APTA STANDARDS PROGRAM
RECOMMENDED PRACTICE

APTA SS-SIS-RP-016-15, Rev. 1
First Published: March 1, 2015
First Revision: January 23, 2024
APTA Security Risk Management Working Group

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.

Foreword

The American Public Transportation Association is a standards development organization in North America. The process of developing standards is managed by the APTA Standards Program's Standards Development Oversight Council (SDOC). These activities are carried out through several standards policy and planning committees that have been established to address specific transportation modes, safety and security requirements, interoperability, and other topics.

APTA used a consensus-based process to develop this document, which is detailed in the manual for the APTA Standards Program. This document was drafted in accordance with the approval criteria and editorial policy as described. Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

This document was prepared by the APTA Infrastructure and Systems Security Working Group (ISSWG) as directed by the APTA Security Standards Policy and Planning (SSPP) Committee.

This document 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 recommended practices or guidelines contained herein is voluntary. APTA standards are mandatory to the extent incorporated by an applicable statute or regulation. In some cases, federal and/or state regulations govern portions of a transit system's operations. In cases where there is a conflict or contradiction between an applicable law or regulation and this document, consult with a legal adviser to determine which document takes precedence.

This is a revised document.

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Participants

The American Public Transportation Association greatly appreciates the contributions of the **APTA Transit Infrastructure and Systems Security Working Group**, which provided the primary effort in the drafting of this document.

At the time this standard was completed, the working group included the following members:

Lurae Stuart, *WSP USA*, Chair
Mark Uccardi, *Booz Allen Hamilton*, Vice Chair

Aldon Bordenave, *LA Metro*
Ryan Chelski, *Sound Transit*
Neil Crosier, *King County Metro*
Matthew Dimmick, *STV*
Tony Easterling, *TSA*
Dean Fajerski, *TSA*
Kevin Franklin, *Bay Area Rapid Transit*
Stephan Parker, *Transportation Research Board*
Jacob Peltier, *Community Transit*
John Plante, *METRA*
Branden Porter, *Sound Transit*
Jason Powell, *Metro St. Louis*
Diana Rawles, *Denver RTD*
Charles Rappleyea, *WSP USA*
Harry Saporta, *WSP USA*
Jill Shaw, *Dallas Area Rapid Transit*
Kirsten Tilleman, *WSP USA*

Project team
Polly Hanson, *American Public Transportation Association*
Eric Halzel, *Eagle Hill Consulting*

Introduction

This introduction is not part of APTA SS-SIS-RP-016-15, Rev. 1, "Tunnel Security for Public Transit."

APTA recommends the use of this document by:

- individuals or organizations that operate public transit systems;
- individuals or organizations that contract with others for the operation of public transit systems; and
- individuals or organizations that influence how public transit systems are operated (including but not limited to consultants, designers and contractors).

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.

Tunnel Security for Public Transit

1. Transit tunnel security overview

Passenger transit tunnels are an important infrastructure asset for the movement of passengers through regions and communities. However, they gather volumes of people in confined areas with limited means of entry and exit, providing opportunities for adversaries to inflict harm to large numbers of people, damage critical infrastructure and disrupt transit operations. 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 recommended practice promotes measures, practices and strategies to reduce risks related to passenger transit tunnels, complementing other APTA standards and reports that address security for public transportation. Additional information about passenger stations, including those in tunnel environments, can be found in APTA SS-ISS-RP-004-22, "Security Considerations for Public Transit Passenger Stations and Stops."

Transit agencies should use a uniform approach of "problem-seeking" before moving to "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 agencies options to mitigate risk and operate a balanced and effective security program. While highway tunnels have an important role in the nation's transportation networks, including in support of transit bus operations, this recommended practice focuses only on 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

Security for passenger transit tunnels is only one element of the security of the entire transit system. Transit agencies should understand and adopt transit tunnel security protection measures to enhance the security environments of where they operate. Transit agencies should apply the recommendations based on their assessed risk.

1.2 Benefits

Applying this recommended practice will help transit agencies do the following:

- Recognize credible threats to their transit tunnels.
- Enhance security through the reduction of transit tunnel vulnerabilities.
- Reduce the risks related to transit tunnels with the application of appropriate mitigations and controls.

