APPENDIX E:
HNTB PRELIMINARY 30% DESIGN REPORT, COST ESTIMATE, AND PLANS DATED 2011

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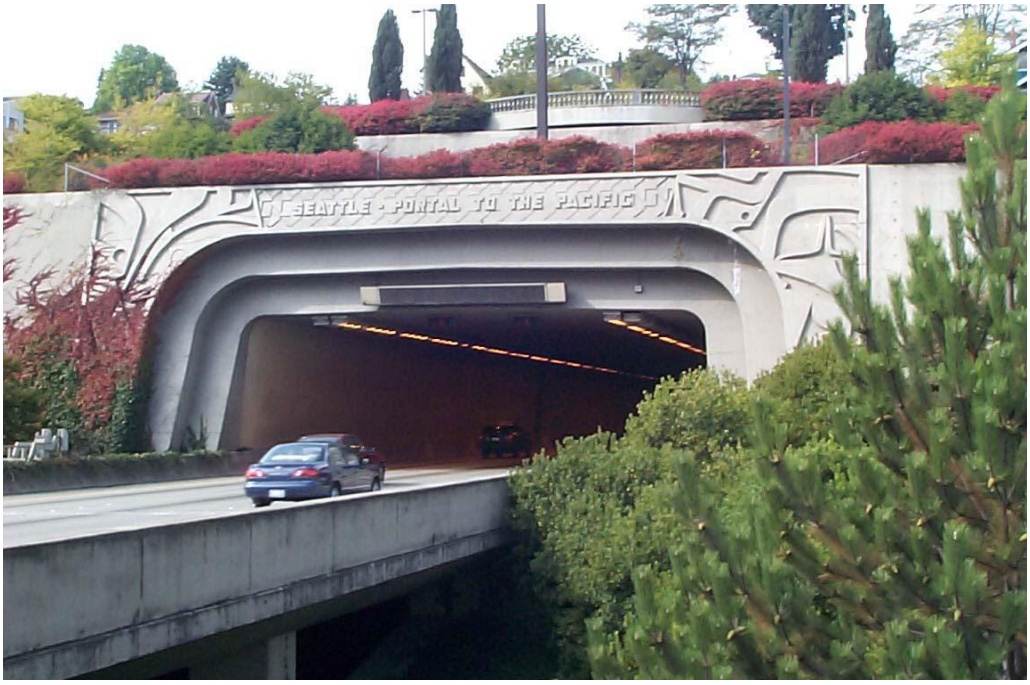
Washington State Department of Transportation

I-90 STAGE 3 PRELIMINARY ENGINEERING
WORK ELEMENT 5.1
TUNNEL ITS DESIGN SUMMARY

Sound Transit Regional Express
I-90 Two-Way Transit & HOV Operations Project



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HNTB

This Tunnel Intelligent Transportation System Design Summary was prepared for the I-90 Two-Way Transit & HOV Operations Project, Stage 3 Preliminary Engineering, Work Element 5.1 by:

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5/13/2011
Date

HNTB

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INTRODUCTION

The I-90 Two-Way Transit & HOV Operations project encompasses the I-90 freeway between I-5 in Seattle and Bellevue Way in Bellevue (mileposts 2.54 to 9.13) as shown in Figure 1. The existing facility, prior to construction of this project, provides three general-purpose lanes in each direction, plus a reversible two-lane center roadway.

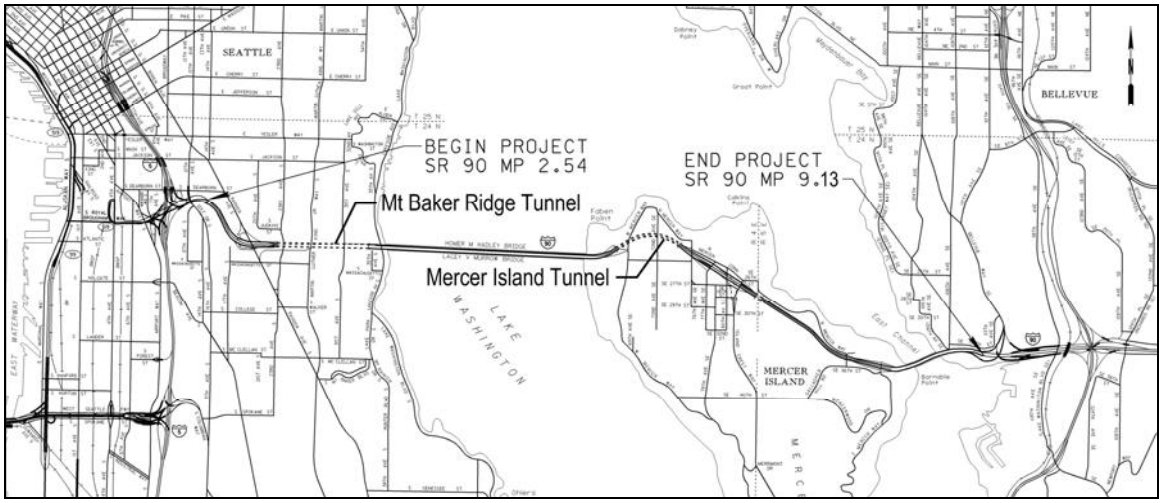


Figure 1
Vicinity Map

The Washington State Department of Transportation's (WSDOT) I-90 Two-Way Transit and HOV Operations project will add an HOV lane to the eastbound and westbound roadways through the Mount Baker Ridge and Mercer Island First Hill tunnels by reducing existing lane and shoulder widths. This report is in support of the Stage 3 project which includes both I-90 tunnels and floating bridges along with the section of corridor between I-5 and the Mount Baker Ridge Tunnel. Stage 1 of the project widened the westbound roadway between Bellevue Way and the Mercer Island Tunnel and was opened to traffic in 2008. It included Intelligent Transportation System (ITS) roadway elements from I-405 to I-5. Stage 2 of the project widens the eastbound roadway from 80th Avenue SE to Bellevue Way, and is currently under construction.

Existing Conditions

The existing I-90 tunnels typically provide three 12-foot-wide traffic lanes with varying shoulder widths in each direction except for the twin-bore portion of the eastbound Mount Baker Ridge (see Figure 2).

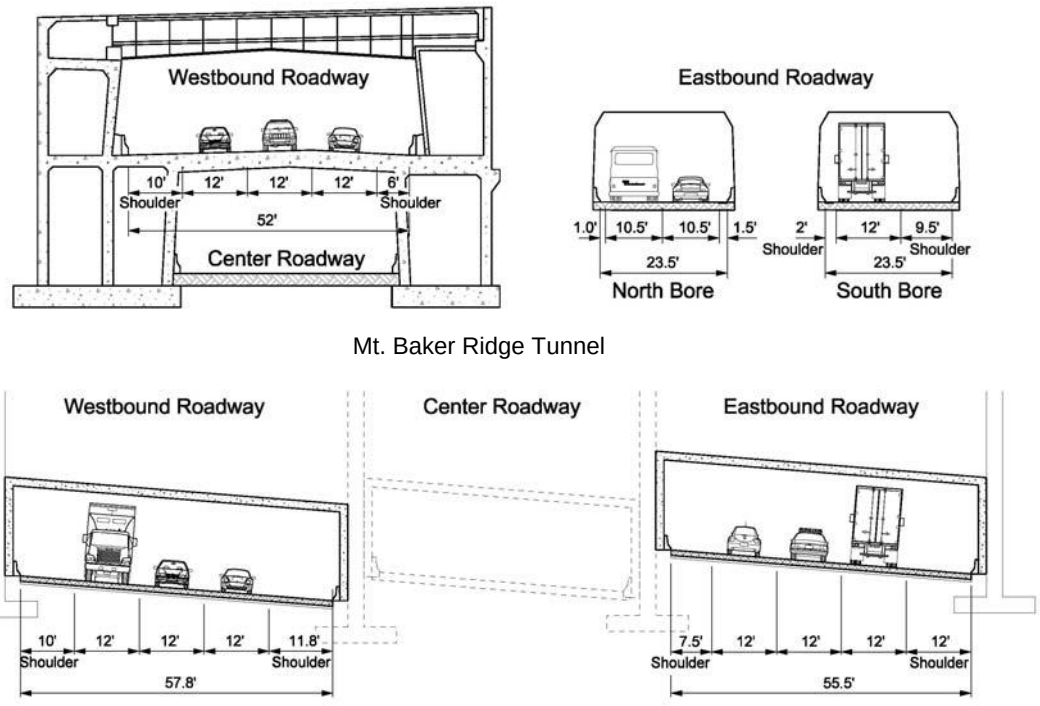


Figure 2
Existing I-90 Tunnel 3-Lane Cross-Sections (Typical)

Proposed Conditions

The I-90 Two-Way Transit and HOV Operations project will modify the outer roadways by adding a new HOV lane in each direction. These approved modifications will be carried through the Mount Baker Ridge and Mercer Island First Hill tunnels where lane and shoulder widths will be reduced (see Figure 3).

