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Tunnel Security for Public Transit

Abstract: This document proposes recommended practices for the security of transit tunnels to enhance the security of people, operations, assets and infrastructure.

Keywords: assessment, balanced security, considerations, security program, tunnels

Summary: Tunnels and the mass transit passengers who travel through them are subject to various threats. Many attacks that are planned against tunnels intend to kill or injure large numbers of people. Because of their open architecture, passenger transit tunnels and tunnel stations present an attack opportunity and a potential for significant consequence. This *Recommended Practice* provides recommended security strategies for agencies with transit tunnel assets to reduce risk to these structures.

Scope and purpose: This document offers best practices in the development of security for transit tunnels and the application and the implementation of security design considerations where applicable. This document outlines the structure of tunnels, potential threats and measures to enhance the security of these structures. Additionally, it recommends technologies, policies and procedures, coupled with the operational aspects for securing tunnels from potential threats.

This *Recommended Practice* represents a common viewpoint of those parties concerned with its provisions, namely, transit operating/planning agencies, manufacturers, consultants, engineers and general interest groups. The application of any standards, practices or guidelines contained herein is voluntary. In some cases, federal and/or state regulations govern portions of a transit system's operations. In those cases, the government regulations take precedence over this standard. NATSA recognizes that for certain applications, the standards or practices, as implemented by individual transit agencies, may be either more or less restrictive than those given in this document.

The purpose of this document is to provide mass transit and passenger railroad stakeholders with guidance for providing transportation sector within this mode. These documents are not to be construed as legally binding requirements of, or official implementing guidance for, any current or future regulations of the Department of Homeland Security.

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The North American Transit Services Association greatly appreciates the contributions of **Bill Pitard**, who provided the primary effort in the drafting of this *Recommended Practice*.

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Introduction

Public transit operates in inherently open environments. It provides ease of access and gathers volumes of people in confined spaces to provide passengers with efficient and convenient public transportation through regions and their communities. These unique attributes make public transportation vulnerable to adversarial targeting and threats. For these reasons, a sound approach to transit tunnel security is necessary so agencies can effectively manage the risks of their environments.

This document provides recommended practices related to mitigating risk to public transit tunnels. The information and resources within should be implemented where appropriate to enhance an agency's security posture.

While transit security programs may implement or operate using different strategies, measures or solutions, a basic level of "Security 101" knowledge consisting of appropriate strategies should be understood to reduce risk and enhance the posture of all transit properties. This document provides recommendations for transit agencies to assess, analyze and mitigate tunnel security within their own transportation systems. It builds upon and incorporates previously developed information listed in the series of infrastructure security *Recommended Practices* and other documents prepared for transit passenger facilities (see link below).

Other Security Standards Program documents are also listed as resources herein to aid with the development of a balanced security program. The documents should also be used where applicable. See APTA's Security Standards documents: http://www.apta.com/resources/standards/Pages/Security-Standards.aspx.

> **NOTE:** For the benefit of users of this document, the word "shall" is used to indicate a mandatory requirement. The word "should" is used to indicate a recommendation. The word "may" indicates a permissible action, and the word "can" is used for statements of possibility and capability.

Tunnel Security for Public Transit

1. Transit tunnel security overview

Transit agencies should use a uniform approach of “problem seeking” before moving to a “solution providing” of security issues in the transit tunnel environment. Methodically identifying the issues by using a recognized assessment or analysis process (i.e., determining threats, critical assets, vulnerabilities, consequences, risks and mitigations) before applying solutions is an effective tunnel security program approach. After the “problem seeking” phase is completed, the proposed solutions described herein may be used as standalone solutions or be incorporated with other solutions to provide a multilayered integrated approach to securing the assets. When effectively applied, these solutions offer an agency options to mitigate risk and to operate a balanced and effective security program. While highway tunnels have an important role in the nation’s transportation networks, this *Recommended Practice* will focus only on rail and transit tunnels.

Adversaries may target people, operations, assets and infrastructure in the transit environment. To reduce risk, agencies should assess or analyze the risks to their systems and properties and implement effective risk-reduction solutions, coupled with the appropriate countermeasures. Recommendations within this document will assist with this process.

1.1 Stakeholder considerations

Transit agencies should understand and adopt transit tunnel security protection measures to enhance the security environments of where they operate. To the extent possible, the application of the actions presented in this *Recommended Practice* should be considered to help agencies meet their program requirements and enhance their safe operations.

1.2 Benefits

An agency’s security program that includes transit tunnel security provisions can provide the following benefits:

- Develop and reinforce and agency’s security awareness program.
- Provide passengers and employees with a sense of ownership.
- Improve capacity to manage and respond to security threats.
- Enhance the safety and security of its ridership within the transit environment.

2. Security risk assessment

2.1 System security risk assessment

Transit agencies should complete a system-wide security risk assessment to determine the threats and vulnerabilities to their systems. A risk-based approach that factors threat, vulnerability, consequence, risk and mitigation should be used to identify security measures that mitigate or control risk to an accepted level while

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enhancing protection. For more information about various system security risk assessment methodologies, refer to the following (see also References):

- "A Guide to Highway Vulnerability Assessment for Critical Asset Identification and Protection," American Association of State Highway and Transportation Officials (AASHTO).
- "National Infrastructure Protection Plan (NIPP)," Department of Homeland Security (DHS)

2.2 Site-specific security risk assessment

Tunnels provide a specific risk within the transit environment. Targeted security risk assessments should be performed to assess the unique threats posed by tunnels and tunnel stations within the transit system. An understanding of tunnel types, attributes, systems, and associated vulnerabilities should be incorporated into the tunnel security assessment. For more information about various targeted site-specific security risk assessment methodologies for tunnels, refer to the following (see also References):

- "Making Transportation Tunnels Safe and Secure," Transit Cooperative Research Program, Report 86, Vol. 12.
- "Risk Management for Terrorist Threats to Bridges and Tunnels," Federal Highway Administration (FHWA)/U.S. Army Corps of Engineers (USCOE).
- "Integrated Rapid Visual Screening Series (IRVS) for Tunnels," Department of Homeland Security (DHS).

3. Tunnel overview

Tunnel design is typically driven by site conditions, operational requirements, cost and political considerations. Designs are not typically developed based on security considerations. Nevertheless, assessment of tunnel designs for security is essential to maintaining a secure transit environment. Each type of design, or design element, of a tunnel presents potential vulnerabilities that should be reviewed for the risks it presents. It is much more effective and cost effective to design out vulnerabilities and design in mitigations than it is to retrofit tunnels with security technology or to implement security procedures to mitigate the vulnerabilities. Understanding the design elements of a tunnel can assist with determining vulnerabilities and potential risks inherent in tunnel designs.

3.1 Tunnel components and systems

Provided herein is general information about tunnel components, such as shape, liners, inverts and construction methods, as well as information about the major systems designed to support the tunnel system, i.e., mechanical, electrical, ventilation and communications. Understanding the basic functions and operations of key tunnel components and systems is essential to identifying tunnel vulnerabilities and implementing effective protection measures.

3.1.1 Basic tunnel design shapes

Rail transit tunnels are typically designed in circular, single-box, double-box, horseshoe or oval shapes. See Appendix A for an illustrated example of tunnel designs. Tunnel designs are related to the geography of the site, which may be different from one location to another along the rail line because of changes in geological conditions. For example, where the primary ground material is soil, a circular tunnel may be constructed in a cut and cover trench. Alternatively, where a tunnel is excavated using a drill and blast method to bore through bedrock material, the resulting bore opening and tunnel cavern may become the structure's unfinished tunnel liner.

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3.1.2 Tunnel liners

Tunnel liners are a component of tunnels built into and/or through rock. The function of tunnel liners is to line the interior of a tunnel bored into or through rock or where soft ground conditions exist. They support, stabilize or reinforce the structural deficiencies that may be found in rock tunnels. Typical types of liners are defined in Appendix B.

3.1.3 Invert types

The invert of a tunnel is the slab on which the track bed is supported. There are two main methods for supporting the track bed (Appendix A). The primary method places the track bed directly on grade at the bottom of the tunnel structure. This method is typically used because rail or track ventilation systems rarely use supply ductwork under the slab. Alternatively, the second method suspends the rail tracks above the tunnel bottom a particular distance to provide space for ventilation and utilities.

3.1.4 Types of tunnels and construction methods

Several factors are essential to determining the types and methods of construction of transit rail tunnels. Agencies should consult with qualified professional engineers who have demonstrated tunneling experience to identify and explain the tunnel’s construction methods, design details and components of the structure. An engineer should review the tunnel’s current technical drawings and provide management with an overview of the findings.

