The number of readers installed at each tolling site is subject to the number of tolled lanes and antennas required. The system design process will include further details.

One antenna will be installed on an overhead structure over each tolled lane. The antenna is mounted to allow for position adjustments. The antennas will be installed at the manufacturer's recommended angle based on the expected vehicle speeds and at a lateral location that eliminates cross-lane (GP lane) reads.

9.3 Transponders

The existing *Good To Go!* transponder is a credit-card-sized, radio-frequency device mounted to the inside of the vehicle's windshield. It enables a unique transponder ID to be detected when passing through a toll zone.

Good To Go! currently offers a transponder disabling "shield" that attaches over the transponder with Velcro on the interior of the windshield. When the customer qualifies for HOV status, the shield should be physically placed over the transponder to avoid paying a toll.

Customer service issues externally-mounted transponders to customers whose vehicle windshield contains metallic oxide particles that interfere with radio frequency (RF) signal transmissions. Since the external transponders are normally mounted to the front license plate frame, disabling it for eligible HOV status is problematic.



The Good To Go! transponder shield is applied to the windshield with Velcro.

9.4 A Better Transponder?

WSDOT is considering transponder technology alternatives such as the time division multiple access (ASTM V6) transponder. This transponder operates with an open-protocol design that can be manufactured by several vendors. WSDOT currently uses the ASTM V6 transponder for the Commercial Vehicle Information Systems and Networks (CVISN) program for electronic vehicle weight screening.

The ASTM V6 transponder currently is used on HOT lanes for Minnesota’s MnPASS system. It can be disabled quickly and easily by removing it from a plastic holder on the windshield. Unlike other removable models, it does not require being placed in a



Interior mounted ASTM V6 MnPASS transponder.

shielded bag for deactivation, a potentially hazardous distraction and customer annoyance. MnPASS transponders allow for portability between vehicles, a desirable feature for customers. This type of transponder was identified for evaluation as a possible alternative.

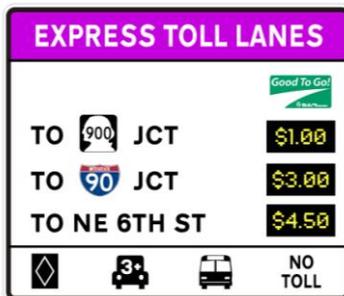
An important distinction between the eGo Plus and the ASTM VG is that the eGo Plus does not provide customer feedback regarding the success of a transaction. The ASTM V6 transponder can be configured to

communicate with the customer using a beep that a transaction was completed.

The eGo Plus is a “passive” transponder that backscatters an encoded signal sent from the reader, while the ASTM V6 transponder is “active” and transmits a response signal after receiving an interrogation signal from the reader. Both transponders can be read and signaled while traveling at highway speeds in free-flow conditions. This capability would enable vehicle detection and identification necessary to toll the vehicle while in the express toll lanes.

9.5 Dynamic Message Signs

On the Eastside Corridor, DMS will be fixed with static information and one to three variable message modules that display current toll rates based on separate destinations. The dynamic display modules will use LED technology to create a maximum of eight characters. Each sign will include a controller, which can be separate or integrated with the DMS display module that interfaces the FMAS server to receive updated display commands and send status messages.



Current design for Eastside Corridor Express Toll Lanes dynamic toll rate sign.

Unlike other message boards that display symbols, words, and graphics in a larger text area, the toll-rate signs for express toll lanes will be limited to just a few digits in each display module.

The toll rate displayed is determined in response to changes in traffic volumes and speed in both the tolled and GP lanes. A direct connection between the DMS and the FMAS is preferred to maintain toll-lane operations in the event of a communication link failure.

The message sign controller will revert to a default display if no new display command is received within a configurable period of time. The default display would allow continued use of the tolled facility by toll-free carpool and transit traffic, while minimizing SOV traffic. This strategy should maintain free-flow conditions when traffic volumes and speed data is unavailable due to a communications link failure.