Sound Transit's East Link project proposes to convert the I-90 center roadway to light rail transit (LRT). The project is currently in the environmental clearance and preliminary engineering stage of development. Preliminary engineering for the project started in summer 2009 and is anticipated to run through 2010.

An Active Traffic Management System (ATMS) is currently being constructed that will provide variable speed limit information and lane control as well as variable traffic information on three highway corridors: I-5, I-90, and SR 520. Along with variable message signs, the ATMS will install lane-use control signals as overhead LED signs that will also display variable speed limits for each individual lane.

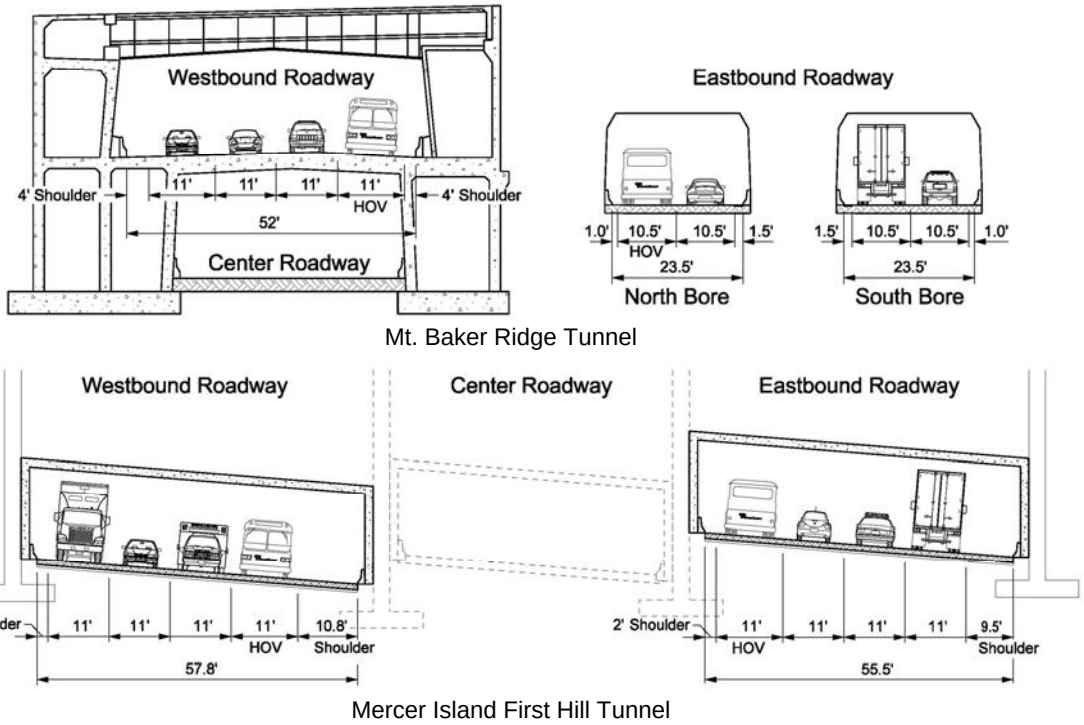


Figure 3
Approved I-90 Tunnel 4-Lane Cross-Sections (Typical)

Design Guidance

Fire and Life-Safety systems for tunnels and limited access highways are prescribed by the 2011 edition of the National Fire Code by the National Fire Protection Association, Inc., NFPA 502 *Standard for Road Tunnels, Bridges and Other Limited Access Highway.* The 2003 *Manual on Uniform Traffic Control Devices* provides guidance for the implementation of highway signs and pavement marking.

National Fire Code, NFPA 502 Standard for Road Tunnels, Bridges, and Other Limited Access Highways

A review of the 2011 edition of the National Fire Code *Standard for Road Tunnels, Bridges, and Other Limited Access Highways* (NFPA 502) provides the guidance summarized below for the life-safety systems in the I-90 tunnels that are relevant to ITS.

Chapter 4 – General Requirements

4.5 Emergency Communications. *Emergency communications, where required by the authority having jurisdiction, shall be provided by the installation of outdoor-type telephone boxes … or other approved devices that meet the following requirements:*

(1) *They shall be made conspicuous by means of indicating lights or other approved markers.*

(2) *They shall be identified by a readily visible number plate or other approved device.*

(3) *They shall be posted with instructions for use by motorists.*

(4) *They shall be located in approved locations so that motorists can park vehicles clear of the travel lanes.*

(5) *Emergency communication devices shall be protected from physical damage from vehicle impact.*

(6) *Emergency communication devices shall be connected to an approved constantly attended location.*

Chapter 7 – Road Tunnels

Tunnel length dictates the minimum fire protection requirements as shown in NFPA 502, Table 7.2. The Mount Baker Ridge and Mercer Island First Hill tunnels are Category D tunnels where the tunnel length equals or exceeds 1,000 m (3,280 feet). The version of Table 7.2, shown as Table 1, is abridged for Category D requirements and focuses on ITS elements.

Table 1
NFPA 502 Table 7.2 Road Tunnel Fire Protection Reference

Fire Protection Systems	NFPA 502 Sections	Provided in Existing I-90 Tunnels	Covered in This Report
Fire Detection			
Detection, ID & Location of Fire	7.4.1	Yes	No
Manual Fire Alarm Boxes	7.4.1.3	Yes	No
CCTV	7.4.1.1	No[1]	Yes[1]
Automatic Fire Detection Systems	7.4.1.4	Yes	No
Fire Alarm Control Panel	7.4.2	Yes	No
Communications			
Radio	7.5	Yes	Yes
Telephone	7.4.5	Yes	Yes
Traffic Control			
Stop Traffic Approaching Tunnel Portal	7.6.1	Yes	Yes
Stop Traffic from Entering Tunnels	7.6.2	Yes	Yes
Fire Protection	Various	Yes	No
Egress			
Emergency Egress	7.15.1.1	Yes	No
Exit Identification	7.15.1.2	Yes	Yes
Tenable Environment	7.15.2	Yes	No
Emergency Exits & Cross-Passageways	7.15.6	No[2]	No
Electrical	Various	Yes	No
Emergency Response Plan	13.3	Yes	No

Note: [1] CCTV surveillance provided for monitoring traffic is used to verify fire conditions. It could be considered as backup for the dedicated fire detection system.
[2] Emergency exits are provided, but do not meet 2011 NFPA 502 Section 7.15.6.2 spacing requirements. This system is discussed in the Fire and Life Safety Systems Modifications Report.

Source: Table 7.2, NFPA 502 2011 edition

The NFPA 502 sections that are relevant to ITS are listed below.