Typically, the type of tunnel proposed for a particular location is, in part, based on engineering analyses of ground soil conditions in the proposed area of the structure. The analysis, referred to as a geotechnical soils analysis, evaluates the ground soil conditions. The results help designers and engineers determine which type of tunnel and what methods of construction should be considered.

The six primary methods of tunnel construction and types of tunnels by shape are described in **Table 1**. See Appendix C for additional information.

TABLE 1

Types of Tunnels and Construction Methods

Method of Construction	Type of Tunnel		
	Circular	Horseshoe	Rectangular
Cut and cover			X
Shield-driven	X		
Bored	X		
Drill and blast	X	X	
Immersed tunnel	X		X
Sequential excavation		X	
Jacked tunnels	X		X

3.1.5 Tunnel finishes

Transit tunnels often do not have an interior finish because the public is not exposed to the tunnel lining except as the tunnel approaches the stations or portals. Where subgrade transit stations are a component of a tunnel, its finish is important to the overall function of the tunnel and station. For example, tunnel finishes can become a source of primary or secondary conflagration when broken into small pieces, and may become

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flying hazards during a blast event. Possible mitigations to explore may range from the removal of tunnel ceiling panels to the installation of a reinforcing membrane to hold wall tiles in place. Agencies should analyzed their tunnel liner designs to determine their potential or degree of damage. Other supporting tunnel elements, such as tunnel lighting, signaling and ventilation fixtures, may also be considered hazards and considered for hardening or removal.

The design and shape of a tunnel or tunnels, along with its surrounding ground conditions, environment, location, proximity to other critical assets, etc., can increase or decrease the vulnerabilities of the structure. Agencies should evaluate their rail transit tunnels' shape, ground conditions, environments, locations and proximity to other critical infrastructures to identify the vulnerabilities associated with a particular design. Then identify mitigation measures that would effectively reduce risk by implementing mitigation measures to enhance the overall security of the structure.

3.1.6 Tunnel ventilation systems

Rail transit tunnels often have ventilation systems in below-grade stations or at intermediate fan shafts, but during typical operations rely mainly on the piston effect of the train pushing air through the tunnel to remove stagnant air. Many rail transit tunnels have emergency mechanical ventilation systems that work only in the event of a fire. The five major types of tunnel ventilation systems are listed in Appendix D.

3.1.6.1 Fans

The primary types of mechanical ventilation fans used to circulate tunnel air are axial and centrifugal. They can be installed directly in the tunnel tube to provide ventilation or be housed in out-buildings (also known as vent houses) or in tunnel vent shafts. The type of fans required to support tunnel ventilation must be based on sound engineering analysis using the tunnel's design parameters.

3.1.6.2 Ventilation system supplemental equipment

Electrical motors, fan drives, sound attenuators and dampers are essential components of a tunnel ventilation system. The loss of any single or multiple components may result in system-wide failure and the inability to adequately mitigate the hazard.

3.1.7 Lighting

Transit tunnels require sufficient lighting for operations, maintenance and to support passenger evacuation or other incident response. Tunnel lighting should provide for incremental adjustment when entering or leaving the tunnel threshold so that operators do not experience vision impairment when entering or leaving a tunnel or station. Lighting should also support CCTV camera coverage and illuminate the assessment zone evenly with the necessary intensity for the video surveillance system to properly function.

3.1.8 Electrical system

A tunnel's electrical system typically draws its power requirements from different utility service providers to supply power to ancillary, traction and emergency power operations, as well as power communications, signals and general lighting in a tunnel. For example, traction power service can be provided to catenary (overhead) or third-rail (adjacent to train rails) power systems from one power utility service provider, and a different utility service provider may provide power to communications or ancillary spaces.

3.1.9 Signal system

A typical signal system consists of a complex assortment of electrical and mechanical instruments that work together to provide direction for the individual trains within a transit system. Examples include signals, signal cases, relay rooms, switch machines, switch circuit controllers, local cables, express cables, signal power cables, duct banks, messenger systems, pull boxes, cable vaults, transformers, disconnects and local control facilities.

3.1.10 Communications

Tunnel communication systems may be design-built with or have installed mediums to send/receive messages, information or other communications into, within or from a tunnel. These systems include antennas, cable, fiber or other wireless devices. One or more communication mediums may be design-built or installed into a tunnel to operate independently or integrated to function with other media. For example:

- Antennas may be mounted in a tunnel and connected to a receiver/transmitter located outside the structure to send and receive information or to provide two-way radio communications.
- Cable or fiber may be installed to connect interior locations of a tunnel (e.g., ancillary room with the communications center) or connect an interior with an exterior location to send information or data to electronic message boards, broadcast local news, post traveler information, etc.
- Wireless devices may also be installed to provide interior tunnel connections with other interior wireless devices or with an exterior location to send information or data.

Various types of hardware devices are used to communicate or send and receive messages into, within or from a tunnel. A description of some of the more typical devices follows:

- **Emergency call station (ECS).** Communication system that connects the ECS to one or more designated receivers (e.g., Operations Center, first responders, etc.). ECS can be integrated with video surveillance, alarms and hands-free microphone/speaker systems.
- **Global Positioning System (GPS).** A satellite-based navigation system in space designed to work 24 hours a day. GPS receivers may be attached to agency equipment, property or assets. Depending on the number of satellites within a GPS receiver's view, an agency may be able to track movement, determine position, and calculate other information, such as speed, bearing, track, trip distance, distance to destination and more.

  NOTE: GPS receivers typically will not work indoors, underwater or underground.

- **Automated vehicle locator (AVL).** Technology for automatically determining the geographic location of a vehicle and transmitting the information to a requester. Most commonly, the location of the vehicle is determined using GPS integrated with a transmission mechanism (e.g., text, cellular, satellite or terrestrial radio) connecting the vehicle with a radio receiver.
- **Positive train control (PTC).** An advanced technology specifically designed to automatically stop or slow a train before certain accidents occur. In particular, PTC is designed to prevent train-to-train collisions, derailments caused by excessive speed, unauthorized incursions by trains onto sections of track where repairs are being made, and movement of a train through a track switch left in the wrong position.
- **Supervisory control and data acquisition (SCADA).** A computer system for gathering and analyzing real-time data. SCADA systems are used to monitor and control a plant or equipment in industries such as telecommunications, water and waste control, energy, oil and gas refining, and transportation.

4. Tunnel threat and vulnerability environment

Transportation tunnels are attractive threat targets for many reasons. They are considered a relative high vulnerability and have been identified as an attractive target for terrorist attacks because of their inherently open accessibility. Some tunnels serve an economic importance to the traffic and commerce of a geographic location. Other tunnels hold symbolic value within a region. Regardless of significance, any disaster or attack to a tunnel could be costly, cause it to be out of service for long-term repair or replacement, and may generate high public impact from loss of human lives and/or economic activity.

Many tunnels in the United States, including underwater (submersed) transit tunnels, have limited alternative routes because of geographic constraints. Numerous tunnels in the United States are located at critical chokepoints. A critical chokepoint is a point in the transportation network where many trip paths intersect to get through a geographic barrier. The loss of critical tunnels could result in significant casualties, reconstruction costs, and even greater socioeconomic costs. The downtime to a tunnel struck by disaster, attack or as collateral damage could range from days to years.

Tunnels face disruption from terrorist threats (i.e., intentional acts) or hazards that could be caused by human, equipment or natural (i.e., unintentional, accidental) events.

4.1 Tunnel threats

Possible threats to a tunnel environment that could significantly damage, destroy or collapse the structure or harm passengers and employees within a tunnel are described in **Table 2**:

TABLE 2

General Threat Descriptions

Hazard/Threat	Description
Explosive (small, large)	Small (hand-emplaced) or large (vehicle-borne) improvised explosive device (IED) introduced to tunnel and detonated.
Chemical, biological or radiological (CBR)	CBR released in tunnel; agents released into ventilation system intakes.
Improvised incendiary device (IID), fire, arson	Fire intentionally set in tunnel or ignited by accident with transported fuel/materials.
Sabotage	Intentional impairment or destruction of mechanical, electrical or communications (MEC) systems.
Cyber	Attack of agency command and control systems and/or networks.
Maritime incident	Damage or destruction to "fail" exterior shell of tunnel structure.

