



Alaskan Way Viaduct **REPLACEMENT** PROGRAM

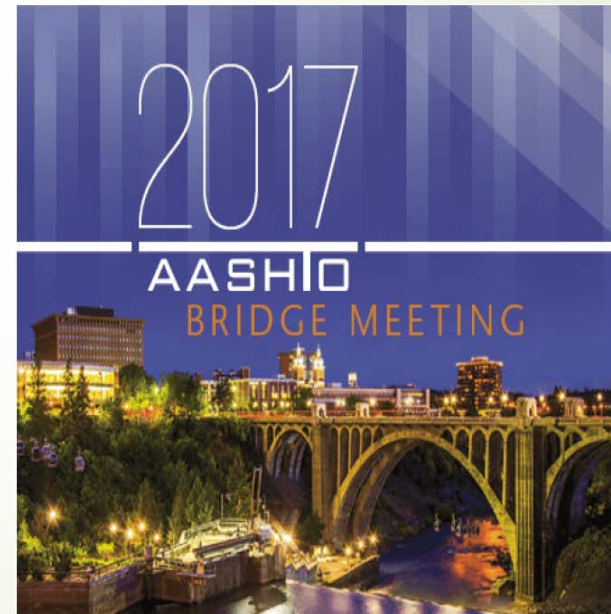
1. PIARC Update

2. Tunnel System

2017 AASHTO T-20

Bijan Khaleghi

WSDOT Bridge & Structures Office



PIARC Update -1

PIARC: Technical Committee D.5 – Road Tunnels
Working Group 5: Large underground interconnected infrastructures

Update on related organisations

- CIE (International Commission on Illumination)
- European Commission Committee on Road Tunnel Safety
- ITA-COSUF (Committee on Operational Safety of Underground Facilities)
- IES (Illumination Engineering Society)
- EFSTG (European Fire Services Tunnel Group)
- NFPA (National Fire Protection Association) - Canada
- AASHTO

PIARC Update - 2

- Seminars in developing or transition countries
- International PIARC Conference on road tunnel operations and safety
- PIARC website and D.5 private workspace
 - WG requirements and expectations
 - Other matters of interest for the whole Committee
 - International winter congress (Gdańsk, Poland, February 2018)
 - Articles for Roads / Routes
 - Fire accident 4/08/2016 Gleinalmtunnel Austria

2018 PIARC TC D.5 Meeting:

May 29-June 1st Seattle WA

Possibility of AASHTO T-20 or TRB AFF60 participation?

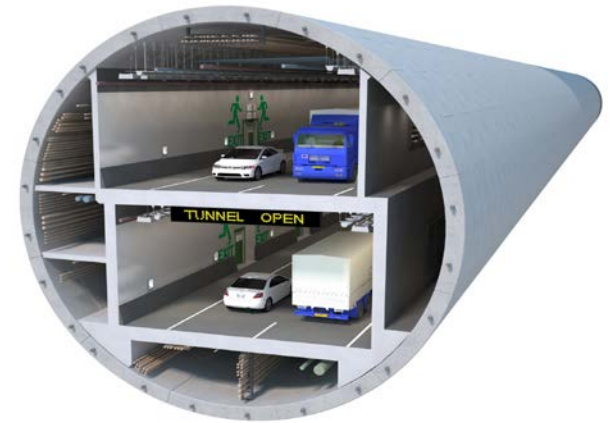
PIARC Update - 3

Monograph and Case Studies: for Cycle 2016-2016 Case Studies “Questionnaire”

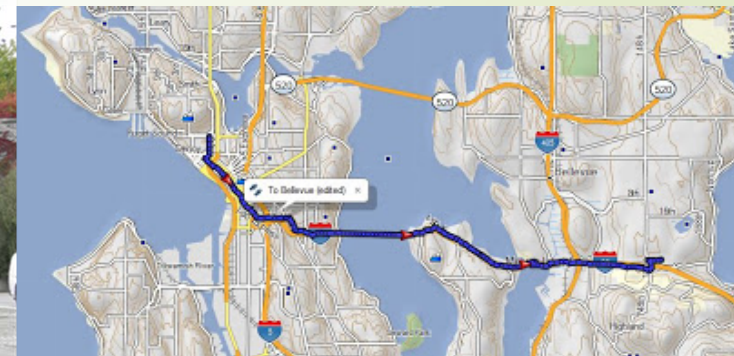
1. Objectives
2. General information
3. Geometry
4. Traffic – conditions and capacity
5. Signalling of the underground interchanges
6. Ventilation
7. Facilities (operation equipment)
8. Safety, escape and behaviour
9. Operation
10. Multimodal tunnels (operation and safety)