7.4 Fire Alarm and Detection

7.4.1.1 *Closed-circuit television (CCTV) systems with traffic-flow indication devices or surveillance cameras shall be permitted to identify and locate fires in tunnels with 24-hour supervision.*

7.4.1.2 *Ancillary spaces within tunnels defined in categories B, C, and D (such as pump stations and utility rooms) and other areas shall be supervised by automatic fire alarm systems in accordance with 7.4.1.4.*

7.4.1.3 Manual Fire Alarm Boxes

7.4.1.3.1 *Manual fire alarm boxes mounted in NEMA Enclosure Type 4 (IP 65) or equivalent boxes shall be installed at intervals of not more than 90 m (300 ft) and at all cross-passages and means of egress from the tunnel.*

7.5 Communications Systems.

7.5.1 *In new and existing tunnels and ancillary structures, wherever necessary for dependable and reliable communications, a separate radio network capable of two-way radio communication for fire department personnel to the fire department communication center shall be provided.*

7.5.2 *A radio network shall be comprised of base transmitters, repeaters and receivers, antennas, mobile transmitters and receivers, portable transmitters and receivers, and ancillary equipment.*

7.6 Traffic Control.

7.6.1 *All road tunnels, as defined by this standard, shall be provided with a means to stop approaching traffic.*

7.6.2 *Road tunnels longer than 240 m (800 ft) shall be provided with means to stop traffic from entering the direct approaches to the tunnel, to control traffic within the tunnel, and to clear traffic downstream of the fire site following activation of a fire alarm within the tunnel. The following requirements shall apply:*

(1) Direct approaches to the tunnel shall be closed following activation of a fire alarm within the tunnel. Approaches shall be closed in such a manner that responding emergency vehicles are not impeded in transit to the fire site.

(2) Traffic within the tunnel approaching (upstream of) the fire site shall be stopped prior to the fire site until it is safe to proceed as determined by the incident commander.

(3) Means shall be provided downstream of an incident site to expedite the flow of vehicles from the tunnel. Where it is not possible to provide such means, under all traffic conditions, the tunnel shall be protected by a fixed fire-fighting system or other suitable means to establish a tenable environment to permit safe evacuation and emergency services access.

(4) Operation shall be returned to normal as determined by the incident commander.

7.15 Means of Egress.
7.15.1 General.

7.15.1.2 *Reflective or lighted directional signs indicating the distance to the two nearest emergency exits shall be provided on the side walls at distances of no more than 25 m (82 ft).*

7.15.6 Emergency Exits

7.15.6.2 *Spacing between exits for protection of tunnel occupants shall not exceed 300 m (1000 ft).*

Annex B – Tenable Environment

B.2.3 Smoke Obscuration Levels*. Smoke obscuration levels should be continuously maintained below the point at which a sign internally illuminated at 80 lx (7.5 fc) is discernible at 30 m (100 ft) and doors and walls are discernible at 10 m (33 ft).*

Manual on Uniform Traffic Control Devices (MUTCD)

The 2003 Edition of the *Manual on Uniform Traffic Control Devices* (MUTCD) provides guidance on lane-use control signals, but does not specifically address illuminated pavement markers. The 2009 Edition of the MUTCD contains revisions to the 2003 Edition including illuminated raised pavement markers. The State of Washington has not yet adopted the 2009 Edition, but must adopt it within two years. The 2009 Edition should be in effect by the time the Stage 3 project is implemented.

Lane-Use Control Signals

The following excerpts relating to lane-use control signals are taken from the 2003 Edition of the MUTCD.

Section 4J.02 Meaning of Lane-Use Control Signal Indications

A. A steady DOWNWARD GREEN ARROW signal indication shall mean that a road users is permitted to drive in the lane over which the arrow signal indication is located.

B. A stead YELLOW X signal indication shall mean that a road user is to prepare to vacate the lane over which the signal indication is located because a lane control change is being made to a steady RED X signal indication.

E. A steady RED X signal indication shall mean that a road user is not permitted to use the lane over which the signal indication is located and that this signal indication shall modify accordingly the meaning of other traffic controls preset.

Section 4J.03 Design of Lane-Use Control Signals

Nominal minimum height and width of each DOWNWARD GREEN ARROW, YELLOW X, and RED X signal face shall be 18 inches for typical applications.

The color of lane-use control signal indications shall be clearly visible for 700 m (2,300 feet) at all times under normal atmospheric conditions, unless otherwise physically obstructed.

In areas … with minimal visual clutter and with speeds of less than … 40 mph, lane-use control signal faces with nominal height and width of 12 inches may be used for the DOWNWARD GREEN ARROW, YELLOW X, and RED X signal faces …

Illuminated Raised Pavement Markers

The following excerpts summarize the standards and guidance in the 2009 Edition of the MUTCD relative to illuminated raised pavement markers.

Section 3B.11 Raised Pavement Markers

When used, internally illuminated raised pavement markers shall be steadily illuminated and shall not be flashed.

Section 3B.12 Raised Pavement Markers as Vehicle Positioning Guides with Other Longitudinal Markings

Retroreflective or internally illuminated raised pavement markers may be used as positioning guides with longitudinal line markings without necessarily conveying information to the road user about passing or lane-use restrictions. In such applications, markers may be positioned in line with or immediately adjacent to a single line marking ….

Section 3B.13 Raised Pavement Markers Supplementing Other Markings

Raised pavement markers also may be used to supplement other markings such as channelizing islands, gore areas, approaches to obstructions, or wrong-way arrows.

Section 3B.14 Raised Pavement Markers Substituting for Pavement Markings

Retroreflective or internally illuminated raised pavement markers … may be substituted for markings of other types.

Section 3B.23 Curb Markings

Retroreflective solid white markings should be used when traffic is permitted to pass on either side of the island.

Retroreflective or internally illuminated raised pavement markers of the appropriate color may be placed on the pavement in front of the curb and/or on the top of curbs of raised medians and curbs of islands, as a supplement to or substitute for retroreflective curb markings used for delineation.

DETECTION SYSTEM DESIGN

CCTV Cameras

The existing closed circuit television (CCTV) cameras are used for traffic surveillance and confirmation of incidents. The SR 99 Bored Tunnel request for proposals (RFP) proposed both surveillance cameras and incident detection cameras. Adding incident detection capabilities to the CCTV cameras in the I-90 tunnels is proposed for this project. WSDOT requested that all cameras in the tunnels have pan/tilt/zoom functions.

Justification

Incident detection requires full coverage of the traffic lanes and shoulders; to provide full coverage, additional cameras are needed. Incident detection software requires the camera maintain a fixed view. WSDOT's proprietary camera, Cohu 3965, has 64 preset positions that include pan, tilt, zoom, and focus.

Minimum resolution for detecting pedestrians is two pixels per foot. The Cohu cameras will provide more than 3 pixels per foot at 350 feet from the camera.

The November 2010 Value Engineering Study recommended that the cameras in the Mercer Island First Hill Tunnels not be replaced as they were replaced by another project in 2007. The draft 30% ITS design has been modified to keep the existing cameras in this tunnel.

Design

- Replace all existing cameras in the Mount Baker Ridge Tunnel with new analog pan/tilt/zoom cameras to meet WSDOT Northwest Region ITS General Special Provisions. Cameras shall be 3960 series I-View as manufactured by Cohu. The replacement cameras will use existing mounting locations and conduit.

- Relocate four cameras I the Mercer Island First Hill Tunnel and install additional cameras in each tunnel to provide continuous coverage of the tunnel roadways. New structural openings, conduit, and cabinets for the new or relocated camera equipment will be required.

- Camera installation will maintain a vertical clearance of 16.5 feet above the roadway surface.

- Upgrades to existing video switching, archiving and other equipment in the control rooms will be required.

Video Incident Detection

Video incident detection was recommended in the Type, Size and Location (TS&L) report to provide incident and smoke detection capabilities with automatic operator notification.

Justification

Video incident detection is included in the SR 99 Bored Tunnel RFP Technical Requirements as a separate fixed-camera system. Retrofitting the I-90 tunnels with a separate set of fixed cameras for incident detection would double the number of cameras in each tunnel. Section 7.4.1.1 of NFPA 502 permits CCTV system to identify and locate fires in tunnels with 24-hour supervision; however, the I-90 tunnels currently primarily rely on an automatic fire detection system consisting of spot heat detectors.