4.2 Tunnel vulnerabilities

Several characteristics or features may result in vulnerabilities in tunnels. For example:

- **Access.** For the most part, tunnel portals, fan or vent houses, or other support equipment are by necessity unrestricted features of the structure. For similar reasons, access to the same areas make them vulnerable to trespassing, intrusion, sabotage, and other hazards and threats. Access may allow the introduction of hand-emplaced, vehicle-borne explosive or incendiary devices into the structure.
- **Portal.** Although a tunnel portal is susceptible to an explosive detonation event, the blast loads are less confined due to the open space and may result in less overall damage to the structure. Failure of the portal may also cause collapse of the ground material surrounding the opening.
- **Liners.** An explosive or fire event inside a tunnel may cause ceiling panels, mounted objects, attached equipment, etc. to fail, become airborne, turn into fragmentation or, worst case, to fail and collapse a section of a tunnel. If a tunnel liner fails, causing a breach in the tunnel's liner, the ground material and/or water surrounding the tunnel may also fail and collapse into or flood the structure. Additionally, damage to a tunnel's liner may affect tunnel joints and cross-passages.

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- **Length.** The length of a tunnel may present another security vulnerability. Specifically, the length of a tunnel provides an adversary with more time on target, additional targets of opportunity to attack, the potential to increase the level of damage and destruction, and increased injuries during periods of peak vehicle and ridership volumes. The length of a tunnel may also determine the type of ventilation operated in the structure.
- **Location.** Human-made and natural hazards in the vicinity of rail tunnels may impact their use and operations. Commercial, industrial and residential sites are being built closer to rail tracks and tunnel structures. Knowing the general operations and missions of nearby businesses and what they manufacture, transship, store or use at their sites is also important to ensure adequate contingency and response planning that may impact tunnel operations or the structure.
- **Geography.** External human-made factors, such as development, may cause the land mass to be altered, which could increase vulnerabilities to tunnel structures (for example site excavation and buildup). Also, the proximity of natural ground materials, bedrock, soils, vegetation and water sources surrounding a tunnel may shift, move, break down and cause additional stress and wear to the tunnel liner and overall structure. These events could be caused by fire, flood, landslide, sinkholes, etc.
- **Ventilation.** Depending on their length, tunnels may be vented naturally, by the piston effect, or by forced air supply and returns (full transverse ventilation system). The air intake source for a tunnel may be at a different geographic location than the structure (e.g., vent house for an immersed river tunnel). The air supply, air returns and other air handling equipment at the source or along the supply route may be vulnerable, too. Depending on several factors (design, location, environment, etc.), unrestricted access to an air handling system may lead to tampering or sabotage of the unit. Additionally, hazards released in the proximity of air intakes may be captured by and distributed throughout a tunnel by its air handling system.
- **Mechanical, electrical and communications (MEC).** Tunnel life-safety and security systems are supported by MEC equipment and components. Access to tunnels, insufficient surveillance or perimeter protection may allow access to MEC systems and make them vulnerable to system sabotage and other hazards and threats.
- **Other threats by type of tunnel:**
  - **Immersed.** These types of tunnels are covered with a limited thickness of backfill material. Because it may provide only a minimum amount of additional protection to the exterior tunnel shell, heavy objects (metal, concrete, etc.) that are dropped on, dragged over (e.g., ship's anchor and chain), or driven into (e.g., maritime barge) a tunnel's exterior shell may penetrate the backfill material and breach or puncture the tunnel to cause rapid flooding from the high pressures of the water that surrounds it.
  - **Cut and cover.** Cut and cover tunnels (on land) have a similar vulnerability with a limited amount of backfill material covering the top of the structure. An attack to the interior or exterior of a cut and cover tunnel could damage, destroy or collapse the structure.
  - **Air-rights.** Built to create a transportation tunnel under vertical structures, the ease of access to this type of structure makes them vulnerable to explosive or fire events from above and inside the structure.

4.3 Consequences

Consequences are the likelihood of a threat (explosives, CBR release, etc.) occurring at a specific target, coupled with the severity of its impact to the target (level of damage, destruction, casualties, etc.).

The basis for the potential consequences occurring inside of a tunnel structure is listed in **Table 3** (e.g., fire/smoke, etc.). While threats can remain consistent, their consequences are potentially magnified in a tunnel environment because of the enclosed environment, ventilation challenges, location and length. **Table 3** identifies potential consequences to threats targeting a tunnel.

TABLE 3
Potential Consequences

Threats	Potential Consequences of threat occurring inside of a tunnel structure						
	Fire/Smoke	**Flooding**	**Structural Integrity Loss**	**Contamination**	**Utility Disruption**	**Extended Loss of Use**	**Extended Public Health Issues**
Explosive (small, large)	✓	✓	✓	✓	✓	✓	✓
CBR				✓		✓	✓
IID, fire, arson	✓	✓	✓	✓	✓	✓	✓
Sabotage (of MEC)	✓	✓	✓	✓	✓	✓	✓
Cyber					✓	✓	
Maritime incident		✓	✓			✓	

4.4 Mitigations

Mitigations should be designed and implemented in layers to require an adversary to encounter and overcome more challenging obstacles when moving toward an asset. Mitigations can include physical barriers, procedural processes, or equipment and technologies. Mitigations are most effective when identified and planned into the tunnel design, rather than implemented in retrofit efforts. Transit agencies must require and incorporate security design reviews of tunnels and tunnel stations throughout the design process. This allows the most effective security for the tunnel environment. To confirm installation of the designed security mitigations, they must be validated during the construction and prior to acceptance of the structure. This can be done through a validation and verification process.

For existing tunnel infrastructure, retrofits or procedural security measures may be the only alternative if the tunnel environment was not constructed with identified security measures. This typically provides for a more costly and potentially less effective security solution.

Whether the security is designed into the tunnel or it is retrofitted, mitigations must be monitored to confirm that they continue to provide the needed level of security warranted by the threat environment.

Some recommended mitigations for tunnel vulnerabilities are described in **Table 4**. Mitigations should be selected and integrated based on the vulnerabilities and threats identified during the security assessment process. Not all tunnels require implementation of the mitigations listed. Tunnel length, design, location and operation use all impact the mitigations that should be considered.

The APTA *Standard* "Security Program Considerations for Public Transit" series of documents also provides information about designing and implementing effective layers of protection and other security measures.

TABLE 4

Mitigation Measures

Mitigation Measures	Description
Access control system (ACS)	• Incorporates access control database systems with procedures to manage and monitor movement into, out of, or within the tunnel environment and associated infrastructure. • Systems should be located at the entry control point of the tunnel portal or associated infrastructure. • ACS should augment physical security equipment/technology entry control measures.
Anti-vehicle barrier (AVB)	• Uses to obstruct and prevent the movement of vehicles into the tunnel portal, e.g., Jersey-style concrete barriers, bollards, mobile barrier devices, etc.
Barriers and fencing	• Used to restrict trespass, control entry and identify boundaries. • Install barriers along perimeter boundaries to prohibit trespass and/or control entry to tunnel critical infrastructure. Barriers may include fencing and gates, doors, panels, etc. • May include floating maritime barriers or submersed interwoven metal cable to form a subsurface protective barricade in the form of a net.
Clear zone	• An area adjacent to and near tunnel infrastructure that is clear of visual obstructions and landscape material to allow natural surveillance and to limit concealment.
Crime prevention through environmental design (CPTED)	• Design principles that incorporate natural access control, natural surveillance, territoriality, activity support and maintenance into designs.
Designated zones	• Clear designation of public, semi-public, semi-private and private zones to promote appropriate use. • Used to prevent unauthorized access to restricted areas such as tunnel portals. • Encourages openness and unrestricted passage to areas where the traveling public is authorized. • Post designation of zones with appropriate signage.
Electronic security systems (ESS)	• These include a variety of security systems that can stand alone or be integrated for security purposes. Some systems that are typically integrated include access control, intrusion detection and video surveillance systems. • May include a maritime fiber-optic intrusion detection cable interwoven into a submersed and interwoven metal cable forming an underwater protective barricade for submerged tunnels. • Cabling would be connected to a central control center.
Emergency egress	• Used to evacuate tunnel occupants or as an entry point for first responders. • Shall include signage and wayfinding, emergency lighting, and communications to and within egress area.
Emergency [electrical] power	• Provides backup [electrical] power to critical tunnel systems.
Entry control	• The physical equipment used to control the movement of people on property and into primary and ancillary spaces within the structure. • When entry control is combined with access control measures, they establish defense in depth (layered protection) for a site.
Fire detection systems	• Detects smoke, senses heat and reports event to an operations, command or communications center. • Fully integrate fire and smoke detection, fire suppression, smoke evacuation, and ventilation control systems allowed or required by local, regional or state code.
Fire suppression systems	• Suppresses smoke and /or fire. • Systems may disperse water or other chemical solution to extinguish fire. • Fully integrate fire detection, fire suppression and ventilation controls systems as allowed by fire code.