Seattle Tunnels Submitted To PIARC

AWV Tunnel Case Study Questionnaire - Monograph



Mount Baker Tunnel Case Study Questionnaire - Monograph



AWV Tunnel

- South cut-and-cover
- North portal
- Bored tunnel
- South Access





BREAKTHROUGH

drone footage

SR 99 TUNNEL TIME LAPSE ROAD BUILDING WHILE TUNNELING



Video: Building a road

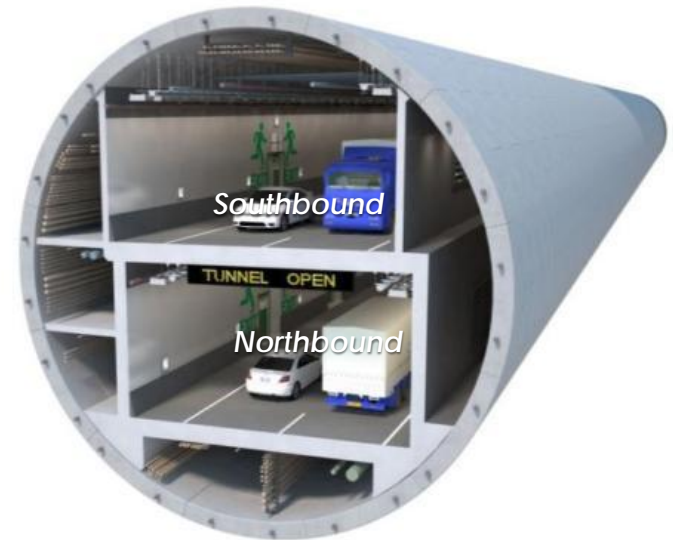
INSIDE THE TUNNEL

Key tunnel system and life safety activities

- Tunnel life safety and security systems
- Fire System
- Ventilations system
- Electrical and ITS
- Control rooms
- Emergency coordination
- Emergency plan and scenarios and drills



- Approximately two miles long.
- Two lanes with eight-foot safety shoulder in each direction
- 2- 11' lanes in each direction
- 8' shoulder on the WEST side (so right shoulder SB and left Shoulder NB) The west side is where the egress doors and walkway are located.
- 2' shoulder of the EAST side.



State-of-the-art Safety features

11

- ✓ Egress door to refuge area 650' spacing Doors will be lighted with strobe lights.
- ✓ Fire extinguishers, emergency phones which go directly to 911 SPD at each access door
- ✓ Walking man symbols on the tunnel walls with distances to the egress doors
- ✓ Variable message signs spaced at about 325'
- ✓ Incident detection camera system – stopped vehicles, wrong way, peds, debris, haze
- ✓ Linear heat detectors with a fixed suppression system – sprinklers (will operate automatically or manually)
- ✓ AM/FM Radio rebroadcast system and PA system

Tunnel Safety Systems

Safety elements include:

- Safety shoulder
- Emergency power
- Ventilation
- Drainage
- Incident response
- ITS
- Emergency notifications
- Fire detection & Suppression

Design concept of tunnel interior.