When provided with pre-set positions, the replacement pan-tilt-zoom cameras should provide adequate incident detection. The video detection will also provide backup for the traffic speed, volume, occupancy, and vehicle classification that is currently supplied by the traffic detection loops.

Design

- Video-based incident detection system software and hardware will be installed in the control rooms to operate with the installed CCTV camera systems.

- The incident detection system will identify and trigger an alarm for: reductions in speed, queues of vehicles, stopped vehicles, debris, pedestrians, and smoke.

Video Fire Detection

Video fire detection was examined at WSDOT's request. Video fire detection has a detection range of 150-200 feet based on a one-foot pan fire. The system requires the use of fixed-type cameras and would require a separate set of cameras, conduit, cabinets, software, and integration into the fire-life-safety systems. This system is not included in the 30 percent ITS plan submittal.

A white paper has been issued discussing video and other forms of supplemental fire detection for the I-90 tunnels. The white paper recommended that the existing pan/tilt/zoom cameras be replaced with a video fire detection system with fixed cameras in both directions for each fire zone to supplement the existing spot heat detection system.

Two-way fixed cameras for video fire detection at every fire would provide complete visual coverage of the tunnel roadway and could reduce CCTV requirements and associated costs. The video image can be used for surveillance operations if the pan/tilt/zoom function is not a requirement. The image can also be used by the incident detection software.

Vehicle Detection

The project will restripe the lanes in the outer roadways to accommodate a 4th lane. New induction loops will be installed to keep the loops centered within the restriped lane lines. Westbound Mount Baker Ridge roadway is on structure through the bored tunnel section. In this section, alternative methods of detection other than induction loops were investigated. Sensys Networks magnetic detectors were recommended as the best alternative solution.

Justification

Within the portion of the westbound Mount Baker Ridge roadway that is on structure, the existing loops were cut into the roadway pavement in a shallow, half-inch-deep configuration before a 1½-inch latex modified concrete wearing course was installed. This resulted in three inches of cover over the structural reinforcement. Traffic movement since 1992 has worn this cover to less than three inches. Sawcutting new loops to the standard 2½-inch to 3-inch depth could potentially damage existing structural reinforcement.

Sensys Networks magnetic sensors have statewide blanket proprietary approval for use in highway projects. The installation of a magnetic detector requires a 4-inch-diameter by 2¼-inch-deep cored hole in the center of each lane. The hole is then filled with epoxy and the encapsulated magnetic detector. The epoxy cover over the encapsulated detector is ¼-inch to ½-inch thick.

Radar and video detection sensors mounted to the side of the roadway would be subject to occlusion of traffic in the far lanes due to truck traffic in the near lanes.

Design

- New detection loops will be cut near existing loops and centered between new lane lines. Existing loops will be abandoned in place.
- Lane lines will not be shifted in the eastbound Mount Baker Ridge Tunnel north twin-bore and existing loops will not be replaced.
- Speed loop and data loop location spacing will remain as currently configured.
- Existing barrier junction boxes and conduit will be used to pull loop lead-in cables from roadway to existing 170 controllers. Saw cuts will be made near the face of the barrier to reach existing junction boxes from new loop locations.
- Sensys magnetic sensors will be installed on the westbound Mount Baker Ridge Tunnel bored structure in lieu of cutting new loops.

COMMUNICATION SYSTEM DESIGN

Emergency Fire-Telephone Cabinets

Emergency fire-telephone systems include the fire-telephone cabinets and associated signs. Each cabinet contains an emergency telephone, a fire extinguisher, and a fire alarm pull station per NFPA 502 Section 7.4.1.3.1.

Existing fire-telephone cabinets are installed at a nominal 300-foot spacing on both sides of all tunnel roadways except the eastbound Mount Baker Ridge south twin-bore. The existing south twin-bore has fire-telephone cabinets on only the south wall next to a 9.5-foot-wide shoulder (see

Figure 2). The project will add a second lane to the south twin-bore making it identical in configuration to the north twin-bore (see Figure 3).

Signs marking the location of each fire-telephone cabinet were designed to be mounted perpendicular to the wall, but be narrow enough to avoid being struck by the mirror of a vehicle. The original sign mounts are double-leaf spring-loaded hinges.

Justification

The location of emergency telephones on both sides of a tunnel is not required by NFPA 502. However, for a motorist with a breakdown on the left-hand lane, the installation of emergency telephones, extinguishers, and alarm pulls on the north wall would eliminate the need to cross an active lane of traffic to reach the emergency devices on the south wall.

The replacement of the existing telephone handset in each existing cabinet with a speaker-phone would provide a secondary, supplemental means of emergency communications as part of the integrated mass notification system. This speaker would not be audible in all areas of the tunnel roadways. However, the speaker-phones, located along the egress paths by the tunnels walls, would reinforce and supplement visual messages provided by the traffic control signs and egress signage.

Over time, the spring-loaded hinges used as sign mounts have filled with dirt and no longer return the sign to the perpendicular orientation. The SR 99 Bored Tunnel RFP includes low-profile triangular signs to mark fire-telephone cabinets. WSDOT has requested that the existing signs in the I-90 tunnels be replaced with similar signs.

Design

- The telephone handsets will be replaced with speaker-phones in each existing emergency fire-telephone cabinet. The speaker-phone will be flush-mount in the existing cabinet door with the door bolted closed, or the door will be replaced with the flush-mount speaker-phone.

- Five additional fire-telephone cabinets with flush-mount speaker-phones will be installed on the north wall of eastbound Mount Baker Ridge south twin-bore.

- New structural openings, conduit, and wiring for the speaker-phone and fire alarm pull station in the new fire-telephone cabinets will be required.

- Low-profile triangular fire-telephone signs will be installed above each new and existing fire-telephone cabinet.

Mass Notification

An integrated mass notification system provides visual and audible messages to motorists during emergencies.

Justification

A mass notification system is not required by NFPA 502, however, representatives of the Seattle Fire Department have suggested that the system should be considered. NFPA 72 provides requirements for the installation of a mass notification system.

The original RFP for the SR 99 Bored Tunnel included requirements for a mass notification system. Subsequent amendments have removed this requirement and replaced it with addressable speakers at each emergency telephone. Our understanding is that this substitution is related to the difficulty of providing a speaker system in a roadway tunnel environment. The SR 99 tunnel will also include AM/FM radio rebroadcast and override.

The Value Engineering Study recommended that the ceiling-mounted speakers at 20-foot spacings included in the draft 30% ITS design be eliminated.

Similar to the SR 99 Bored Tunnel, the I-90 tunnels will include an integrated system of multiple types of visual and voice notification. Primary visual mass notification will be provided by electronic variable message signs. Secondary audible mass notification will be provided by paging emergency speaker-phones that will replace existing emergency telephone handsets. Existing AM/FM radio rebroadcast and override systems in the I-90 tunnels will be maintained. The mass notification systems for the I-90 tunnels will include the following elements:

Visual Notification

- Electronic traffic control signs (see page 13)
- LED and strobe lights at egress doors and portals (see page 19)
- Static egress signage (see page 19)

Audible Notification

- Emergency speaker-phones with mass paging capability (see page 10)
- Existing AM/FM radio rebroadcast and override (see page 13)

Design

- Speaker-phones will be installed to replace the existing telephone handsets in each existing emergency fire-telephone cabinet.
- New emergency fire-telephone cabinets will include speaker-phones.
- Messages will be both prerecorded and sent from a local microphone.
- Each lane control sign will be able to display a four-to-six-character word to create four-word messages.
- Each tunnel control sign will be able to display messages 16-18 characters long.
- LED lights will outline and a strobe light will be located above each exit door.

- Strobe lights will be located above the traffic barrier on each side of each exit door as well as at each tunnel portal on the exit door side.

- Static egress signs with distances to exits will be installed at nominal 80-foot spacing on the exit door walls of each tunnel.

Radio Rebroadcast

The existing radio rebroadcast system meets NFPA 502 Section 7.5.1 and will be maintained and protected during the installation of other systems within the tunnels.