TABLE 4

Mitigation Measures

Mitigation Measures	Description
Intrusion detection systems (IDS)	• Detects intrusion into a protected space or restricted area. • Sensors should be positioned to allow for maximum response time. • Integrate with access control and video surveillance to enable complete assessment of alarm.
Layered protection	• Implemented layers of protection at each designated zone boundary requires an adversary to overcome each additional physical security measure before reaching the final destination. Layers may include barriers, access control badges, doors, alarms, etc. • Any single defensive measure may be breached, and having more than one means of defense (layers of protection) in place is more difficult to penetrate because it requires an adversary to overcome additional obstacles to reach the intended target. • The mitigation works best when combined with two or more different layers of protection.
Security patrols	• Operational security element to support other mitigation strategies. • Patrols tunnel property and responds incidents, security alerts or calls for service.
Security and emergency response policies and procedures	• Written guidelines for police, fire, EMS and others to handle responding to routine and emergency security and emergency operations and events. • Include event-specific response(s), training, maintenance and all-hazard responses to National Terrorism Advisory System (NTAS) alerts, TSA/FTA Security and Emergency Management Action Items for Transit Agencies, etc.
Security and emergency lighting	• Provides artificial lighting to non-lighted areas, considered a deterrent. • Implement continuous, standby or mobile lighting as operations require. • Coordinate lighting with video surveillance fields of view and screen images. • Integrate with motion sensor technologies or installed with timing clocks or photocell sensors to operate only during specific hours. • Incremental illumination at portal entries should be considered to ease the transition when entering or departing from a tunnel or tunnel station.
Sensitive Security Information (SSI) protocols	• Implemented to designate and control sensitive tunnel information about security design features and characteristics, plans, policies, procedures and vulnerabilities.
Signage	• To inform, provide notice or give warning. • Post at appropriate locations to identify property boundaries and to inform potential trespassers of restrictions, prohibitions, surveillance activities and about other measures that may be in effect. • Couple with buoys or other floating devices as wayfinding features to signal maritime traffic of a restricted waterway area.
Standoff distance	• Implemented to establish distance between target and threat in order to reduce [blast] overpressures and damage. • Time and distance reduce blast overpressure. The farther the distance of the threat from the target, the lower the blast overpressure should be when reaching it.
Video surveillance system (VSS)	• Used to assess, capture and record video images. • Should be monitored or integrated with other detection systems to be alerted about suspicious activity. • Coordinate with security and emergency lighting.
Walkways	• Designated safe space for movement of people and equipment through tunnels, either for maintenance, emergency incident response or evacuation.

4.5 Threats and mitigations

The potential threats and mitigations to tunnels previously described (**Table 2** and **Table 4**) are combined below in **Table 5**. The information provides owners/operators with possible options to consider when mitigating the risk of threats to their critical assets. Mitigation measures may be implemented as single solutions to a specific threat/vulnerability or combined and integrated with others to provide the asset or assets with layered protection.

TABLE 5

Threats and Mitigations Matrix

Mitigation Measures	Threats					
	Explosives	**CBR**	**IID Fire/Arson**	**Sabotage**	**Cyber**	**Maritime Incident**
Access control systems	✓	✓	✓	✓		
Anti-vehicle barriers	✓	✓	✓	✓		
Barriers and fencing	✓	✓	✓	✓		✓
Clear zones	✓	✓	✓	✓		✓
Crime prevention through environmental design (CPTED)	✓	✓	✓	✓		✓
Designated zones	✓	✓	✓	✓		✓
Electronic security systems (ESS)	✓	✓	✓	✓		
Emergency egress	✓	✓	✓	✓		✓
Entry control	✓	✓	✓	✓		
Fire detection systems	✓	✓	✓	✓		
Fire suppression systems	✓	✓	✓	✓		
Intrusion detection systems (IDS)	✓	✓	✓	✓		
Layered protection	✓	✓	✓	✓	✓	✓
Security patrols	✓	✓	✓	✓		✓
Security and emergency response policies and procedures	✓	✓	✓	✓	✓	✓
Security and emergency lighting	✓	✓	✓	✓		
Sensitive Security Information (SSI)	✓	✓	✓	✓	✓	✓
Signage	✓	✓	✓	✓		✓
Standoff distance	✓	✓	✓	✓		✓
Video surveillance systems (VSS)	✓	✓	✓	✓		✓
Walkways	✓	✓	✓	✓		✓

5. Tunnel security recommendations

5.1 Security design/engineering cycle

Successful implementation of appropriate security mitigations for tunnel structures requires a thorough understanding of how the risk analysis process complements the design/engineering cycle.

First, a security assessment (Analysis & Planning) should be completed with a goal of problem seeking before problem solving. This initial and important process provides agencies with a clear understanding of the problems discovered at the property. This includes a complete understanding of assets, components, site operations, and other influencing factors — e.g., threats, critical values, circulations, operations, etc. Mitigations are most effective when identified and implemented into a tunnel's design, rather than incorporated after final construction as retrofits.

Proposed security then must be identified and analyzed to determine its impact on risk. When determined which systems and technologies will be designed, a concept of operations should be developed. This and other programming documents (e.g., master security plan, basis of design, security design criteria) provide designers with the customer's vision of the solution, a concept of how it will work at the site, and how it will be implemented. The system engineering and design process also identifies standards, specifications and guidelines for mitigation solutions. It incorporates design reviews to ensure that the system and technologies follow design and engineering planning and provides for performing a quality management system process review to ensure quality assurance and control of the process and design (System Engineering & Design).

Integration of systems may include newer updates of technologies or incorporate complementary technologies into a single solution, such as VSS with ACS and IDS (Integration).

Implementation is the build-out of the systems and technology in a space, structure or area (Implementation), where operation of the system and technology includes initial acceptance testing, training of users and system maintenance (Operation). This allows for implementation of the most effective security for the tunnel environment (**Figure 1**).

For existing tunnel infrastructure, incorporating retrofits or implementing procedural security measures may be the only way to include security features into a tunnel environment if they were not designed or constructed prior to commissioning. To understand which critical security mitigations might be effective, a security assessment should be performed on the existing structure. Retrofitted security measures are a more costly and potentially less effective security solution.

FIGURE 1

Security Design/Engineering Cycle

Whether security measures are designed/engineered into the tunnel or the structure is retrofitted with measures, transit agencies should monitor their mitigation measures to confirm that they continue to provide the necessary level of security as warranted by the threat environment.

5.2 Security systems integration

As described above, many of the security measures become more effective when integrated with other systems. Integrating access control with intrusion detection protection and video surveillance systems provides more robust security than implementation of a single system. It is critical to assess the integration of implemented security systems to ensure optimum protection. Procedural measures should also be considered to support implemented security technologies.

5.3 Update of plans, policies and procedures

Agencies should review and update their system security and emergency plans, including plans, policies and procedures for tunnels, on an annual basis. Any changes to the tunnel environment should be addressed. As a resource, agencies and their owners/operators should consider reviewing APTA's Security Standards program for *Recommended Practices* and *Standard* information about transit security and emergency plans, policies and procedures.

5.4 Safeguard tunnel security information

Information pertaining to tunnel design and drawings, security assessments, the implementation of security measures, the review of design vulnerabilities, the implementation of security measures designed to mitigate security risks and vulnerabilities, and other issues related to tunnel security should be safeguarded as sensitive information. The above list is not all inclusive to the types of documents or information that warrants being designed and protected as Sensitive Security Information (SSI). Other types of information exist, and they should be identified and protected accordingly by the holding agency.

SSI is information that, if publically released, would be detrimental to transportation security. It is based on U.S. law and protected by federal regulation. The Department of Homeland Security (DHS) provides oversight of SSI policy through its SSI Office. The Code of Federal Regulation (CFR) identifies 16 types of information that require SSI protocol safeguarding. Only four types of information apply to transportation security:

- security programs and contingency plans
- vulnerability assessments
- threat information held by the federal government
- other information, as determined in writing by the Transportation Security Administration (TSA) administrator

Accordingly, documents (electronic, paper or other media) containing SSI must be properly secured, marked and disposed of when no longer useful. Documents containing any of the types of SSI above, regardless of quantity or volume, must mark every page of the document with an SSI header and footer. If combined with other sensitive but unclassified information (Law Enforcement Sensitive [LES], etc.), the document must be marked SSI, but if not possible, the Sensitive Security Information must be removed from the document. The DHS Transportation Security Administration, SSI Office, has published SSI best practices information that is available to all transportation industry stakeholders; see the following:

- Sensitive Security Information (SSI): Designation, Markings and Control, Resource Document for Transit Agencies: http://transit-safety.volpe.dot.gov/publications/order/singledoc.asp?docid=968

- 49 CFR Part 15, Protection of Sensitive Security Information: http://www.fhwa.dot.gov/legsregs/directives/orders/ssi/ssiregulations.htm

5.5 Security training

5.5.1 Drills and exercises

Transit agencies must include the tunnel environment into their emergency response drills and exercises. The drills should include both internal, agency-only events and complex multi-agency or regional activities. It is critical that first responders have opportunities to practice responses within the transit agency tunnel environment. Some form of security and emergency response drill or exercise should be held annually in the overall exercise program.