Tunnel Safety Systems

13

• Power

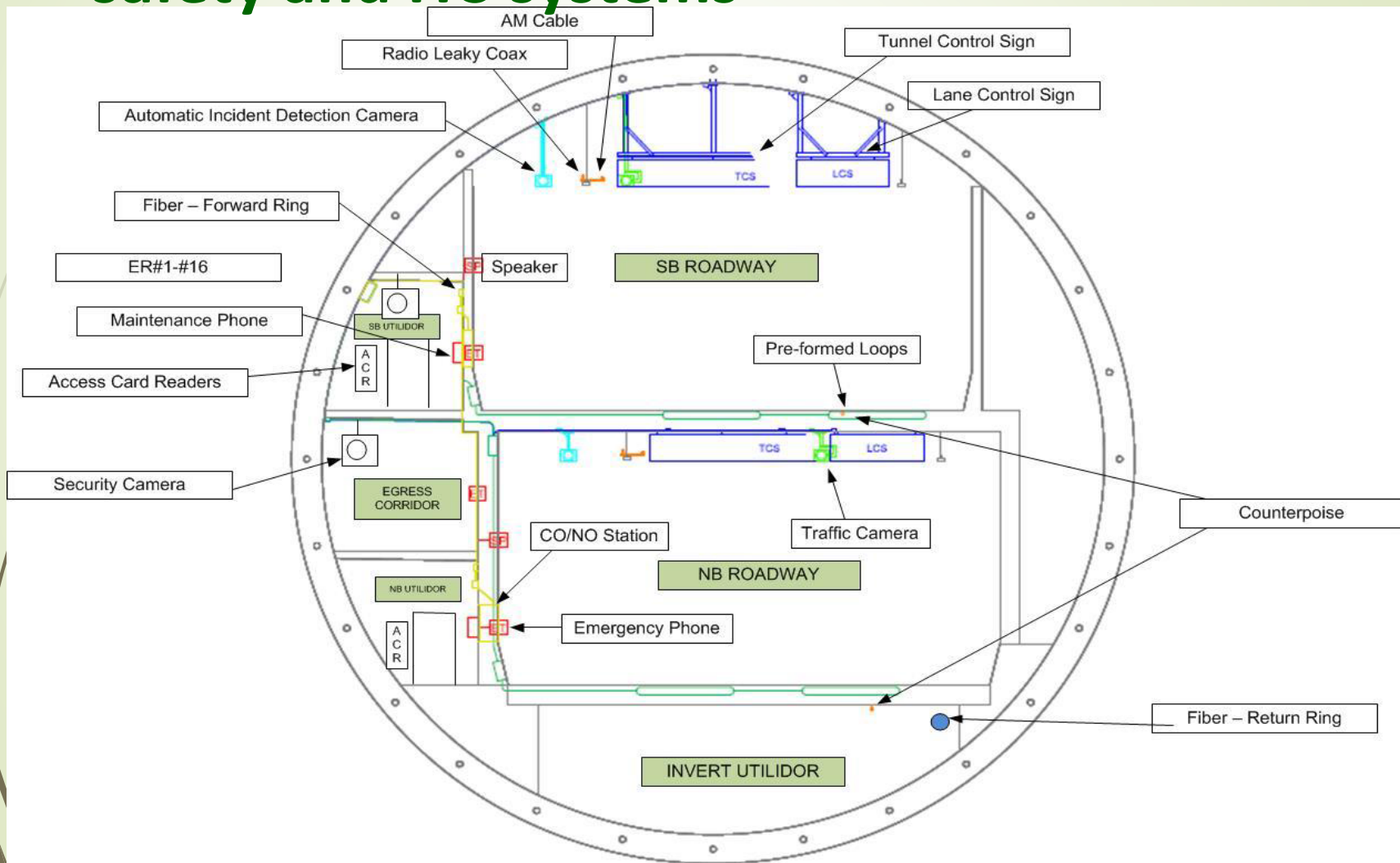
- Distributed from 16 electrical rooms
- Redundant power supply.
- The north and south end of the tunnel connected to separate substations and the tunnel control system can switch from one substation to the other.
- Emergency generators and EPS (battery systems).