2. Security risk assessment

Transit agencies should complete a current system-wide security risk assessment with recommendations to identify, evaluate and reduce risks to the system's people, assets, operations and infrastructure. Additional information about security risk assessments can be found in APTA SS-SIS-S-017-21, "Security Risk Assessment Methodology for Public Transit."

2.1 Site-specific security risk assessment

Transit 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. Tunnel characteristics, systems and associated vulnerabilities should be incorporated into the tunnel security assessment. For a comprehensive analysis on the tunnel, a blast analysis and fire analysis should be completed. Emergency evacuation simulation modeling is also helpful.

The following documents may assist transit agencies in developing security risk assessments for tunnels (see References for additional resources):

- "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/U.S. Army Corps of Engineers
- "Integrated Rapid Visual Screening Series (IRVS) for Tunnels," Department of Homeland Security

3. Tunnel overview

Tunnel designs are not typically developed based on security considerations. The assessment of tunnel structural 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 they present. 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. The reality is that many transit tunnels in operation today were designed and constructed a very long time ago; some transit tunnels are more than 100 years old and may not easily be retrofitted.

3.1 Tunnel components and systems

Understanding the structural design and basic functions and operations of key tunnel components and systems—such as mechanical, including drainage pumps; electrical; ventilation; and communications—is essential to identifying tunnel vulnerabilities and implementing effective protection measures.

3.1.1 Basic tunnel design characteristics

The design and shape of a tunnel, 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 consult with qualified engineers to evaluate their current or future transit tunnel shape, ground conditions, environments, locations and proximity to other critical infrastructures to identify the vulnerabilities associated with a particular design. They should then identify mitigation measures that would effectively reduce risk by enhancing the overall security of the structure.

For example, an immersed tunnel is vulnerable to flooding in the event of an explosion. The risk is due to limited soil cover over the tunnel and high hydrostatic water pressures. The vulnerability should be assessed for both structural damage and flood potential. Similarly, cut-and-cover tunnels are less blast-resistant than tunnels built around rock, as they have limited soil backfill over the tunnel structure. This reduces the amount of confinement to an internal or external explosion. Bored or mined tunnels are more resistant to a blast, as they are built in rock with deep cover.

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. Example materials include reinforced concrete, non-reinforced concrete, gunite and shotcrete, which are all in use in transit tunnels.

Depending on the size and shape of an explosive device, an explosion can damage the liner and tunnel support systems by fragmenting the liner and overstressing the tunnel support systems. The potential for breach failure due to an explosion should be considered in the tunnel lining vulnerability assessment.

3.1.3 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, 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 they may become 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. Other supporting tunnel elements, such as tunnel lighting, signaling and ventilation fixtures, may also be considered hazards and should be considered for hardening or removal.

3.1.4 Tunnel ventilation systems

Transit tunnels and enclosed stations often require mechanical emergency ventilation systems to remove heat and smoke during a fire event, as well as exhaust emissions from motor vehicles and diesel-powered equipment during tunnel maintenance activities. Tunnels of 1000 ft or less may rely solely on natural convection or ventilation via the piston effect of a train pushing air through the tunnel to remove stagnant air. A system analysis should be conducted to determine the safety and security impacts of the tunnel ventilation system during safety and security events in the tunnel, including the loss of availability of the ventilation system. The five major types of tunnel ventilation systems are listed in Appendix A.

3.1.4.1 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 outbuildings (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. The security assessment should consider the impacts of fan disablement and the use of fans in the inadvertent distribution of contaminants, such as chemical or biological agents.

3.1.4.2 Ventilation system supplemental equipment

Electrical motors, fan drives, sound attenuators and dampers are essential components of a tunnel ventilation system. The loss of single or multiple components may result in system-wide failure and the inability to adequately mitigate the hazard. The security assessment should consider the impacts of ventilation system failures, such as loss of dampers and other components.