TRAFFIC CONTROL SYSTEM DESIGN

LED Traffic Control Signs

LED traffic control signs within the tunnels will consist of lane control signs (LCSs) and tunnel control signs (TCSs). The LCSs will replace existing traffic signals that are mounted horizontally to the tunnel ceilings at 500-foot to 600-foot spacings. The typical traffic signal installation has two signals with 12-inch lenses mounted over three lanes. Additional signals are located over merging ramp lanes.

In the eastbound Mount Baker Ridge twin-bores, signals with 8-inch lenses are mounted over each lane. The signals are mounted in 2-inch-deep notches in the ceiling such that no more than nine inches of the signal housing extends below the ceiling.

With the exception of the eastbound twin-bore tunnels, vertical clearances within the Mount Baker Ridge Tunnels range from 18.5 feet to over 19 feet. Vertical clearance in the Mercer Island First Hill Tunnels is 18 feet.

Justification

Both LCSs and TCSs are required by the RFP for the SR 99 Bored Tunnel. To provide consistency between the major roadway tunnels in the region, the Technical Requirements included in the RFP were used as guidelines for the retrofit design in the I-90 tunnels. These signs support the NFPA 502 Section 7.6 requirement to stop traffic approaching a fire and expedite the flow of vehicles downstream of an incident site. These signs also provide a continuation of the Active Traffic Management System through each tunnel, which should reduce the risk of congestion and/or incident-related crashes within the I-90 tunnels.

Due to the nominal 18-foot vertical clearance in the Mercer Island First Hill Tunnels and the bored section of the westbound Mount Baker Ridge Tunnel, the display area of the LCSs will be limited to a 12-inch height. This allows for 12-inch-high characters or symbols. This is less than the 18-inch height required by the MUTCD for lane-use control signals in typical applications. The proposed height would be consistent with the MUTCD guidance for installation with minimal visual clutter and speeds less than 40 mph, since these signs would primarily be used to manage incidents when the ATM system would be displaying reduced speed limits.

WSDOT has requested that the signs be as wide as possible to allow for short messages or graphics such as chevrons. WSDOT has also requested that the sign width allow maintenance access without requiring a full closure of the affected tunnel. The width of ceiling-mounted signs in the I-90 tunnels is limited by the location of existing and proposed lighting fixtures and associated wireways. The width of the sign should allow 12-inch lane control symbols to be positioned near the center of both existing and proposed lanes.

A 15-inch display height was investigated, but the sign manufacturers could not provide a 15-inch display area within an 18-inch-high sign housing.

The eastbound Mount Baker Ridge Tunnel twin-bore ceilings have an existing vertical clearance of 16.75 feet. Any equipment mounted on the ceilings of the twin-bores can have no more than a 9-inch height and maintain a minimum vertical clearance of 16 feet. A low-profile LCS would have to have character heights that are less than six inches. An alternative of replacing the existing signal lenses with green arrows, red Xs and yellow Xs would not be in compliance with the 2003 MUTCD Section 4D.15 which restricts arrow signal indications to 12-inch signal lenses.

TCSs will be installed in areas where the existing vertical clearance will allow a 24-inch-high sign housing. These signs will allow for more motorist information than can be displayed on the LCSs. The width of the TCSs will be controlled by the location of the tunnel lighting fixtures.

Design

- Four-foot-wide by 18-inch high LCSs with 3.5-foot-wide by 12-inch-high, full-color, full-matrix LED sign displays will be installed for lane control. These LCSs will replace the existing ceiling-mounted traffic signals in all tunnels except the eastbound Mount Baker Ridge Tunnel twin-bores. Character and symbol heights will be 12 inches.

- The existing signal installations in the eastbound Mount Baker Ridge Tunnel twin-bores are located over each proposed lane of traffic and will be maintained in their current configuration.

- Additional LCSs between the existing signal locations are required in the Mercer Island First Hill Tunnel due to horizontal sight distance restrictions created by the tunnel walls.

- The height of all LCS sign housings will maintain a minimum of 16.5 feet of vertical clearance from the roadway surface to the bottom of the signs.

- Three 14-foot-wide by 24-inch-high TCSs with 13.5-foot-wide by 18-inch-high, full-color, full-matrix LED sign displays will be installed for traffic control in the eastbound Mount Baker Ridge Tunnel before the beginning of the gore for the twin-bore lane split. Character and symbol heights will be 18 inches. Existing vertical clearance to the ceiling at this location is greater than 19 feet; a minimum of 16.5 feet of vertical clearance to the bottom of the sign housings will be maintained.

- LCS and TCS signs inside the tunnels will be installed on ceiling mounted brackets and will allow for quick disconnect and removal for sign maintenance or replacement.

Active Traffic Management System (ATMS)

The ATMS design-build project in the I-90 corridor calls for the mounting of LED signs on the eastbound Mercer Island First Hill Tunnel portal face. Additional ATM signs will be mounted to the portal faces of the westbound Mercer Island First Hill Tunnel and the eastbound Mount Baker Ridge Tunnel. These signs will be mounted above the tunnel closure sign that is also on the tunnel portal. The ATMS project will locate ATM signs on the west highrise of the floating bridge about 1,450 feet in front of the westbound Mount Baker Ridge Tunnel portal. The artwork on this portal precludes the installation of signs on the portal face.

Justification

Mounting full-size LED signs on the other tunnel portal faces will provide motorists with ATM information at the beginning of each tunnel. This information can then be supplemented by the reduced-size LCSs within the tunnels.

Design

- ATM signs, as used for the ATMS project, will be installed on the portal faces for the eastbound Mount Baker Ridge and westbound Mercer Island First Hill tunnels.
- A fourth sign will be installed on the portal face of the eastbound Mercer Island First Hill Tunnel.
- Mounts for the ATM signs on the portal faces will resemble the top of sign bridges positioned horizontally. The mounts will be located in front of the fractured-fin finished portion of the portal faces.

Illuminated Pavement Markers and Guide Signs

Illuminated pavement markers and illuminated guide signs will be installed in the Mount Baker Ridge Tunnel.

Justification

The Record of Decision (ROD) for the project Environmental Impact Statement provides a list of mitigation measures that will be implemented. Under Enhanced Delineation and Signing, the ROD states, "*The feasibility of installing illuminated pavement markers in the lids and tunnels will be investigated further as a part of final design, including consideration of trade-offs with potential tunnel lighting enhancements.*"

With the proposed enhancements to the interior tunnel lighting, profiled striping will provide good lane delineation. At the gore area in the eastbound Mount Baker Ridge Tunnel, the four-lane mainline will split with two lanes entering the north twin-bore and two lanes entering the south twin-bore. Illuminated pavement markers, employed as supplemental raised pavement markers, will enhance delineation for this mainline split and guide motorists toward the twin-bores and away from the median obstruction.

MUTCD Section 3B.12 allows the use of internally illuminated raised pavement markers as positioning guides with longitudinal line markings. Section 3B.13 allows the use of raised pavement markers to supplement other markings such as gore areas.

The ROD also states, "*Additional illuminated guide signs westbound in the Mount Baker Ridge lid could give motorists more time to change lanes for the Rainier Avenue South and I-5 exits.*" The first of two Rainier Avenue exits is within 400 feet of the westbound Mount Baker Ridge Tunnel exit portal. Motorists currently have inadequate advance notification of these exits.

The SR 99 Bored Tunnel RFP Technical Requirements state, "*Internally illuminated signs shall use light emitting diode (LED) edge-lit technology …*" The Technical Requirements also state, "*The minimum mainline spacing is 100 feet between sequential guide sign panels in a given series.*" In the westbound Mount Baker Ridge Tunnel, two series of four illuminated sign panels will represent advance guide signs for the northbound and southbound Rainier Avenue exits.

Design

- Illuminated pavement markers will be installed on the edge lines delineating the gore for the eastbound mainline lane split in the Mount Baker Ridge Tunnel based on Standard Plan M-2.40-01. The illuminated markers will be spaced at 20 feet on-center through the gore area and 40 feet on-center past the impact attenuator and into the twin-bores.