• Lighting

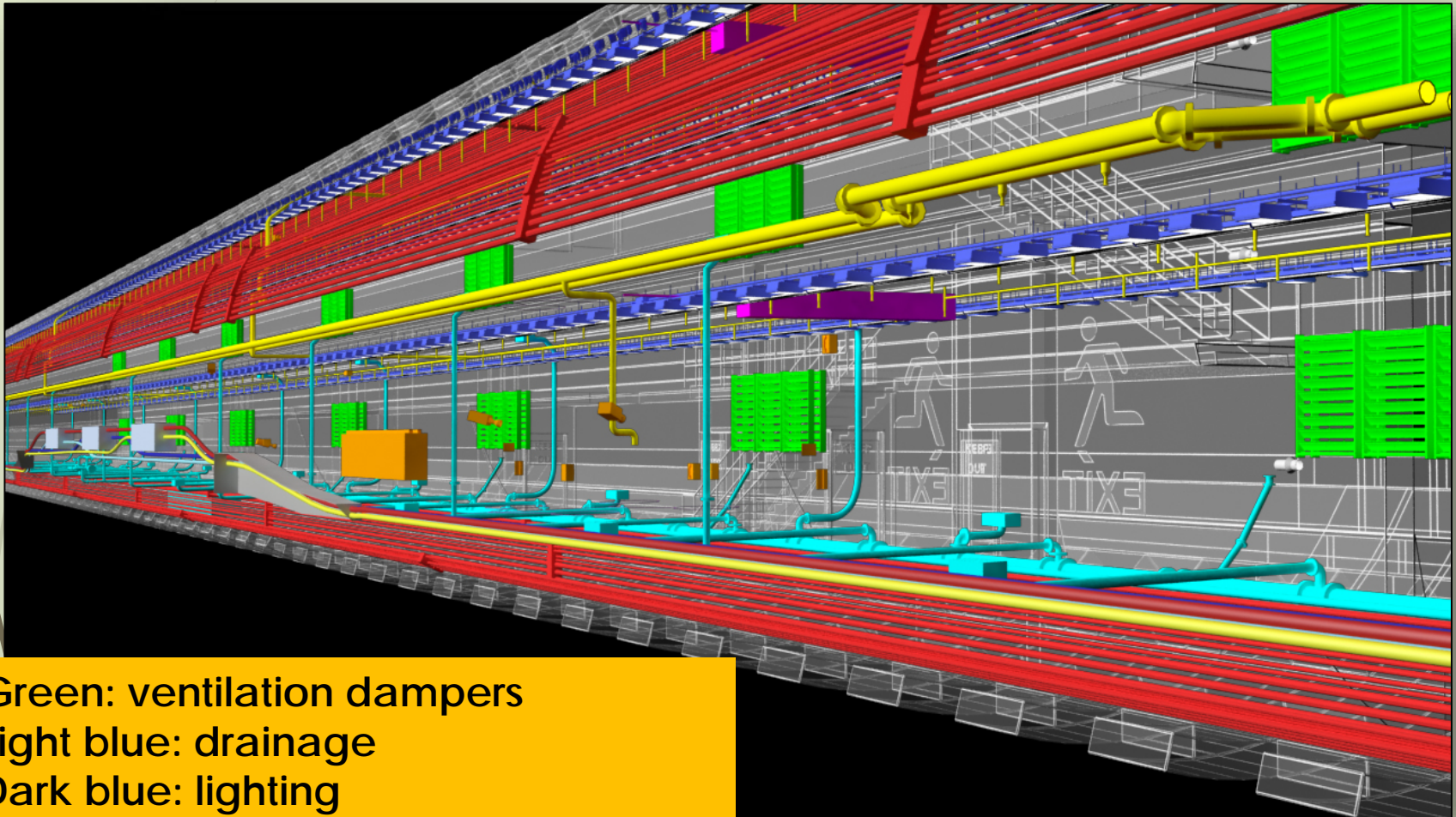
- Normal – HID and fluorescent (high intensity discharge)
- Emergency – Part of tunnel lighting and connected to generators
- Door marker – flash when evacuation is underway. Bright LEDs that will be easier to see through smoke than conventional lighting.

14	Tunnel System - Item	Quantity
	Exhaust Fans	8
	Jet Fans	17
	Exhaust Dampers	187
	Maintenance Air Dampers	30
	CO and NOx Sensors	10
	Deluge nozzles	1,318
	Deluge Valve Stations (208 valves)	55
	Fire Hose cabinets	97
	Storm Water Pumps 3 @ 50 HP, 2 @ 20 HP	5
	Low Point Booster Pumps 4 @ 20 HP	4
	Sewage Ejector Pumps	2
	Generators, 1 @ 900 KW, 1 @ 600 KW	2
	Tunnel Roadway Lighting Fixtures	5700
	Roadway and 165 Security CCTV Cameras 136	301
	Color Matrix TC Signs & LCS	35 & 66
	Roadway Emergency phones	98
	Egress refuge - Emergency Exits	32
	Lane Traffic Data Stations	32
	Strobes and LED Light Strings (each egress exit)	34
	Roadway speakers (each egress exit)	34

Tunnel cross section showing the fire life safety and ITS systems



Schematic of interior tunnel systems.



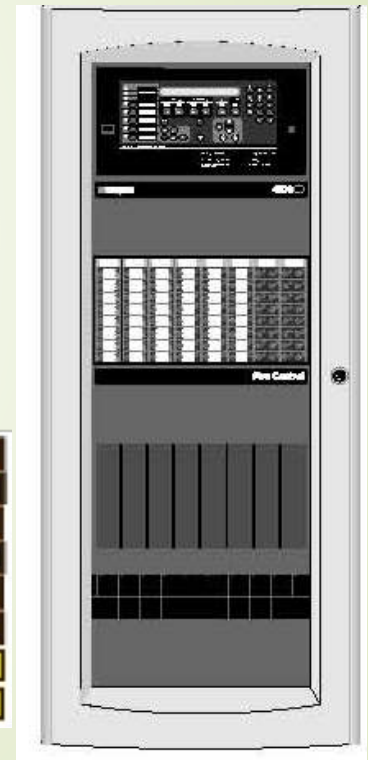
- Green: ventilation dampers
- Light blue: drainage
- Dark blue: lighting
- Yellow: waterlines and sprinklers
- Red: conduit
- Orange: devices, such as cameras

Intelligent Transportation Systems & Motorist Communication

Supervisory Control And Data Acquisition systems (SCADA)

SCADA Interfaces with Other Systems:

- Maintenance management
- Fire control.
- Security.
- Emergency phones



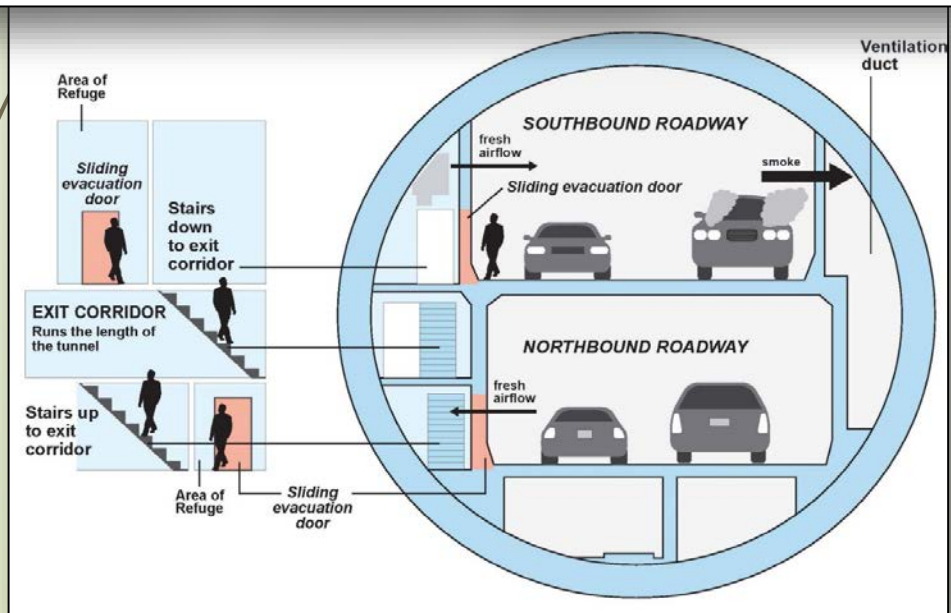
Fire control system

Systems in the SR 99 TUNNEL

Tunnel will feature:

- safe and effective evacuation routes for motorists.
- Enclosed emergency walkways with independent ventilation and fire control systems.