Additional drill and exercise information is available through the DHS/FEMA Homeland Security Exercise and Evaluation Program (HSEEP) framework, Transportation Security Administration's Intermodal Security Training Exercise Program (I-STEP), and through the APTA *Standard* "Transit Incident Drills and Exercises" (APTA-SS-SEM-S-004-09):

- **HSEEP:** https://www.llis.dhs.gov/hseep
- **I-STEP:** http://www.tsa.gov/stakeholders/i-step-background-information
- **APTA *Standard*:** http://www.apta.com/resources/standards/Documents/APTA-SS-SEM-S-004-09.pdf

5.5.2 Security awareness training

Security awareness training should be provided to all transit employees. In addition to baseline security awareness training, more specialized training should be provided for specific job categories with additional security responsibilities, such as frontline employees and law enforcement positions. Additionally, agency standard operating procedures should be included with employee-specific tunnel training. Local first and emergency responders and first receivers should be invited to familiarize themselves with the characteristics, operations and environment of tunnels.

Other security-related training resources described below should be reviewed and considered to augment an agency's security awareness training program:

- **APTA Security Standards Program:** http://www.apta.com/resources/standards/Documents
- **National Transit Institute (NTI):** www.ntionline.com/courses/courseinfo.php?id=128
- **FEMA Independent Study Program (ISP):** http://training.fema.gov/is/

5.6 Maintenance

5.6.1 Security equipment maintenance

Security equipment must be maintained to be effective. Many manufacturers have available the appropriate diagrams, maintenance schedules and procedures for maintaining their security equipment systems. Agencies should have the appropriate spare parts available to keep their systems operational (e.g., on-hand, contract distributor or supplier, special order, etc.). The operational performance of the equipment should be monitored, analyzed, audited, reviewed or tested according to the manufacturer's recommendations, or at least monthly, to ensure its operational readiness.

5.6.2 General maintenance and housekeeping

General maintenance and repair of equipment and structures provide an environment that is perceived as safe and free of crime. For example, fire and accumulated debris could lead to an intentional or unintentional fire or vandalism, and damage to property lead to additional damage. As described by the “Broken Windows” theory (Kelling and Wilson, 1982), maintaining and monitoring the tunnel environments in a well-ordered condition may stop or prevent the escalation of further vandalism into more serious crime. Transit agencies should ensure that they maintain an environment that supports acceptable public behavior for the ridership to perceive the system as safe.

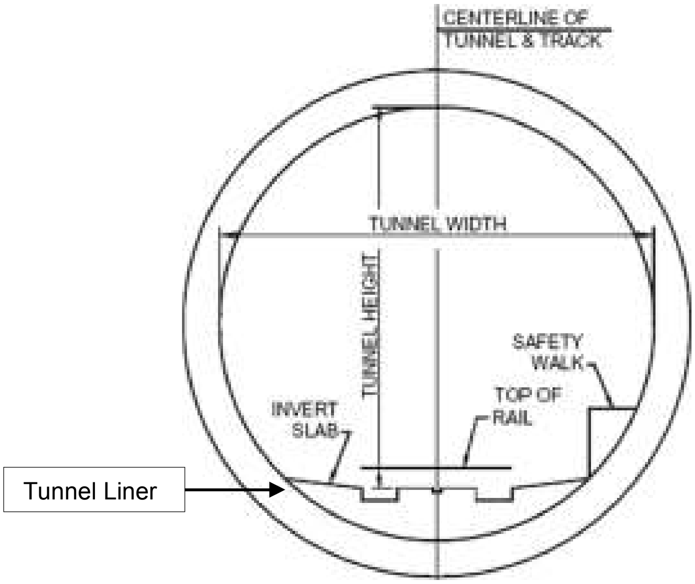
Appendix A: Rail transit tunnel design

Rail transit tunnels are typically designed in circular, single-box, double-box, horseshoe and/or oval shapes. Tunnel designs are related to the geography of the site, which may be different from one location to another along the rail line because of changes in geological conditions.

A qualified professional engineer with demonstrated tunneling experience should be consulted to identify, describe and explain a tunnel's construction method, design details and components, and describe and explain the tunnel's current technical drawings, to ensure a full understanding of the asset.

FIGURE 2

Circular Tunnel Shape

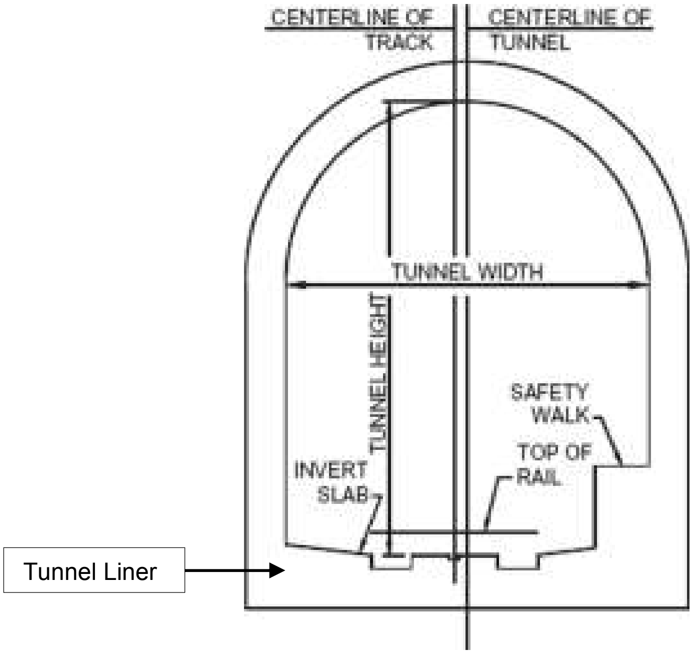


Circular Tunnel

- Designed in a round shape.
- Designed for submerged or soil-covered tunnel.
- Typically a single track and one safety walk.
- The tunnel's invert slab is placed on the top of the interior liner.

FIGURE 3

Horseshoe Tunnel Shape

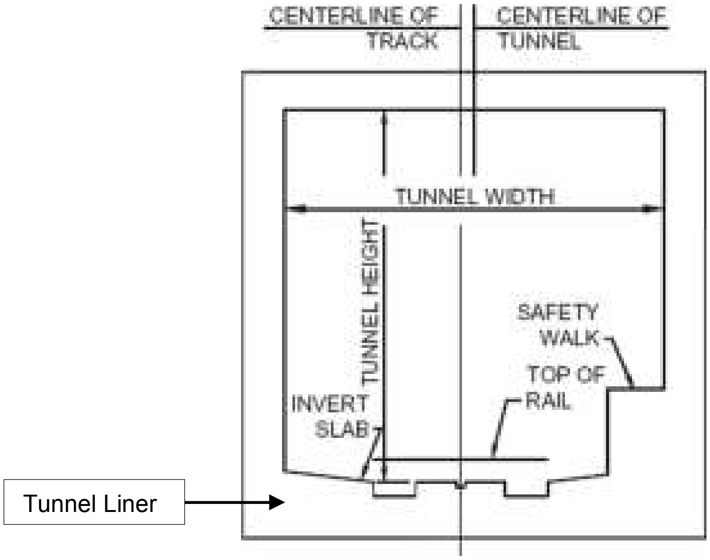


Horseshoe Tunnel

- Designed in a horseshoe shape.
- Shape typically exists in rock conditions and may be unlined within stable rock formations.
- Designed for a single track with one safety walk.
- The tunnel's invert slab is placed on the grade of the liner.