3.1.5 Electrical system

A tunnel's electrical system typically draws its power requirements from different utility power grids 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 for rail transit systems may be provided to catenary (overhead) or third-rail power systems from one power utility service provider, and a different utility service provider may provide power to communications or ancillary spaces. A power analysis should be performed to determine the frequency of power loss in each power grid and the availability of redundant power, including the need for emergency power generators and uninterruptable power supply systems.

3.1.6 Signal system

A typical signal system consists of a complex set of electrical and/or mechanical components to determine the position of trains, maintain train separation, and control movements over track switches. Signal systems consist of wayside signals, signal cases and rooms, switch circuit controllers, and other components. For rail transit systems, the risk assessment should include the criticality of the signal system to the operation of a rail system and the impacts to safety and security.

3.1.7 Communications

Tunnel communication systems may be design-built with or have installed media to send/receive messages, information and other communications into, within or from a transit tunnel. These systems include antennas, repeaters, cable, fiber or other wireless devices. One or more communication media 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 (Operations Control 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 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.

- **Automatic 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.
- **Signaling and train control system (STCS).** Technology 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.

The security risk assessment should consider the criticality of these devices and systems and the impacts if compromised.

4. Tunnel threat and vulnerability environment

Transportation tunnels are attractive threat targets for many reasons. They are considered to have a relatively 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 may hold symbolic value within a region. Regardless of significance, any disaster or attack to a tunnel could be costly both economically and in public perception, cause the asset to be out of service for long-term repair or replacement, generate high public impact from loss of human lives and/or economic activity, and require alternate means of transit services. Further, utility lines (e.g., electricity, communications, water) that are colocated in a tunnel could increase the attractiveness of the target due to additional economic impacts.

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 1**.

TABLE 1
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 immersed tunnel structure by ship anchors or large explosive device delivered by boat/vessel.

4.2 Tunnel vulnerabilities

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

- **Access.** Access to support equipment, making it 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.** Access to tunnel portals is typically unrestricted by necessity, allowing trespass and intrusion into the tunnel structure. An explosive detonation event may result in less overall damage to the structure, as the blast loads are less confined due to the open space of the portal. Failure of the portal may also cause collapse of the ground material surrounding the opening.
- **Design.** Tunnel designs have varying vulnerabilities, which include the following:
  - **Immersed tube tunnels.** Immersed tube tunnels are under high hydrostatic water pressure. Because they are typically surrounded by porous backfill materials with limited soil thickness, the potential for damage is high. A breach would cause rapid flooding of the tunnel.
  - **Cut-and-cover tunnels.** Cut-and-cover tunnels are usually 45 to 60 ft in depth. They are structures constructed in trenches and then covered with fill materials. Because of the shallow depth and the type of backfill materials, they are less resistant to the effects of an explosion. Cut-and-cover tunnels in areas with high groundwater levels may be subject to water intrusion.
  - **Bored or mined tunnels.** Tunnels may be bored or mined in soft soil or rock. The greater the rock or soil cover over the tunnel structure, the greater the structure protection and the lower the potential for structural damage. The primary concern with tunnels in soft soil is soil stability and groundwater condition. Under an explosive condition, the tunnel elements would bend and may shear. Bored or mined tunnels in rock are the least subject to damage due to the strength of the rock. Damage is usually confined locally and may be more easily repaired.
- **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. Liners can be composed of reinforced concrete, non-reinforced concrete, gunite, shotcrete, etc.

- **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.
- **Location.** Human-made and natural hazards in the vicinity of transit 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 the vulnerability of 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 from the structure (e.g., vent house for an immersed tunnel). The air supply, air returns and other air handling equipment at the source or along the supply route may be vulnerable to the release of chemical agents. 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 or into 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 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

While threats can remain consistent, their consequences are potentially magnified in a tunnel because of the enclosed environment, ventilation challenges, location and length. **Table 2** identifies potential consequences to threats targeting a tunnel.

TABLE 2
Potential Consequences of Threats in Tunnel Structures

Threats	Casualties and Equipment Loss	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 (immersed tunnel)	✓		✓	✓			✓	

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, equipment and technologies. Mitigations are most effective when identified and planned into the tunnel design, rather than implemented in a retrofit effort. Transit agencies should 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 through a safety and security certification process, or other means of validation and verification.