Each sign will also be capable of displaying other messages. This allows the flexibility to close a tolled lane ingress point for any reason. A “CLOSED” message on the toll-rate sign would restrict entry by any vehicle during incidents, lane blockages, or maintenance in the express toll lanes. Or, an “HOV ONLY” message could manage volume increases as tolled-lane traffic speeds approach the 45 mph performance-standard minimum. An “OPEN TO ALL” message would convey no toll is needed to enter the express toll lane when it becomes necessary to route vehicles past an incident in the GP lanes or during hours when the tolling system is not operating.

The signs will be programmed to display alternate messages as required. The TMC will override the management system control of the signs to clear traffic incidents from the facility. It would be possible for the TMC to override the SOV toll if an incident in the GP requires use of capacity in the express toll lanes during a very significant traffic event.

Each sign location requires electrical power and digital communication services. Fiber optic cable will be routed from the sign controllers to the nearest existing WSDOT hub for network connection.

9.6 Vehicle Detector Stations

New dual-loop detector stations will be required on the facility where single-loop detectors already exist. Dual loops are preferred for their greater accuracy in measuring vehicle speed. A dual loop will also be installed at each tolling zone to input a vehicle count to the toll zone controller. The dual loops will connect to a detector unit amplifier to be housed inside the lane roadside cabinets. This dual-loop configuration could also function as a trigger for a camera-based enforcement system or vehicle classification if included in the facility.



A flow operator monitors Seattle-area traffic inside WSDOT's Northwest Region traffic management center in Shoreline.

9.7 Central Processing System Equipment, Peripherals

The FMAS will include a server for high reliability and data storage. The proposed location of the FMAS server is the computer room at WSDOT Northwest Region Headquarters in Shoreline. The server and associated storage devices will be rack-mounted and share the existing cooling and uninterruptable power supply (UPS) system. Workstations will provide a management interface and reporting capability to WSDOT staff.

The management system will receive, process, store, retrieve, and report toll transactions and traffic and toll-rate data. It will compile and distribute transponder status files, calculate toll rates, build toll trips, record maintenance events and roadside-equipment alarms, and manage system security. FMAS also will interface all toll zone controllers to synchronize timing, provide system access authorization, build and update transponder status files, and process toll transactions and maintenance messages.

The system will also interface TMC servers and receive message sign display commands and traffic data from all vehicle detector stations.

FMAS software will manage toll trip data by merging individual toll transactions into discrete trips. Rule-based processing will help sort individual transactions into one or more trips. The system will follow WSDOT business rules based on hierarchy of events, including a travel-time offset between the assessed toll rates and toll rates to be posted on DMS. The management system database will support and maintain the calculated toll display tables unique to each message sign. The system will also be equipped to archive and retrieve data.

9.8 Uninterruptible Power Supply

A UPS is necessary for conditioning and filtering utility electrical service. Additionally, a UPS provides backup power for enough time to allow an emergency generator to start and power service to automatically switchover, or, if necessary, computer systems to shutdown properly. The facility management and administration system share the existing UPS at the WSDOT Northwest Region Headquarters Building.

Chapter 10

POTENTIAL OPERATIONAL CONSTRAINTS

With any implementation of electronic tolling, there are potential operational constraints. Presented below is a list of possible operational constraints for the Eastside Corridor Express Toll Lanes Project that should be considered as the project proceeds.

Potential Issues to Keep In Mind	
Funding and legislation	The Eastside Corridor Express Toll Lanes Project will require a funding source and legislative action for tolling authority and state tolling law amendments.
Meeting expectations	The new tolling system needs to be operated in a manner that meets expectations of both customers and state lawmakers.
Enforcement	Enforcement is critical to achieving and maintaining public acceptance and trust in the system's effectiveness.
Transponders	The eGo Plus transponder does not signal to drivers success or failure of a transaction, and it is not easily disabled (or shielded), when compared to the ASTM V6 type transponder and other transponder options. The license plate-mounted transponder cannot be disabled by practical means. In addition to these devices, other technologies should be considered.
No operational cut-off for HOV	Enforcement could be more difficult and less effective if additional HOV traffic is free to enter the toll lanes during periods of high demand, when toll-lane speed is slower than 45 mph. The result could degrade express toll lane performance, or the express toll lanes might experience excess volumes.
Future automated enforcement	In the future, the project may include an automated enforcement system. This approach would affect which vehicles are required to carry a transponder when driving in the express toll lanes.