FIGURE 4

Single-Box Tunnel Shape

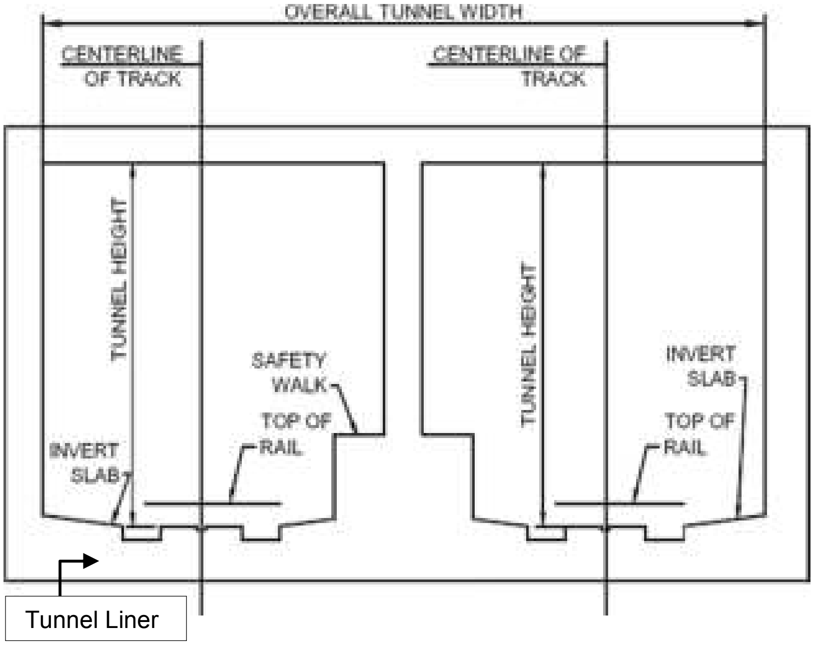


Single-Box Tunnel

- A single-box tunnel is usually constructed beside another single-box tunnel for travel in the opposite direction.
- Single-box design has a squared box shape.
- Design includes a single rail track and safety walk.
- The tunnel's invert slab is placed on the grade of the liner.

FIGURE 5

Double-Box Tunnel Shape

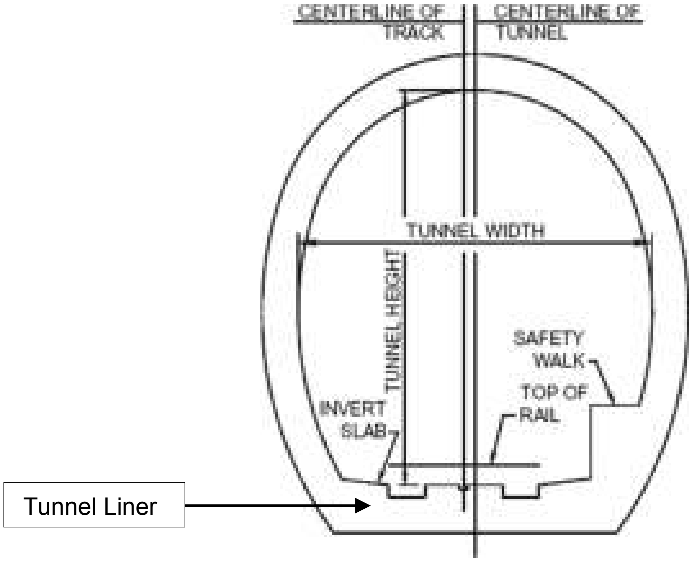


Double-Box Tunnel

- Consists of two single-box tunnels.
- Each box is typically designed with a single track and one safety walk in each box.
- Depending on location and loading conditions, the center wall of the tunnels may be solid or composed of consecutive columns.
- The tunnel's invert slab is placed on the grade of the liner.

FIGURE 6

Oval Tunnel Shape

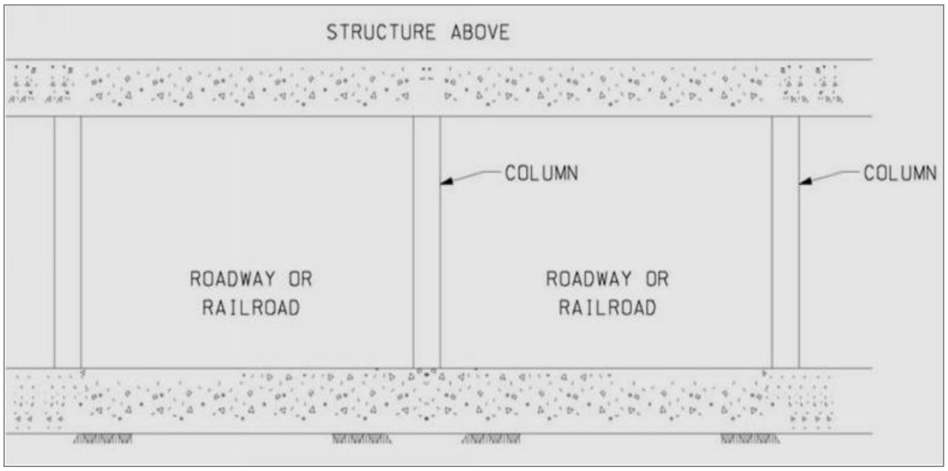


Oval Tunnel

- Oval shape design
- Designed for a single rail track and a single safety walkway.
- The tunnel's invert slab is placed on the grade of the liner.

FIGURE 7

Air Rights Tunnel Shape



Air Rights Tunnel Structure

- Structure built over a roadway as a bridge using the road's air rights and forming a tunnel for vehicle traffic to travel through.
- The structure above the tunnel can be a building of any type, a transit or rail station, a parking garage or a parking lot.
- Air rights structure tunnels may be constructed to enclose both road and rail operations.

Appendix B: Types of tunnel liners

unlined rock: This type of tunnel (**Figure 8**) is one in which no lining exists for the majority of the tunnel length. Linings of other types may exist at portals or at limited zones of weak rock.

rock reinforcement systems: Rock reinforcement systems are used to add additional stability to rock tunnels in which structural defects exist in the rock. Reinforcement systems include the use of metal straps and mine ties with short bolts, untensioned steel dowels or tensioned steel bolts. To prevent small fragments of rock from spalling off the lining, wire mesh, shotcrete or a thin concrete lining may be used in conjunction with the above systems.

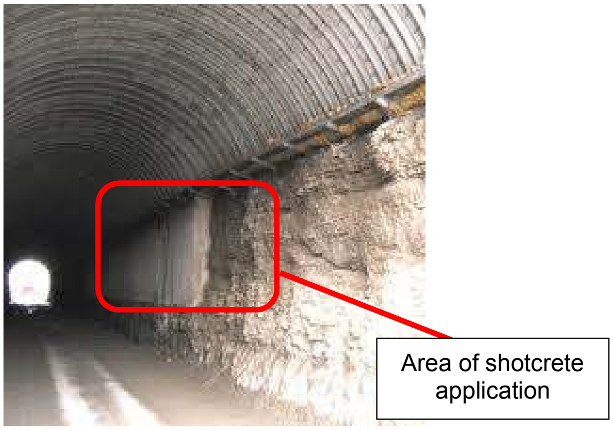
shotcrete: This type of liner (**Figure 9**) is primarily used as a temporary application prior to a final liner being installed or as a local solution to instabilities in a rock tunnel; however, it can be used as a final lining when applied with additional materials and layering.

FIGURE 8

Unlined Rock Tunnel

FIGURE 9

Shotcrete Liner



ribbed systems: Ribbed systems are typically a two-pass system for lining a drill-and-blast rock tunnel. The first pass consists of timber, steel or precast concrete ribs, usually with blocking between them. This provides structural stability to the tunnel. The second pass typically consists of poured concrete that is placed inside the ribs.

segmental: Segmental linings are primarily used in conjunction with a tunnel boring machine (TBM) in soft ground conditions. The prefabricated lining segments are erected within the cylindrical tail shield of the TBM. These prefabricated segments can be made of steel, concrete or cast iron and are usually bolted together to compress gaskets for preventing water penetration.

poured concrete: Placed concrete linings are usually the final linings that are installed over any of the previous initial stabilization methods. They can be used as a thin cover layer over the primary liner to provide a finished surface within the tunnel or to sandwich a waterproofing membrane. They can be reinforced or unreinforced. They can be designed as a non-structural finish element or as the main structural support for the tunnel.

slurry walls: Slurry wall construction type liners vary, but typically they consist of excavating a trench that matches the proposed wall profile. This trench is continually kept full with a drilling fluid during excavation, which stabilizes the sidewalls. Then a reinforcing cage is lowered into the slurry, or soldier piles are driven at a predetermined interval, and finally concrete is placed into the excavation, which displaces the drilling fluid. This procedure is repeated in specified panel lengths, which are separated with watertight joints.