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 3**. 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, criticality of systems and operation use all impact the mitigations that should be considered.

TABLE 3
Mitigation Measures

Mitigation Measure	Description
Access control system (ACS)	• Incorporates access control database systems with procedures to manage and monitor movement into, out of or within the tunnel ancillary rooms and associated infrastructure such as signal and communication rooms. • 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)	• Used to obstruct and prevent the movement of vehicles into the tunnel portal or restrict vehicle movement, e.g., Jersey-style concrete barriers, bollards, mobile barrier devices.
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 for stations and tunnel infrastructure entry points.
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 and back-of-the-house areas. • Encourages openness and unrestricted passage to areas where the traveling public is authorized. • Post designation of zones with appropriate signage.
Drainage/flood control system	• Incorporation of drainage systems, including pumps, to protect against flooding of stations and trainway. • Floodgates to prevent water intrusion from adjacent waterways.
Electronic security system (ESS)	• Includes 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.
Electrical power	• Backup electrical power for critical tunnel systems. • Includes the use of redundant power grids for systems, such as emergency ventilation fans that most backup generators are unable to accommodate.
Emergency egress	• Used to evacuate tunnel occupants or as an entry point for first responders. • Incorporates signage and wayfinding, emergency lighting, and communications to and within egress area.
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 system	• Detects smoke, senses heat and reports events to an underground station and/or 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.

TABLE 3
Mitigation Measures

Mitigation Measure	Description
Fire suppression system	• Suppresses smoke and/or fire. • System 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.
Intrusion detection system (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	• Implementing 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 patrol	• 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, 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 install 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	• Informs, provides notice or gives warning. • Post at appropriate locations to identify property boundaries and to inform potential trespassers of restrictions, prohibitions, surveillance activities and 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 for an immersed tunnel.
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 threat from the target, the lower the blast overpressure should be when reaching it.
Structural protection	• Hardened against the effects of a blast. • Provides fire protection of structural members. • For immersed tunnels, prevents damage from anchors.

TABLE 3
Mitigation Measures

Mitigation Measure	Description
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 3**) are combined in **Table 4**. This information provides agencies 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 4
Threats and Mitigations Matrix

Mitigation Measures	Threats						
	Explosives	CBR	IID, Fire, Arson	Flooding	Sabotage	Cyber	Maritime Incident
Access control system	✓	✓	✓		✓		
Anti-vehicle barrier	✓	✓	✓		✓		
Barriers and fencing	✓	✓	✓		✓		✓
Clear zone	✓	✓	✓		✓		✓
Crime prevention through environmental design (CPTED)	✓	✓	✓		✓		✓
Designated zones	✓	✓	✓		✓		✓
Drainage/flood control system				✓			
Electronic security system (ESS)	✓	✓	✓		✓		
Electrical power							
Emergency egress	✓	✓	✓		✓		✓
Entry control	✓	✓	✓		✓		
Fire detection system	✓	✓	✓		✓		
Fire suppression system	✓	✓	✓		✓		
Intrusion detection system (IDS)	✓	✓	✓		✓		
Layered protection	✓	✓	✓		✓	✓	✓

Commented [JVK1]: Need to add to be consistent with Table 3

TABLE 4
Threats and Mitigations Matrix

Mitigation Measures	Threats						
	Explosives	CBR	IID, Fire, Arson	Flooding	Sabotage	Cyber	Maritime Incident
Security patrols	✓	✓	✓		✓		✓
Security and emergency response policies and procedures	✓	✓	✓		✓	✓	✓
Security and emergency lighting	✓	✓	✓		✓		
Sensitive Security Information (SSI) protocols	✓	✓	✓		✓	✓	✓
Signage	✓	✓	✓		✓		✓
Standoff distance	✓	✓	✓		✓		✓
Structural protection	✓		✓				✓
Video surveillance systems (VSS)	✓	✓	✓		✓		✓
Walkways	✓	✓	✓		✓		✓

5. Other tunnel security considerations

5.1 Integrating security systems

Many security measures become more effective when integrated with other systems. Integrating access control with intrusion detection protection and VSS 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.