Enclosed emergency walkways with independent ventilation system



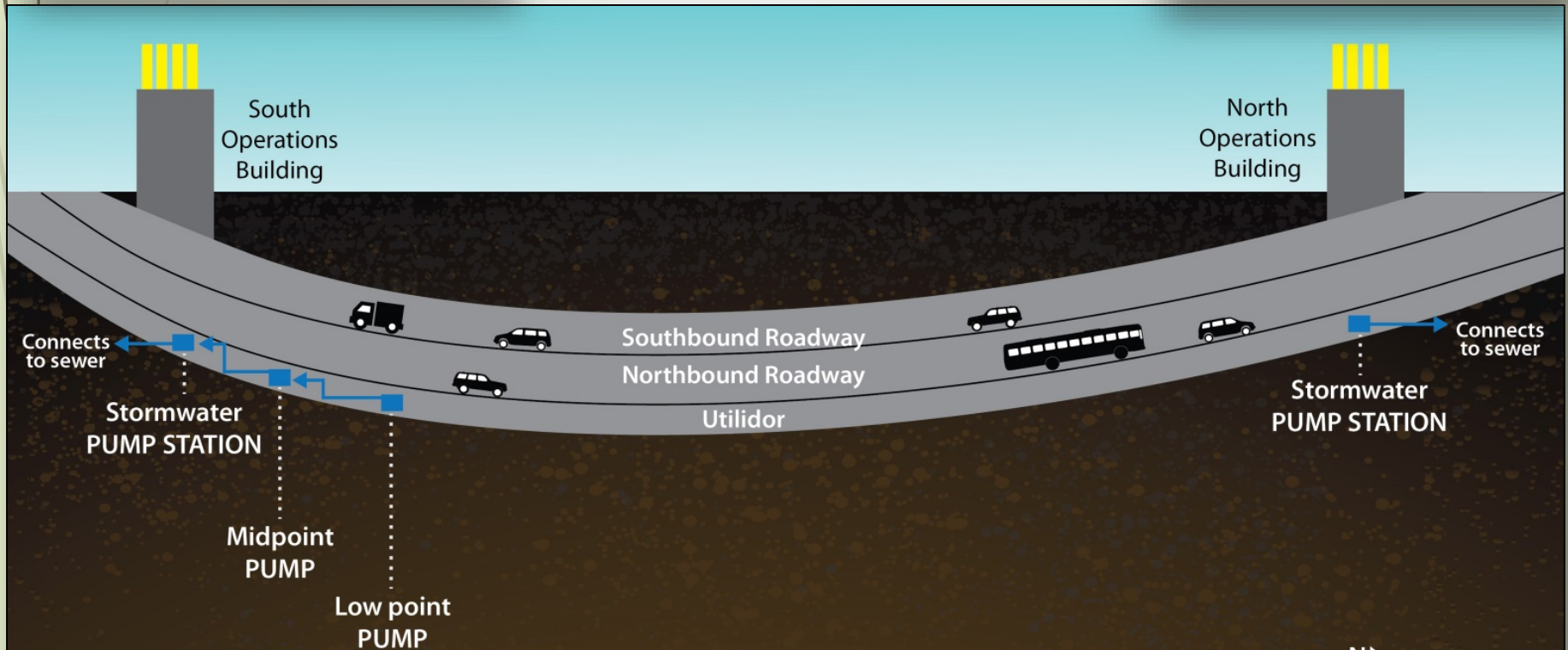
Tunnel's emergency exits



A typical video surveillance camera



Tunnel pump station



Fire detection & suppression systems

20

- Tunnel is broken up into 208 fire detection and suppression zones
- The tunnel system fire response would be either automatic or done by the :
 - *Automatic response*: There are heat detectors on the tunnel roadway ceiling that can trigger an alarm to the tunnel control system which then triggers the deluge, ventilation and messaging systems for that zone
 - *Remote manual response*: If an operator notices a fire (via CCTV, incident detection systems, pull station etc.), he/she can trigger the same fire response through the tunnel control system (There are over 70 incident detection cameras)

Fire detection & suppression systems

21

Roadway sprinkler system to put out a fire:

- ✓ 13 mm of water per minute or 2.4 feet of water per hour. (That is so much water that the interior structures would not collapse due to the weight of the water)
- ✓ There are 4 pump stations: 1 low point pump station, 1 mid-level pump station and 2 stormwater pump stations at each portal
- ✓ The stormwater pump stations are designed to limit the amount of rain water drainage outside of the tunnel from going into the tunnel. They will clean the collected water and then pump it out into the sewer system.

Fire Detection & Suppression

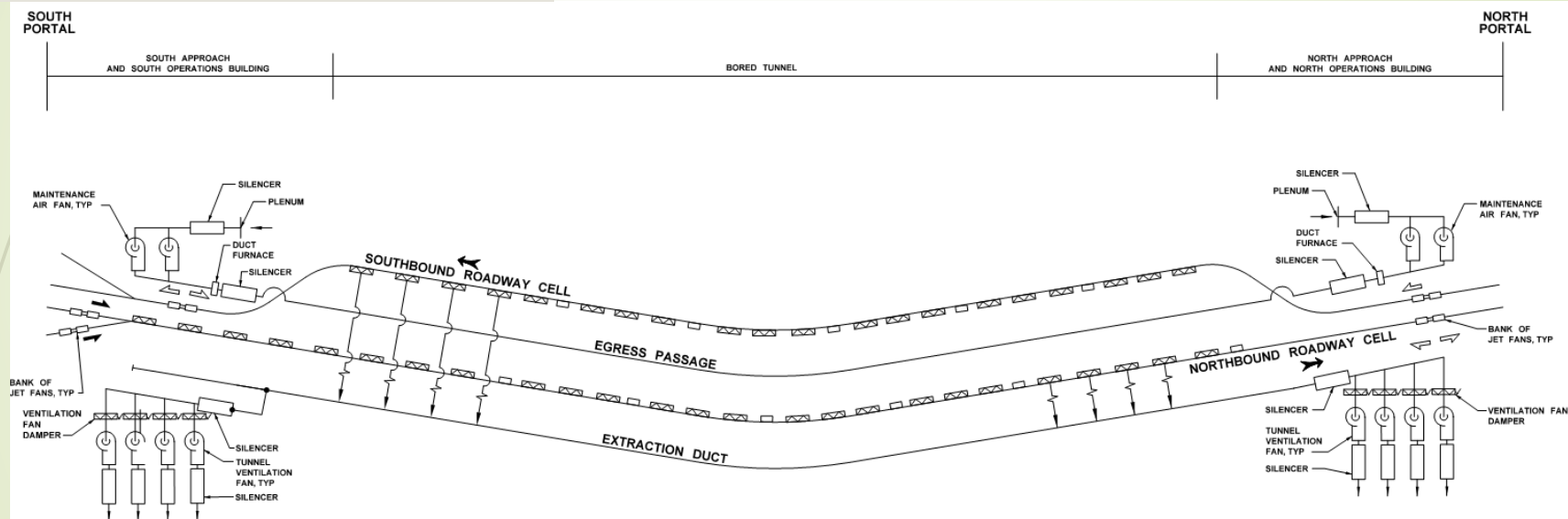
Crews testing the deluge system in the I-90 tunnel