- Illuminated signs will be 24-inch-high by 10-foot-wide LED edge-lit signs. These signs will allow 18-inch-high characters. Tunnel vertical clearance at this location is greater than 19 feet; a minimum of 16.5 feet of vertical clearance to the bottom of the sign housings will be maintained.

- Four illuminated signs in series will represent the four lines of legend in a standard advance guide sign, and will be spaced 100 feet apart.

- The 10-foot sign width will facilitate maintenance by limiting lane closures when accessing a sign.

Tunnel Closure Signs

Tunnel closure signs include tunnel closure signs in advance of the entrance portals that warn motorists of tunnel closures. These signs are normally blank and only display a message when it is needed.

Three sets of tunnel closure signs are located on the roadways approaching each tunnel entrance. These signs are typically paired on each side of the roadway, but are also found on entrance ramps that are near entrance portals. A closure sign is also attached to the face of each tunnel entrance portal. The existing signs are neon, except where signs have been replaced in conjunction with the Stage 1 roadway widening (see Table 2).

Where either sign of an existing set was impacted by the Stage 1 project roadway widening, both neon signs were replaced with LED signs. Neon sign sets that were not impacted by the roadway widening were not replaced.

Table 2
Neon Signs by Roadway and Type

Roadway Segment	Signs Type A	Signs Type B	Signs Type C	Portal Signs
Mount Baker Ridge Tunnels				
Eastbound Outer Roadway	**2**	**2**	**2**	**1**
Eastbound Rainier Av On-Ramps	**4**	**2**	**2**	**-**
Westbound Outer Roadway	**2**	**2**	2[1]	**1**
Mercer Island First Hill Tunnels				
Eastbound Outer Roadway	**2**	**2**	**2**	**1**
Westbound Outer Roadway	2[1]	2[1]	2[1]	**1**
Westbound 76th Av On-Ramp	**1**	-	1[1]	-
Replacement Sign Totals	**11**	**8**	**6**	**4**

Note: [1] Neon signs that have already been replaced with LED signs in Stage 1.
Signs in boldface will be replaced.
Source: HNTB Corporation, 2010

Justification

Neon signs break easily during routine maintenance and require careful handling. WSDOT has asked that all neon tunnel closure signs be replaced with LED signs.

The Type A and B tunnel closure signs for the Mount Baker Ridge Tunnel on the westbound floating bridge are currently mounted on the north and south sides of the floating pontoons. When light rail is operating in the center roadway, the south side sign will be obscured from westbound traffic. This sign needs to be moved to the barrier between the westbound and center roadways.

Design

- Assume all Type A, B, C, and portal neon tunnel closure signs will be replaced. Twenty-nine existing neon signs will be replaced with LED signs as indicated in Table 2.

- Other ground-mounted neon signs, one near the eastbound Mount Baker Ridge Tunnel portal on the Rainier Avenue on-ramp and two near the westbound Mercer Island First Hill Tunnel portal on the 76th Avenue on-ramp will have their functionality replaced by ATM signs mounted on the portal face. These signs will be removed and they will not be replaced.

- New ground-mounted LED signs will be similar to the signs installed in Stage 1.

    - Type A signs will have red LEDs, 9-inch characters, 34mm pixel spacing
    - Type B signs will have red LEDs, 12-inch characters, 46mm pixel spacing

- Type C signs will be full-color, full-matrix, 34mm pixel spacing

- The existing Type A and B signs on the north side of the westbound floating bridge will be replaced and new signs will be installed on the barrier between the outer and center roadways to provide paired sets of tunnel closure signs for the outer roadway.

- The existing Type A and B signs on the south side of the westbound floating bridge will be maintained and remain operable as long as the center lanes are used for vehicular traffic.

- Twenty-foot-wide by 18-inch-high, full-color, full-matrix LED sign displays will be installed at each portal to replace the existing neon tunnel closure signs. Character and symbol heights will be 18 inches; the sign housings will be 24 inches high.

- New LED cabinets will be installed near the new signs in most locations.

- Six-strand fiber optic cable will provide communication from the new LED cabinets to the tunnel control rooms.

Tunnel Closure Gates

Tunnel closure gates are gates located near the entrance portals that will close the roadway and prevent vehicles from entering the tunnel. The existing gates are manually operated and are currently locked in the open position.

Justification

NFPA 502 Section 7.6.2 requires a means to stop traffic from entering tunnels in such a manner that responding emergency vehicles are not impeded. Automatic gates can be activated by the tunnel operator remotely or locally after an incident has been verified and tunnel closure procedures have been initiated.

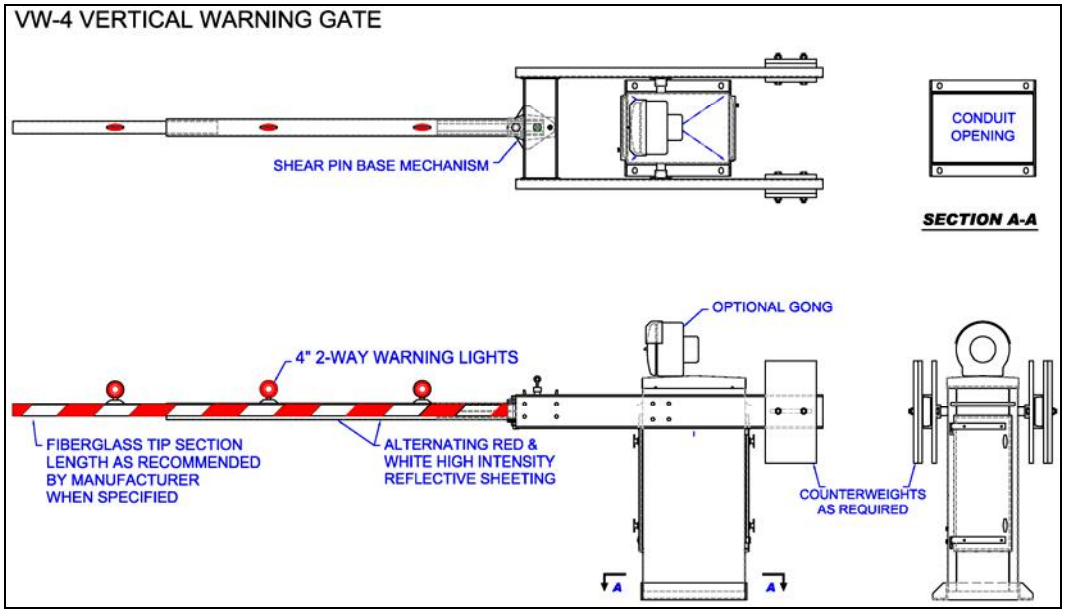
Automatic horizontal swing gates are included in the SR 99 RFP and the following procedure is given:

> "*The gates will be operable locally, either manually or via an actuator, and the gates will be capable of being operated remotely from the primary and secondary tunnel operations control centers. Remote operation will not be automatic and will require verification that it is safe to open or close the gates.*"

A horizontal swing gate could become inoperable if traffic is stopped in the lane next to the gate's location. A vertical drop-arm gate, as shown in Figure 4, would have a limit switch to stop the motion if an object is in the way. A vertical drop-arm could also be lifted to allow emergency vehicles to pass. A shear pin mechanism would minimize damage to the gate and the vehicle in the event of a collision.

Design

- Automatic vertical gates will be installed on the mainline and ramp roadways in front of each tunnel entrance portal.
- New gate control cabinets will be installed at each tunnel entrance portal.
- Six-strand fiber optic cable will provide communication from the new gate control cabinets to the tunnel control rooms.
- Gate locations will be coordinated with emergency and maintenance access points.



Source: B&B Roadway, 2010

Figure 4
Typical Automatic Vertical Drop-Arm Gate

EGRESS SYSTEM DESIGN

Proposed egress systems will provide enhancements to exit delineation, including strobe lights, LED outlines, and signs at each exit door. Signs indicating the direction and distance to each exit will also be provided.