5.2 Updating 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. The plans should include procedures to address specific threats, including explosives, chemical release, cyber attack, etc. Any changes to the tunnel environment should be addressed.

5.3 Safeguarding 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 warrant being designed and protected as SSI. Other types of information exist, and they should be identified and protected. See APTA SS-ISS-RP-002-21, "Sensitive Security Information Policy," for additional details about protecting SSI.

5.4 Security training and exercises

Transit agencies should address tunnel-specific training and exercises as part of their training and exercise programs. For instance, transit agencies should include the tunnel environment in their emergency response exercises, as it is critical for first responders to have opportunities to practice responses within the transit agency tunnel environment. Security and emergency response exercises should be held in accordance with the transit agency safety, security or emergency management plan. See APTA SS-SEM-S-004-09, "Transit Exercises," for additional details about exercises in the transit environment.

Likewise, transit security awareness training should include tunnel-specific information, such as standard operating procedures in tunnels. Similarly, local first responders, emergency responders and first receivers should be invited to familiarize themselves with the characteristics, operations and environment of tunnels. See APTA SS-SRM-RP-005-12, "Security Awareness Training for Transit Employees," for additional details about security awareness training for public transit agencies.

5.5 Security equipment and general maintenance

Security transit 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, or special order). The operational performance of the equipment should be monitored, analyzed, audited, reviewed or tested according to the manufacturer's recommendations to ensure its operational readiness. The maintenance schedule may be revised based on historical data that supports revision to more frequent or less frequent intervals.

Likewise, general maintenance, housekeeping, and repair of equipment and structures provides an environment that is perceived as safe and free of crime. For example, fire and accumulated debris in the trackway could lead to an intentional or unintentional fire or vandalism, and damage to property could lead to additional damage. Transit agencies should ensure that they maintain an environment that supports acceptable public behavior for the ridership to perceive the system as safe.

Related APTA standards

APTA SS-ISS-RP-004-22, "Security Considerations for Public Transit Passenger Stations and Stops"
APTA SS-SEM-S-004-09, "Transit Exercises"
APTA SS-SIS-RP-007-10, "Sensitive Security Information Policy"
APTA SS-SIS-S-017-21, "Security Risk Assessment Methodology for Public Transit"
APTA SS-SRM-RP-005-12, "Security Awareness Training for Transit Employees"

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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—e.g., 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.

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.

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

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

Abbreviations and acronyms

ACS	access control system
AVB	anti-vehicle barrier
AVL	automatic vehicle locator
CBR	chemical, biological or radiological
CPTED	crime prevention through environmental design
ECS	emergency call station
ESS	electronic security system
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
GPS	Global Positioning System
IDS	intrusion detection system
IID	improvised incendiary device
IRVS	integrated rapid visual screening
MEC	mechanical, electrical or communications [system]
NIPP	National Infrastructure Protection Plan
NTAS	National Terrorism Advisory System
SCADA	supervisory control and data acquisition
SEM	sequential excavation method
SSI	Sensitive Security Information
STCS	signaling and train control system
TCRP	Transit Cooperative Research Program
TSA	Transportation Security Administration
VSS	video surveillance system

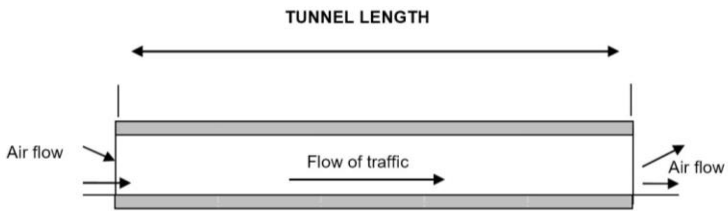
Document history

Document Version	Working Group Vote	Public Comment/ Technical Oversight	Rail CEO Approval	Policy & Planning Approval	Publish Date
First published	—	—	—	—	March 1, 2015
First revision	May 6, 2023	July 30, 2023	September 30, 2023	October 21, 2023	Jan. 23, 2024

Appendix A: Ventilation system types

natural: In a naturally ventilated tunnel (**Figure 1**), the movement of air is controlled by meteorological conditions (elevations, temperature differences at portals, winds, etc.) and the piston effect created by moving traffic pushing the stale air through the tunnel.