Appendix C: Tunnel construction methods

cut and cover: The excavation of an open trench where the tunnel is constructed to the design finish elevation and then subsequently covered with various compacted earthen materials and soils.

shield driven: This method involves pushing a shield into the soft ground ahead. The material inside the shield is removed, and a lining system is constructed before the shield is advanced further.

bored: This method refers to using a mechanical tunnel boring machine (TBM) in which the full face of the tunnel cross-section is excavated at one time using a variety of cutting tools that depend on ground conditions (soft ground or rock). The TBM is designed to support the adjacent soil until temporary (and subsequently permanent) linings are installed.

drill and blast: A process of drilling a hole or holes, packing dynamite into them, and detonating and explosive blast to loosen and or break up rock material.

immersed tube: Method often used when a canal, channel, river, etc. needs to be crossed. A trench is dug at the water bottom, and prefabricated tunnel segments are made watertight and sunken into position, where they are connected to the other segments. Afterward, the trench may be backfilled with earth to cover and protect the tunnel from the waterborne traffic, such as ships, barges and boats.

sequential excavation method (SEM): Soil in certain tunnels may have sufficient strength such that excavation of the soil face by equipment in small increments is possible without direct support. The cohesion of the rock or soil can be increased by injecting grouts into the ground prior to excavation of that segment. Once excavated, the soil face is then supported using shotcrete, and the excavation is continued for the next segment.

jacked tunnels: First, jacking pits are constructed. Then, tunnel sections are constructed in the jacking pit and forced by large hydraulic jacks into the soft ground, which is systematically removed in front of the encroaching tunnel section.

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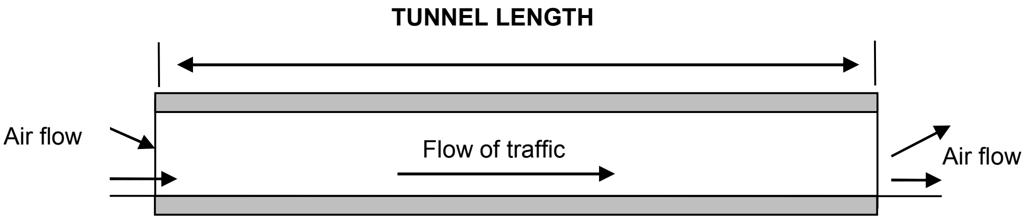
Appendix D: Ventilation system types

natural: In a naturally ventilated tunnel (**Figure 10**), the movement of air is controlled by meteorological conditions (i.e., elevations, temperature differences at portals, winds, etc.) and the piston effect created by moving traffic pushing the stale air through the tunnel.

FIGURE 10
Natural Ventilation



longitudinal: Longitudinal ventilation is similar to natural ventilation, in that air flow is moved through the tunnel by the piston effect of traffic, but supplemented with the addition of mechanical fans installed in the tunnel structure to ensure circulation of air into or out of the tunnel. For example, when required, longitudinal fans may be operated and controlled under specific conditions to move stagnant or contaminated air, to reduce concentrations of contaminants to acceptable levels, or to control smoke or heated gases during a fire emergency. Longitudinal fans may also be operated either in the forward or reverse direction. They may be installed in portal buildings, to the center shaft, or mounted inside the tunnel (**Figure 11** and **Figure 12**).

FIGURE 11
Natural Ventilation Tunnel with Longitudinal (Mechanical) Ventilation

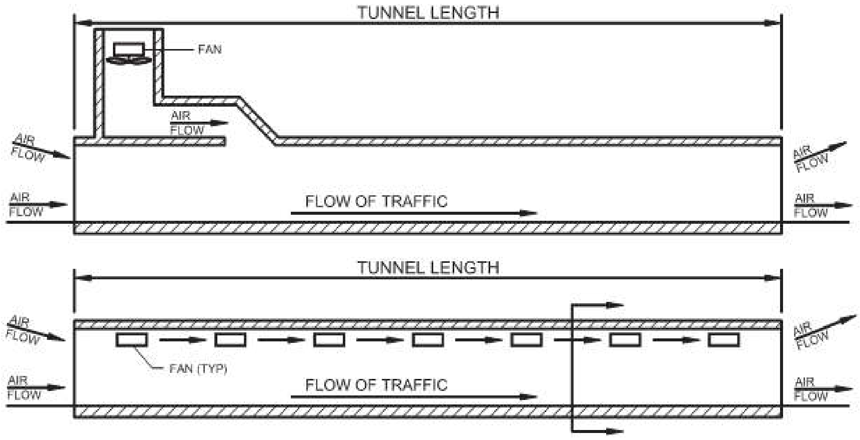


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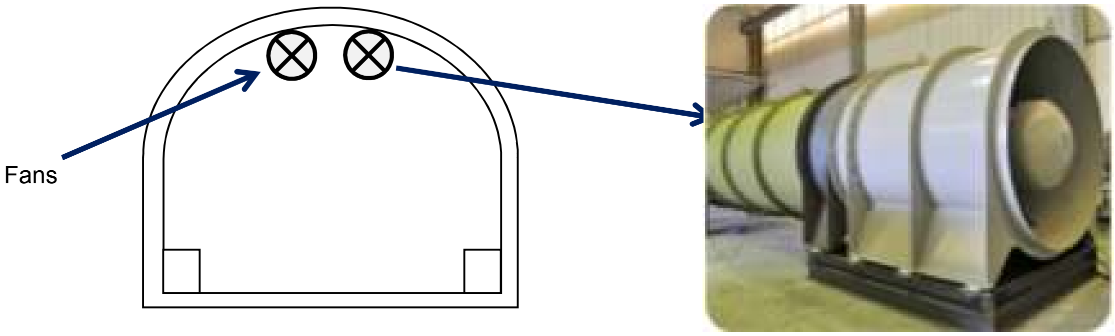
FIGURE 12

Example of Longitudinal (Mechanical) Ventilation



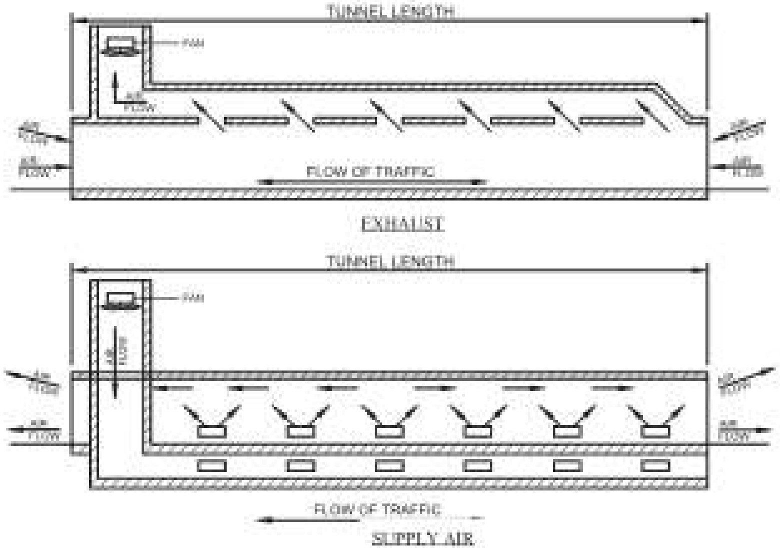
Tunnel Cross-Section

Enlargement of a Longitudinal (Axial) Ventilation Fan

semi-transverse ventilation: This system of ventilation (**Figure 13**) also makes use of mechanical fans for movement of air. However, a separate plenum or ductwork is added either above or below the tunnel with flues that allow for uniform distribution of supply air into or exhaust out of the tunnel. There are many variations of semi-transverse tunnels — for example supply semi-transverse, exhaust transverse or two separate semi-transverse systems, one to pull supply air into a section of the tunnel, while the other semi-transverse system pushes air from the tunnel system.

FIGURE 13

Semi-Transverse Ventilation (Exhaust and Supply)



full-transverse ventilation: With components similar to semi-transverse ventilation, full-transverse ventilation incorporates both supply air and exhaust air together over the same length of tunnel (**Figure 14**). This method is used primarily for longer tunnels that have large volumes of air that need to be replaced or for heavily traveled tunnels that produce high levels of airborne contaminants.

