FTA RESEARCH
FEDERAL TRANSIT ADMINISTRATION

FTA Standards Development Program: Mitigations for Trespasser and Suicide Fatalities and Injuries

PREPARED BY
Center for Urban Transportation Research

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FTA Standards Development Program: Mitigations for Trespasser and Suicide Fatalities and Injuries

Metric Conversion Table

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
NOTE: volumes greater than 1000 L shall be shown in m^3				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
TEMPERATURE (exact degrees)				
^{o}F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^{o}C

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14. ABSTRACT
This research focused on mitigation strategies and countermeasures that may be used by rail transit agencies (RTAs) to reduce trespasser and suicide fatalities and injuries, including RTA practices and practical and promising strategies and countermeasures. This report can serve as a toolbox for RTAs to provide mitigation strategies identified from a literature review and employed by RTAs, including 11 case studies; promising existing and emerging technology applications to detect and/or prevent rail transit trespassing and suicides; and key research findings for mitigating injuries and fatalities associated with trespassing and suicide events.

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Abstract

This research focused on mitigation strategies and countermeasures that may be used by rail transit agencies (RTAs) to reduce trespasser and suicide fatalities and injuries, including RTA practices and practical and promising strategies and countermeasures. This report can serve as a toolbox for RTAs to provide mitigation strategies identified from a literature review and employed by RTAs, including 11 case studies; promising existing and emerging technology applications to detect and/or prevent rail transit trespassing and suicides; and key research findings for mitigating injuries and fatalities associated with trespassing and suicide events.

Executive Summary

Suicides and trespassing events are responsible for 70% of rail transit agency (RTA) reported fatalities in the United States. Based on National Transit Database (NTD) data obtained from the Federal Transit Administration (FTA), from 2011 through 2019, rail transit agencies reported 595 rail transit fatalities due to suicides and 209 fatalities due to trespassing.[1] These fatalities account for 52% and 18% of all rail transit agency fatalities reported for that time period, respectively.

In addition, trespassing along railroad rights-of-way (ROW) is the leading cause of freight and commuter rail related fatalities in the United States, and approximately 71% of all freight and commuter rail fatalities are the result of trespassing and suicide events. According to Federal Railroad Administration (FRA) data, more than 500 trespassing fatalities and 1,000 casualties (fatalities and injuries) have occurred each year since 2017. Between 2011 and 2019, fatalities associated with trespassing and suicide events accounted for 45% and 26% of fatalities along railroad ROW, respectively.[2]

As illustrated above, FTA and FRA data establish the ongoing, credible risks associated with suicides and trespassing events to the nation's rail systems—both FTA and FRA regulated systems. Recognizing the importance of reducing preventable fatalities and injuries from trespassing and mitigating fatalities and injuries from suicide attempts on RTA properties, this research sought effective and promising strategies, practices, and new and emerging technologies to mitigate trespasser and suicide injuries and fatalities. The study included detailed RTA trespassing and suicide data collection and analysis, an extensive literature review, and RTA case studies. Findings included in this report were based on the research performed.

Mitigation Strategies and Countermeasures for Trespassing

From the literature review, researchers identified major strategies and associated countermeasures to detect and prevent trespassing on rail transit ROWs, train stations, and other RTA facilities that include engineering, education, enforcement, and technology. Major strategies and associated countermeasures include:

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[1] National Transit Database, Safety & Security Time Series Data, 2011–2019.
[2] FRA Office of Safety Analysis, Railroad Accident/Incident Reporting System (RAIRS), 2011–2019.

- **Engineering**
  - Signage Installation – Placement of "No Trespassing" and suicide prevention life-line signs at train stations, highway-rail crossings, and along railroad tracks to inform people of trespassing prohibitions and penalties.
  - Fencing and Barriers – Design and installation of fence or barrier along rail transit ROWs especially for new rail lines, and installation of inter-track fencing or barriers at new train stations.
  - Rail Infrastructure Modification – Modification or addition of rail transit infrastructure such as landscaping, end-of-platform gates, platform edge (screen) doors, refuge space along or a pedestrian bridge over the tracks, or tunnels under the tracks at train stations, as deemed necessary.
  - Speed Restrictions – Train speed restrictions when approaching grade crossings or stations, especially at locations with significant pedestrian traffic (and potential trespassers), known trespassing incidents, or other serious concerns.