FIGURE 1
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 2** and **Figure 3**).

FIGURE 2
Natural Ventilation Tunnel with Longitudinal (Mechanical) Ventilation

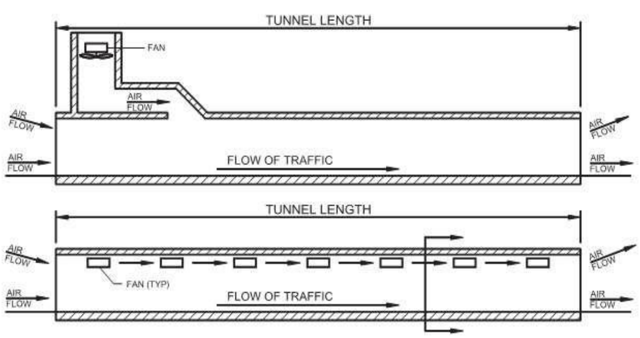
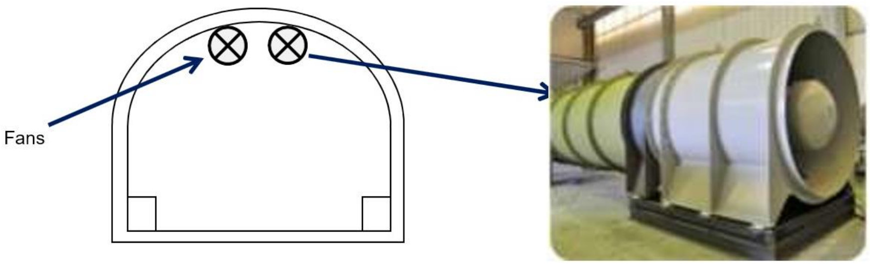
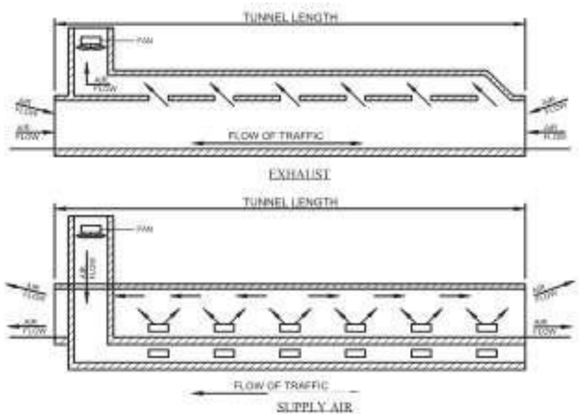


FIGURE 3
Example of Longitudinal (Mechanical) Ventilation



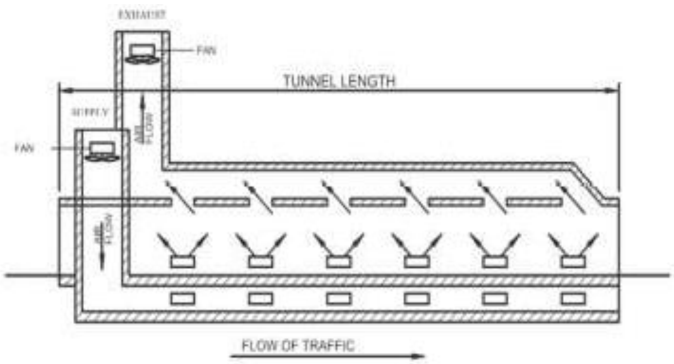
semi-transverse ventilation: This system of ventilation (**Figure 4**) also makes use of mechanical fans for movement of air. However, a separate plenum or ductwork is added either above or below the tunnel with flues that allow for uniform distribution of supply air into or exhaust out of the tunnel. 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 4
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 5**). 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.

FIGURE 5
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.

Appendix B: 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 6**).

FIGURE 6
Axial Fan

centrifugal fan: These fan types move air in a direction 90 deg. from the initial direction from which the air is obtained (**Figure 7**). Centrifugal fans are commonly selected over axial fans because they have higher capacity, require less horsepower and are less expensive to operate.

FIGURE 7
Centrifugal Fan