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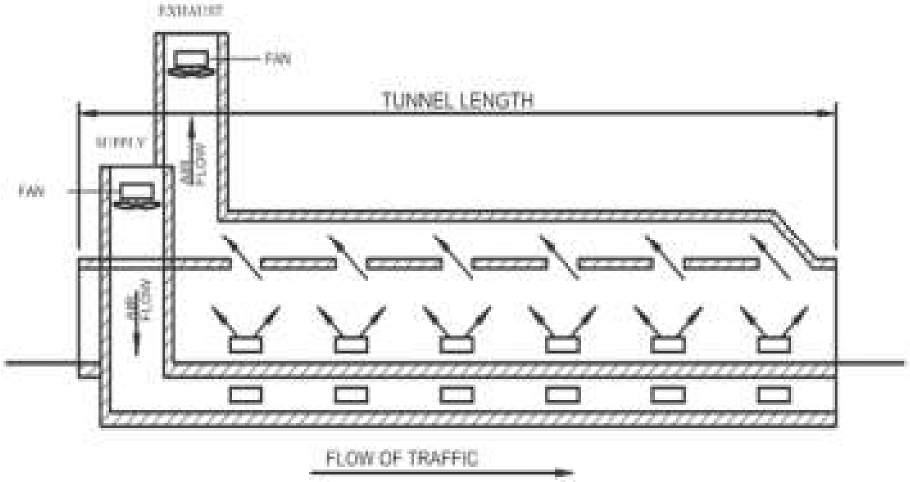
FIGURE 14

Full-Transverse Ventilation (Exhaust and Supply)



single-point extraction: In conjunction with semi- and full-transverse ventilation systems, single-point extraction can be used to increase the airflow caused by fire or an increase in airborne contamination within the tunnel. The system works by allowing the opening size of select exhaust flues to increase during an emergency.

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Appendix E: Fan types

axial fan: These fan types move air parallel to their impellor shafts. They may be mounted horizontally on the tunnel ceiling at intervals throughout the tube or mounted vertically within a ventilation shaft that exits to the surface. Longitudinal ventilation is an example of axial fan mountings in a tunnel (**Figure 15**).

centrifugal fan: These fan types move air in a direction 90 degrees from the initial direction which the air is obtained (**Figure 16**). Centrifugal fans are commonly selected over axial fans because they have higher capacity, require less horsepower, and are less expensive to operate.

FIGURE 15

Axial Fan

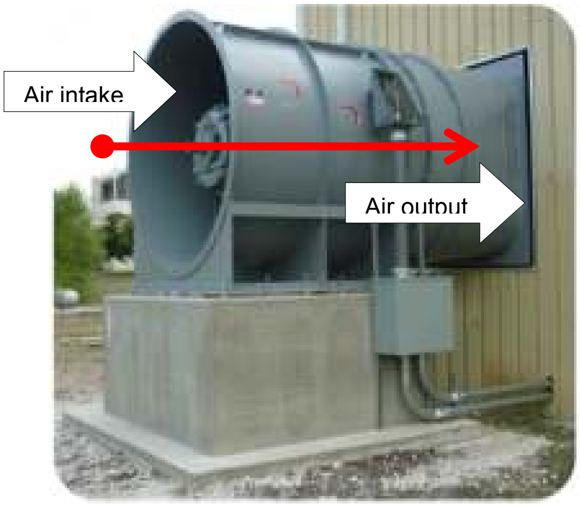
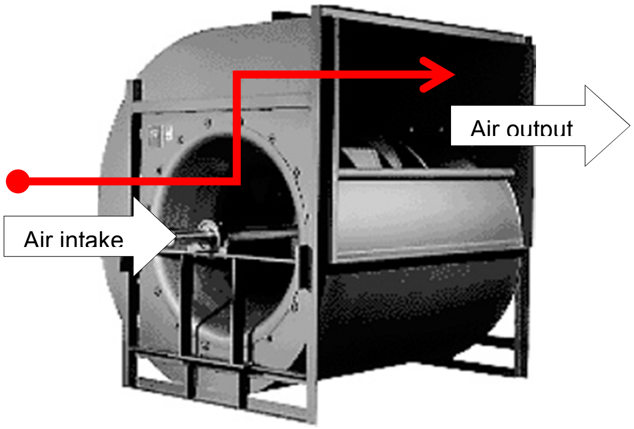


FIGURE 16

Centrifugal Fan



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Summary of document changes

Document Version	Working Group Vote	Public Comment/ Technical Oversight	CEO Approval	Policy & Planning Approval	Publish Date
First published					
First revision					
Second revision					

Definitions

air rights structure tunnel: A structure built over a roadway using the road's air rights. The structure above the tunnel can be a building of any type, i.e., a transit or rail station, a parking garage or a parking lot. Air rights structure tunnels may be constructed to enclose both road and rail operations.

access control: An aspect of security that often uses physical security equipment/technology entry control systems and specialized procedures to manage and monitor movement into, out of or within a specific protected area. Access to various areas may be limited by need to know, place, time or a combination of all.

clear zone: An area that is clear of visual obstructions and landscape material that could conceal a threat or perpetrators, e.g., the space immediately adjacent to and around an inhabited building without obstructions large enough to conceal explosives 6 in. or greater in height.

crime prevention through environmental design (CPTED): A crime-prevention philosophy based on the theory that proper design and effective use of the built environment can lead to a reduction in the fear and incidence of crime, as well as an improvement in the quality of life.

design shapes: Tunnels are designed in circular, single-box, double-box, horseshoe and oval shapes. The shape of a tunnel typically relates to the method/ground conditions in which it was constructed.

detect: The act of discovering an attempt (successful or unsuccessful) to breach a secured perimeter (such as scaling a fence, opening a locked window, or entering an area without authorization).

entry control: The control of people, vehicles and materials through entrances and exits of a protected area using equipment and/or technology that channels, restricts or controls entry to an area, space or location.

finishes: manufactured material or materials used to line the interior of tunnels. Finishes may enhance the aesthetics of a tunnel, improve lighting, attenuate or intensify sound, and/or reduce tunnel maintenance requirements. Finish types or materials may include ceramic, porcelain, or metal tile; epoxies or enamel-coated panels; pre-cast concrete; and/or coated cement board.

first responders: Local police, fire and emergency medical personnel who first arrive at the scene of an incident and take action to save lives, protect property and meet basic human needs.

invert: The slab on which the roadway or track bed is supported within a tunnel.

layers of protection: Using concentric circles extending out from an area to be protected as demarcation points for different security strategies.

liner: Substances that line the interior of tunnels that are bored into or through rock or where soft ground conditions exist. They support, stabilize or reinforce the structural deficiencies that may be found in tunnels.

plenum: A separate space between the structural ceiling and a drop-down ceiling. A plenum may also be under a raised roadbed or track.

portal: An interface between a tunnel and the atmosphere through which vehicles pass; a connection point to an adjacent facility.

response: Employees, guards or law enforcement representatives who deploy to investigate a detection event or interdict an intruder or a trespasser.

standoff distance: The distance between an asset or building or portion thereof (target) and the potential location of an explosive device (threat).

target: An object, background or reflector at which something (i.e., a threat) is aimed.

threat: Any indication, circumstance or event with the potential to cause loss of life or damage to an asset.

tunnel construction: Tunnel shape (e.g., circular, horseshoe or rectangular) is largely dependent on the method used to construct it. Typical tunnel construction methods include cut and cover, shield driven, bored, drill and blast, immersed tunnel, sequential excavation, or jacked tunnels.

ventilation: A system of circulating fresh air by natural or mechanical means.

Abbreviations and acronyms

AASHTO	American Association of State Highway and Transportation Officials
ACS	access control system
APTA	American Public Transportation Association
AVL	automated vehicle locator
CBR	chemical, biological or radiological
CCTV	closed-circuit television (see VSS)
CFR	Code of Federal Regulation
CPTED	crime prevention through environmental design
DHS	Department of Homeland Security
ECS	emergency call station
ESS	electronic security system
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
GPS	Global Positioning System
HSEEP	Homeland Security Exercise and Evaluation Program
I-STEP	Intermodal Security Training Exercise Program
IDS	intrusion detection system
IID	improvised incendiary device
IRVS	integrated rapid visual screening
ISP	Independent Study Program (FEMA)
LES	Law Enforcement Sensitive
MEC	mechanical, electrical or communications [system]
NCHRP	National Cooperative Highway Research Program

NFPA	National Fire Protection Association
NIPP	National Infrastructure Protection Plan
NTAS	National Terrorism Advisory System
NTI	National Transit Institute
PTC	positive train control
SCADA	supervisory control and data acquisition
SEM	sequential excavation method
SSI	sensitive security information
TBM	tunnel boring machine
TCRP	Transit Cooperative Research Program
TDA	transit domain awareness
TSA	Transportation Security Administration
TSWG	Technical Security Working Group
USCOE	United States Army Corps of Engineers
VSS	video surveillance system

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