- **Education**
  - Community Outreach – Rail safety campaigns and outreach in collaboration with organizations such as Operation Lifesaver to educate the public concerning the dangers associated with railroad trespassing and to distribute educational materials, posters, flyers, and social media posts that may reduce trespassing events and improve railroad safety.
  - Rail Operator and Station Employee Training – Educating rail personnel on how to recognize errant and trespassing behaviors, identify risky areas for trespassing, report trespassing incidents, and take proper actions to mitigate trespasser fatalities and injuries.
  - Procedural Modification – Alteration of operating procedures, such as adding a near-miss trespasser fatality and injury reporting requirement, increasing patrols along the railroad ROW, and requiring consistent and uniform reporting to closely monitor trespassing activity and improve data quality.

- **Enforcement**
  - Law Enforcement – Regular patrol by rail transit police or local law enforcement officers on rail transit ROW, especially known trespassing hot spots, and quick responses to areas where trespassing activities have been reported.

- **Technology**
  - Implementation of New Technologies – Applying various detection technologies and systems such as guideway intrusion detection,

onboard guideway detection, grade-crossing obstacle detection, rail-side guideway detection, and drone patrols to conduct track surveillance and warn trespassers to leave the railroad ROW.

Mitigation Strategies and Countermeasures for Suicides

Suicide prevention efforts can take various forms. Some mitigation strategies are engineering based to physically restrict access to the rail system, while others aim to educate people, encourage them to seek mental health help, and increase patrol of rail transit ROW by law enforcement officers. High-level strategies to mitigate suicide fatalities and injuries include:

- Suicide prevention and intervention education
- Reduction of perceived viability of railroad ROW as a means for suicide
- Prevention of access to ROW
- Increased ability to avoid a train-person collision
- Reduction of the lethality of train-person collision

From the literature review, major mitigation strategies and countermeasures including engineering, education, enforcement, and technology are provided below:

- **Engineering**
  - Fencing and Barriers – Install adequate fence or barriers in known areas of incidents on railroad ROWs to eliminate or reduce accesses for committing suicides.
  - Refuge Space – Install refuge spaces under railroad tracks to enable a person who attempts suicide to fall below the wheelbase and prevent being struck. Refuge space can also be provided adjacent to the track and under the rail platform.
  - Signage and Digital Displays – Install and display suicide prevention signage and suicide hotline messages encouraging those with suicidal thoughts to talk to professionals who can help.

- **Education**
  - Suicide Prevention Events and Education – Facilitate community involvement in suicide prevention to reduce suicide attempts.
  - Social Services/Crisis Intervention Programs – Partner with local suicide prevention groups and social services and crisis intervention programs to prevent suicides at RTA properties.
  - Training for Railroad Employees and Authorities – Train employees to identify the behavioral indicators of suicide among trespassers and

passengers, and how to approach individuals who may be intent on self-harm (QPR: Question, Persuade, Refer).

– Data Collection – Improve data quality and accuracy by standardizing definitions of suicide incidents (suspected suicide attempts, suspected suicide fatalities, and injuries) to better assess implemented strategies and countermeasures.

- **Enforcement**
  – Law Enforcement – Partner with the rail transit agency police department or local law enforcement agencies to patrol, respond, and prevent suicides.

- **Technology**
  – Detection and Monitoring – Implement technology-based detection and monitoring along railroad ROW, train stations, or near railroad grade crossings to overcome some human limitations of in-person monitoring.

  – Platform Edge Doors (also referred to as "Platform Screen Doors") – Install platform edge doors to significantly reduce suicide attempts at train stations.

  – Blue Lights at Train Stations – Consider installing blue lights at train stations to potentially deter suicidal thoughts. However, it must be noted that the effectiveness of blue lights is not proven. Evidence showing the effectiveness of blue lights is based upon a Japanese study that has not been replicated.

Major Findings Based on Rail Transit Agency Surveys and Interviews

Based on survey and interview results from the 11 case studies conducted at the RTAs listed below, many strategies and associated countermeasures either yielded positive outcomes or showed a potential for mitigating suicide and trespasser incidents, injuries, and fatalities:

- Bay Area Rapid Transit (BART), San Francisco, CA
- Brightline (South and Central FL)
- Capital Metro, Austin, TX
- Houston METRO, Houston, TX
- Los Angeles County Metropolitan Transportation Authority (LA Metro), Los Angeles, CA
- Metropolitan Atlanta Rapid Transit Authority (MARTA), Atlanta, GA
- Massachusetts Bay Transportation Authority (MBTA), Boston, MA
- Metropolitan Rail Corporation (Metra), Chicago, Illinois