Ventilation Scheme for Normal Operations

South portal Fan plant: 4 EF

North portal Fan plant: 4 EF



Tunnel Dampers

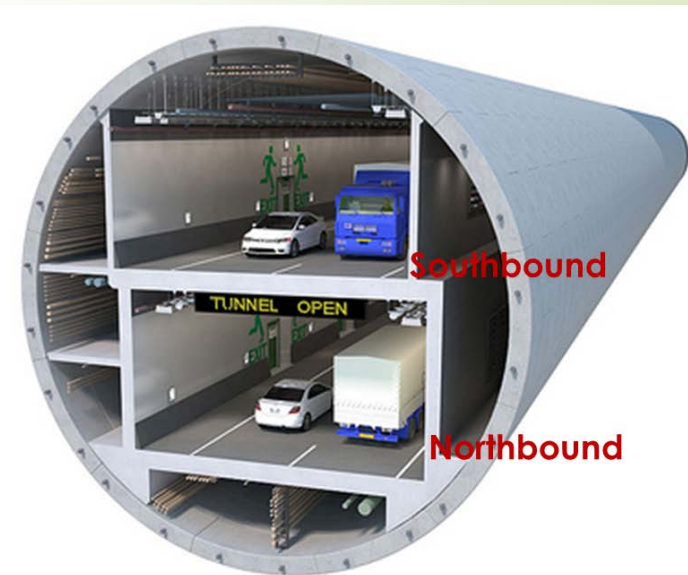
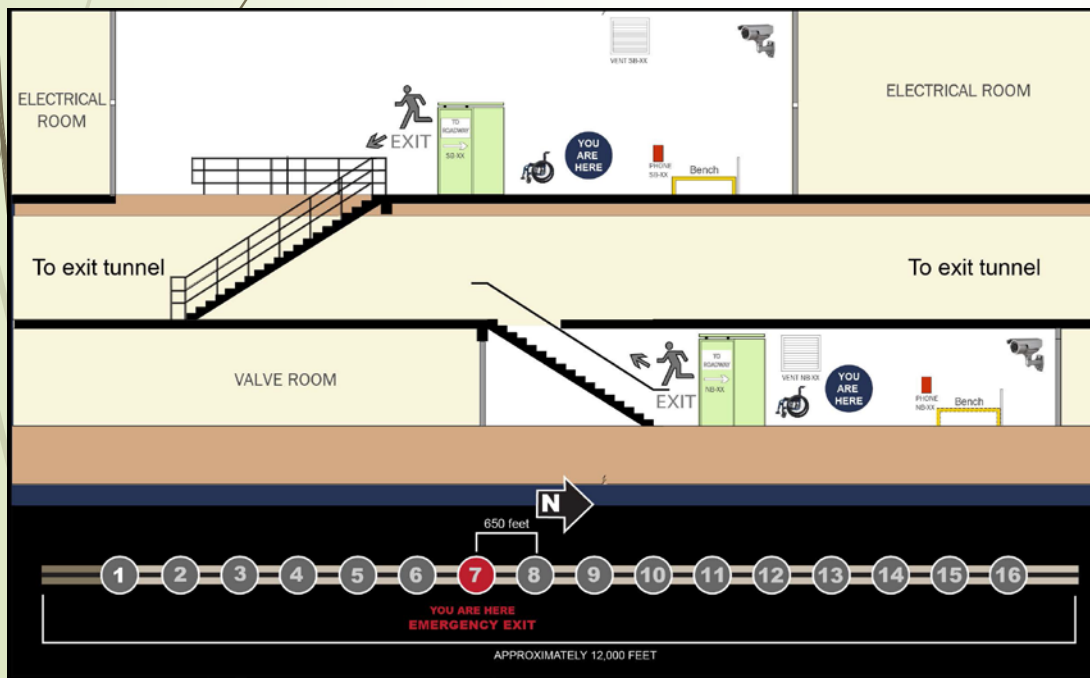


Ventilation Scheme for Fire Event

Fire Life Safety provisions

- Egress doors every 650 ft
- Smoke damper every 108 ft (6 dampers open)
- Portal jet fans
- Local extraction 283m³/s
- Sprinkler at 13mm/min

Refuge Area



Mechanical - Ventilation system

25

- ✓ Jet fans at the ends to supply fresh air, exhaust system with dampers every 108'. Can open 6 dampers in the area of the fire. Exhaust air right in the vicinity of the fire – like a house central vacuum system in a house
- ✓ CO monitoring system
- ✓ Jet fans -- primarily control tunnel air quality
- ✓ Tunnel Ventilation System – primarily used during fire emergencies
- ✓ Maintenance Air System – ventilating the egress corridors and maintenance areas.