Existing emergency exit doors are located near the center of each tunnel. Signing and other existing delineation of these exits is not conspicuous and could result in difficulty locating the exits in an emergency evacuation situation.

Justification

NFPA 502 Section 7.15.1.2 requires directional signs indicating the distance to the two nearest emergency exits on the side walls at distances of no more than 82 feet. These signs are not currently provided within the I-90 tunnels.

Green strobe lights, green LEDs outlining exit doors, directional signs with distances to the two nearest exits, and exit door signs are all included in the SR 99 RFP Technical Requirements. The directional signs and exit door signs include the International Standards Organization (ISO) green "Running Man" symbol. The proposed upgrades included in the I-90 project are consistent with the SR 99 RFP and provide similar sign sizes.

Design

- Green strobe lights will be mounted over each exit door and on the wall above the barrier on the exit door side of each tunnel portal. Wide portals will have strobe lights on both sides of the tunnel.
- Exit doors will be outlined in green LEDs.
- Exit signs will be vertical, low-profile, and illuminated with an emergency power circuit.
- Seven-foot-high ISO "Running Man" reflective signs will be installed at each exit door.
- Five-foot-high ISO "Running Man" reflective signs with distances to exit doors will be installed at nominal 80-foot spacing on the exit door walls of each tunnel.

POWER REQUIREMENTS

Every electrical panel within the I-90 tunnels has two sources of power. Therefore, by definition, all of the ITS devices are connected to emergency power. Uninterrupted power supplies provide critical power for specifically identified equipment. Critical equipment requiring uninterrupted power supply will be determined during final design.

Existing service panels will provide power for the tunnel closure sign replacements and the automatic closure gates. These panels are as follows:

- SUA 3090 West of Mount Baker Ridge Tunnel
- SUA 3176 East of Mount Baker Ridge Tunnel
- SUA 3281 West of Mercer Island First Hill Tunnel
- SUA 3162 East of Mercer Island First Hill Tunnel

Preliminary calculations show that all panels should have adequate capacity for the increased loads. Final design will verify that spare capacity is available.

DEVIATIONS

The 12-inch-high LED matrix of the LCSs will not display the 18-inch symbols per 2003 MUTCD Section 4J.03 for typical applications. A deviation to the MUTCD may be required.

ESTIMATES OF PROBABLE COSTS

The estimates of probable cost are based on equipment vendor budgetary costs and preliminary estimates of the required labor and support structures. Costs include estimated contractor overhead and profit.

Table 3
Probable ITS Construction Costs – Mt. Baker Ridge Tunnel

ITS Equipment	Eastbound	Westbound	Total
Detection			
CCTV Camera Replacement	$490,000	$270,000	$760,000
Incident Detection Software	$160,000	$90,000	$250,000
Vehicle Detection	$90,000	$140,000	$230,000
Communication			
Mass Notification System	$40,000	$40,000	$80,000
Emergency Fire-Telephone Cabinets	$110,000	$0	$110,000
Traffic Control			
LED Signs (LCS, TCS, & ATM)	$800,000	$680,000	$1,480,000
Illuminated Pavement Markers	$150,000	$0	$150,000
Illuminated Guide Signs	$0	$80,000	$80,000
Tunnel Closure Sign Replacement	$1,030,000	$300,000	$1,330,000
Automatic Tunnel Closure Gates	$200,000	$130,000	$330,000
Egress			
Emergency Signing	$260,000	$240,000	$500,000
Exit Door Lighting	$60,000	$30,000	$90,000
Total Mt Baker Ridge Systems	*$3,390,000*	*$2,000,000*	*$5,390,000*

Note: Costs in 2010 dollars do not include mobilization, sales tax, construction engineering and contingencies, or preliminary engineering (PE).
Source: HNTB Corporation, 2010

Table 4
Probable ITS Construction Costs – Mercer Island First Hill Tunnel

ITS Equipment	Eastbound	Westbound	Total
Detection			
CCTV Camera Replacement	$110,000	$120,000	$230,000
Incident Detection Software	$90,000	$95,000	$185,000
Vehicle Detection	$70,000	$115,000	$185,000
Communication			
Mass Notification System	$30,000	$30,000	$60,000
Traffic Control			
LED Signs (LCS, TCS, & ATM)	$950,000	$1,240,000	$2,190,000
Tunnel Closure Sign Replacement	$440,000	$130,000	$570,000
Automatic Tunnel Closure Gates	$130,000	$170,000	$300,000
Egress			
Emergency Signing	$200,000	$210,000	$410,000
Exit Door Lighting	$40,000	$60,000	$1400,000
Total Mercer Island First Hill Systems	*$2,060,000*	*$2,170,000*	*$4,230,000*

Note: Costs in 2010 dollars do not include mobilization, sales tax, construction engineering and contingencies, or preliminary engineering (PE).
Source: HNTB Corporation, 2010

A number of design changes have affected the estimate of probable ITS construction costs since the TS&L report was submitted on May 11, 2010. These changes include the following:

- During the CEVP discussions, the Contractor's labor rate was increased 20 percent.
- Conduit pricing was augmented to account for epoxy-coated or stainless steel installations as specified for the original construction.
- Additional cameras were needed to provide full-coverage for incident detection. A structural opening and steel box were added for each new camera.
- The cost for structural openings was added to the fire-telephone cabinet installations.
- The cost to replace all of the fire-telephone cabinet wall signs in both tunnel outer roadways was added.
- Two type A tunnel closure signs on the Rainier Avenue on-ramp had been overlooked and two new tunnel closure signs were added to the westbound floating bridge.
- The lane control signs were changed from single symbols to 4-foot-wide full-matrix, full-color LED signs. Three larger tunnel control signs were also added.
- ATM signs were added to the tunnel portal faces for eastbound Mount Baker Ridge and westbound Mercer Island First Hill.

- The illuminated guide signs for the westbound Mount Baker Ridge Tunnel were not included in the ITS TS&L, but are included in the 30% design.

- The current FHWA interpretation of the Buy American provision specifically affected the cost of automatic closure gates.

- The Value Engineering Study recommendations deferred the replacement of existing CCTV cameras in the Mercer Island First Hill Tunnels and eliminated the ceiling-mounted speakers for the mass notification system.

SYSTEM OPERATION

The ITS modifications and upgrades described in this Design Summary would operate in conjunction with the I-90 tunnel fire and life safety systems as well as with existing traffic management systems operated by WSDOT in the Northwest Region. Both the traffic management and tunnel systems are primarily controlled from WSDOT's Northwest Region Traffic Systems Management Center (TSMC) that is currently located in WSDOT's Dayton Avenue facility. The tunnel systems can also be controlled from the tunnel control rooms in the Mount Baker Ridge and Mercer Island First Hill tunnels.

Traffic Management Mode

When no tunnel incidents are in effect, the tunnel ITS would operate in traffic management mode and would be controlled remotely from the TSMC. The traffic control devices would be integrated with the corridor-wide active traffic management (ATM) systems, which include dynamic message signs capable of displaying lane control symbols, variable speed limits, and motorist information messages. The ATM signs are spaced at approximately half-mile intervals upstream of the I-90 tunnels between I-5 and I-405. The tunnel ITS devices would perform the functions listed below.

Detection

- **Loops and wireless sensors** would collect traffic data, monitoring traffic flow within the tunnels in the same manner as the existing sensors in the I-90 tunnels.
- **CCTV cameras** would be used for traffic surveillance and incident detection, the latter by way of incident detection software that would alert the TSMC operator to incidents within the I-90 tunnels.

Traffic Control

- **Lane control and active traffic management signs** would display speed limits or traffic control symbols controlled by the existing ATM operating system. The normal mode of operations for these devices would be a blank display with reduced speed limits or traffic control symbols typically displayed only in reaction to a downstream incident in the I-90 corridor,. The TSMC operator could also utilize the lane control and active traffic management signs to close lane(s) upstream of disabled vehicles in the tunnels or tunnel maintenance operations. The signs would supplement the traffic control measures

implemented by Washington State Patrol or other emergency responders, WSDOT's incident response vehicles, and/or maintenance work zone traffic control.

- **Tunnel control signs** would provide traveler information about traffic conditions, be controlled by the TSMC and supplement other systems outside of the tunnels.

Communications

- **Speaker-phones** at tunnel fire emergency cabinets would be available for motorists needing assistance.

Tunnel Incident Mode

When a tunnel incident occurs, such as a fire, that requires activation of the tunnel fire and life safety systems, operation of the tunnel ITS would be controlled by the tunnel operator at the TSMC or from the tunnel control room in coordination with the TSMC. The tunnel ITS devices would perform the functions described below.

Detection

- **CCTV cameras with incident detection software** would notify the TSMC and tunnel operators if smoke were detected by these systems. The tunnel operator could utilize the tunnel CCTV cameras to verify the presence and location of a fire in the tunnels, and then manually activate the appropriate fire and life safety systems.

If a fire incident were detected in an I-90 tunnel, either by the automatic fire detection system with the Simplex tunnel fire alarm system entering a "pre-alarm" state or through notification of and manual intervention by the tunnel operator, the sequence of actions described below would occur. With the exception of the ATM signs, these devices would be controlled or, if automatically activated, monitored by the tunnel operator through the tunnel control system.

Traffic Control

- **Active traffic management (ATM) signs** on and in advance of the tunnel portal would be activated by the TSMC operator to display messages to slow traffic upstream of the tunnel. If congested traffic conditions exist within or downstream of the tunnel, the ATM systems downstream of the affected tunnel could be used to display messages to motorists to facilitate clearing space to allow evacuation of vehicles in the tunnel. Strategies could include instructing motorists to clear a path for evacuating traffic by exiting to surface streets or using shoulder areas. Similarly, the ATM could be used to facilitate emergency response activities by closing lanes for use by emergency responders.
- **Tunnel closure signs** at the entrance portal would turn on.
- **Lane control signs and traffic control signals** within the tunnels would begin a closure sequence upstream of the fire location while displaying green or lane-open signals downstream of the fire.
- **Tunnel closure gates** would drop upstream of the affected tunnel portal.

Communication

- **AM/FM radio rebroadcast system** would be overridden with emergency messages.

- **Lane control signs** would display four-word messages at each sign location advising tunnel occupants of the appropriate action for the particular incident.
- **Tunnel control signs** would display supplemental messages 16-18 characters long.
- **Speaker-phones** would broadcast emergency messages that would be heard by pedestrians utilizing the egress routes along the tunnel shoulders to the emergency exits.

Egress

- **Static signing** on the tunnel walls would advise evacuees of the direction and distance to the closest emergency exit point.
- **Strobe lights** next to exit doors and portals would activate.
- **LED lights** outlining the exit doors would turn on.

OUTSTANDING ISSUES

A few design issues have not been resolved as of this design summary. These include vehicle detection using magnetic detectors, conduit type, mass notification system, coordination with the ATMS project, tunnel closure signs, and system integration.

Sensys Installation

The 30% design for traffic detection in the westbound bored section of the Mount Baker Ridge Tunnel assumes the installation of Sensys detectors in lieu of sawcutting induction loops. The final design of this traffic detection is pending approval by the WSDOT Bridges and Structures Office.

Conduit and Hardware in Tunnels

The specifications for the original construction of both I-90 tunnels require epoxy-coated or stainless steel conduit and associated boxes, fittings, clamps, mounting hardware, etc. in the utilidors, air supply and exhaust ducts, transformer area, and fan rooms. The existing conduit in the Mount Baker Ridge Tunnel utilidors is either PVC-coated or stainless steel; existing conduit in the Mercer Island First Hill Tunnel utilidors is epoxy-coated or stainless steel with some intermediate metal conduit. All boxes, fittings and hardware appear to be stainless steel in both tunnels.

NFPA 502 Section 12.3.2 does not allow PVC coatings on exposed metallic raceways in a road tunnel and ancillary areas. Per NFPA 502, wiring and cable in supply air ducts shall be installed in intermediate metal conduit or rigid metal conduit without an overall nonmetallic covering.

The 30% cost estimate assumes epoxy-coated conduit in utilidors and stainless steel conduit in exposed tunnel areas and air ducts with an allowance for stainless steel boxes, fittings and hardware. At WSDOT's direction, the conduit could be changed to rigid galvanized steel. The estimate does not include costs to retrofit existing PVC-coated conduit.

Tunnel Closure Signs

The 30% design assumes the Type A, B, and C tunnel closure sign specifications will be similar to the signs installed in Stage 1. The Stage 1 sign manufacturer has updated their sign technology and the design is based on available signs that most closely match the Stage 1 signs. The material, type, and configuration of these signs has not been verified by WSDOT.

The replacement portal signs were sized to match the existing 18-inch high by 20-foot wide display size and physical sign housing limitations. The height is limited by the portal overhang, but these signs could be wider if desired.

The 30% design assumes the functionality of the ground-mounted neon signs on the Rainier Avenue and 76th Avenue on-ramps near the tunnel portals will be replaced by the ATM signs mounted on the portal faces. This assumption has not been verified with WSDOT. The costs to replace these closure signs in addition to the ATM signs were included in the CEVP totals for Stage 3. These replacement costs are **not** included in Table 3 and Table 4.

Systems Integration

The ITS systems will need to be integrated with the control systems that are being analyzed in conjunction with the tunnel Fire and Life Safety systems. Consequently, design within the tunnel control rooms is not included in the ITS 30% design or estimates of probable construction cost. Communication between systems needs to be established at both the tunnel operations level and the Northwest Region traffic management level. Integration of the ITS systems with the tunnel control systems will be done during final design.

Coordination with Other Projects and Disciplines

A number of project elements will need to be coordinated with the following projects and disciplines.

Active Traffic Management System (ATMS) Project

- Coordination with the ATMS project is needed to provide similar attachment of ATM signs to the tunnel portals. The 30% design assumes a monotube-type mount on the fractured-fin finished portion of the portal faces.

- The ATM sign type, material, and configuration was obtained directly from the manufacturer of the signs. These specifics need to be verified.

- The ATMS project RFP calls for removal of the pair of eastbound Type B mainline tunnel closure signs west of the Mount Baker Ridge Tunnel. This implies that the closure sign function could be transferred to the signs to be mounted on the gantry uprights. The 30% design includes the replacement of these signs and the associated costs.

- Communication systems for the ATM signs need to be integrated with tunnel operations and with the ATM operations that are controlled by Northwest Region Traffic Systems Management Center (TSMC).

Sound Transit East Link Project

- New conduit will be routed above the center roadway suspended ceiling. Existing conduit is already routed above this ceiling.

- Access to utilidors above the center roadway needs to be maintained both during and after construction of the East Link.

Illumination

- The location of ceiling-mounted LED signs needs to avoid existing and proposed tunnel lighting fixtures and associated wireways.

- Provisions for illumination of exit door signs need to be included.

Mechanical

- The location of ceiling-mounted LED signs needs to be coordinated with existing and proposed fire suppression modifications.

- The location of ceiling-mounted LED signs and cameras needs to be coordinated with any proposed structural openings for fans and dampers.

Structural

- The design of structural openings and enclosures for additional cameras needs to be completed.

- The design of structural openings for fire-telephone cabinets in the eastbound Mount Baker Ridge Tunnel south twin-bore needs to be completed.

Channelization and Roadway Widening

- The location of ground-mounted tunnel closure signs and automatic vertical drop-arm gates may need to be adjusted depending on roadway widening or lane modifications.

- The location and number of ATM signs to be mounted on the eastbound Mount Baker Ridge Tunnel and westbound Mercer Island First Hill portal faces will depend on the phasing of the lane configuration.

- The location of lane control symbols on the LCSs within the tunnels will be dependent on the phasing of the lane configuration.