Centrifugal fans

Tunnel Ventilation Fans (TVF), extract gas and pollutants from the tunnel through a continuous extraction duct that runs along the east side of the tunnel.

Air, smoke and gasses are pulled through large dampers on the tunnel's east wall and vented out of the yellow stacks atop the north and south operations buildings (each building houses four TVF).

Jet fans: 17 jet fans positioned at the tunnel entrances and exits will draw and push fresh air through the tunnel.

Maintenance fans: The four maintenance air fans provide fresh air to the maintenance areas, egress passageways, electrical rooms and other “back of house” areas in the tunnel



Tunnel ventilation systems



Two of the four extraction fans at the south operations building



The tunnel will have seventeen jet fans at the tunnel entrances and exits

Tunnel ventilation systems

28

- 8 centrifugal ventilation fans (in ops building)
- 4 maintenance fans (in ops building)
- 17 jet fans (at tunnel portals)

Day-to-day use

- ✓ Four maintenance fans provide fresh air to the egress corridors, electrical rooms and maintenance areas.
- ✓ The tunnel is equipped with 10 air monitoring stations to ensure the air in the tunnel is safe. (monitoring carbon monoxide, nitrous oxide and particulate matter)
- ✓ Anticipate operating the jet fans during congestion when travel speeds are 20 mph or slower (or during emergencies)
- ✓ Anticipate using the centrifugal fans during congestion when speeds are 5 mph or slower

Tunnel ventilation systems

In case of an emergency

- ✓ In the event of a tunnel fire, there are eight centrifugal/extraction fans (four fans in each operation building)
- ✓ Each fan pulls between 135,000 to 180,000 cubic feet per minute (CFM) out of the tunnel
- ✓ The tunnel's ventilation system is capable of removing 1.4 million cubic feet of air per minute
- ✓ There is also a supply air system that supplies air to the areas of the tunnel outside of the tunnel roadways.

Summary: Tunnel ventilation systems

- Determine portal emission discharge for vehicle speeds (up to 60 mph).
- Operate fans to keep tunnel CO levels beneath 30 ppm.
- Operate fans to keep portal emissions within requirements .
- Use the CO monitors to determine pollution within tunnel and at portals.
- Normal ambient condition = no mechanical fan operation required
- < 30 mph or > 3000 vehicles/hour = exhaust fans should operate
- Annual energy saving will be over 31 million kWh
- Annual savings will be US \$2 million

Overview of the Response Plans

- Minor and Major Fires
- Two separate fires in same roadway
- Incident just outside portal
- Maintenance closure
- Two separate incidents
- Major incident blocking both lanes
- Wrong way vehicle
- SB and NB Off ramp congestion
- Air Quality values exceeding upper limits
- Loss of Power
- Minor incidents – one lane closure
- Maintenance shoulder work
- Major disaster (earthquake, flood, explosion)
- Haz-Mat Spill (minor fuel and unknown contents)

Tunnel Emergency Exercise

- Workshops
- Tabletop Exercises
- Functional Exercise
- Drills

Tunnel Emergency Exercise Participants

- WSDOT
- Seattle Fire Department
- Seattle Police Department
- Washington State patrol
- Home land Security
- FHWA
- Port of Seattle
- King County
- Metro



Systems TESTING

*Emergency responders
testing a response plan*

Commissioning and testing

33

- Brings the tunnel to a fully operational state
- Inspections and quality assurance activities take place through the tunnel design and construction progresses
- All required testing (device testing, system testing, integrated testing)
 - System testing is based on system functional operation modes
 - Example: Tunnel ventilation control
 - Integrated testing for tunnel controls based on developed emergency response plans for tunnel incidents and problems
 - Example: Integrated controls for fire response with closure signing, smoke ventilation and fire suppression

Tunnel Operation Control Centers:

- Primary Control Room in Shoreline
- North Operations Building
- South Operations Building



*The tunnel will have 35
variable message signs*



WSDOT Northwest Region traffic management center



PIARC: Technical Committee D.5 – Road Tunnels
Working Group 5: Large underground
interconnected infrastructures

<https://www.piarc.org/en/Technical-Committees-World-Road-Association/Strategic-Theme-Infrastructure/Technical-Committee-Road-Tunnels-Operations/>

Alaskan Way Viaduct
REPLACEMENT
PROGRAM



Website:
www.AlaskanWayViaduct.org

Twitter:
[@BerthaDigsSR99](https://twitter.com/BerthaDigsSR99)

Email:
viaduct@wsdot.wa.gov

Hotline:
1-888-AWW-LINE