- Port Authority of Allegheny County, d.b.a. Pittsburgh Regional Transit, Pittsburgh, PA
- Southeastern Pennsylvania Transportation Authority (SEPTA), Philadelphia, PA
- Washington Metropolitan Area Transit Authority (WMATA), Washington, DC

Agency self-reported successes included the following:

- Installation of signage and fencing at strategic and hotspot locations
- Rail infrastructure modifications besides fencing and signage, and procedural modifications
- Fostering collaboration with law enforcement agencies
- Community outreach efforts, active advocacy, and partnerships
  - Instituting suicide prevention campaigns, interventions, and mental health awareness training
  - Collaboration with social services and crisis intervention groups on suicide prevention
  - Social media communications and campaigns emphasizing rail safety
- Rail operator training and rail safety education
- Application of existing technologies
- New technology adoption
- Instituting rail safety committees and think tanks promoting and prioritizing rail safety

Effective and Promising Practices for Trespassing Detection and Mitigation

Based on RTA surveys and follow-up interviews, the following practices were identified as effective or promising by case study agencies:

- Fencing rail transit ROW to reduce trespassing incidents, especially at trespassing hot spot locations and areas of serious concern and using cameras for monitoring.
- Conducting community educational outreach activities via collaboration with Operation Lifesaver, rail safety campaigns such as Respect the Train, and targeted campaigns to vulnerable populations.
- Training rail transit operators and employees how to properly handle various trespassing scenarios
- Deploying smartphone apps such as See Say and Transit Watch app (ELERTS Corp) and encouraging passengers to install and utilize the apps to report trespassing or suspicious activities.
- Rail transit police or local law enforcement agency response to reported trespassing and patrolling to reduce trespassing incidents.

- Installing flashing lights or audible alerts at train stations to indicate train arrival and warn passengers.
- Employing technology applications such as drones and ROW intrusion detection systems to detect trespassers.

The use of drones could help RTAs conduct a large-scale patrol of rail transit ROW and identify hot spots. If funding is available, incorporating exclusive rail transit ROW and/or highway-rail grade separation into new rail line design can significantly reduce trespasser fatalities and injuries. Additionally, it is crucial to train new and existing operators and employees to ensure they are aware of the latest tools and standard operating procedures employed by the RTA that will enhance their ability to mitigate trespassing incidents.

Effective and Promising Practices for Suicide Prevention and Mitigation

Based on RTA surveys and follow-up interviews, the following practices were identified as effective or promising by case study agencies:

- Installing signage with suicide hotline messages to direct distressed users to resources such as the National Suicide Prevention Lifeline, 1-800-273-TALK, or 1-800-273-8255.
- Coordinating with social services/crisis intervention programs and organizations such as Samaritans, forming a suicide prevention task force to campaign, and enhancing staff training on suicide prevention.
- Installing refuge spaces under railroad tracks at rail transit stations that enable a person attempting suicide or accidental fall victims to land below the wheelbase, preventing them from being struck.
- Conducting rail operator and agency employee training with suicide awareness modules and utilizing the QPR program used at Metra for training new and existing operators.
- Enhancing community outreach initiatives by including resources from organizations such as Operation Lifesaver and Samaritans and collaborating with community-based organizations that target specific at-risk demographics.
- Preventing access to rail transit ROW via means of restrictions/fencing and platform edge doors at train stations, at hotspot locations, or at locations with serious concerns. While this has not been implemented in the United States, there are systems that are considering platform edge doors or have incorporated this element into future station designs, including BART and SEPTA's City Hall Station redesign.

One of the most effective practices observed across RTAs was the use of suicide prevention hotline signage that effectively communicates available resources for distressed persons. Significant increases in hotline calls after

signage installation by SEPTA, BART, and Metra (as examples) potentially saved many lives. When comparing the number of suspected suicide fatalities and the number of suicide attempts/injuries (1-to-8 ratio), refuge space used by MARTA effectively reduced suicide fatalities. Other innovative solutions include the Buzz Boxx, a mobile barber shop for low-income patrons that educates customers on rail safety (adopted by Brightline), and rail safety excursion trains that are run specially to spread the message of rail safety (implemented by Capital Metro). Training rail transit operators and employees by collaborating with suicide prevention groups or helplines has also proved beneficial.

Promising Existing and Emerging Technologies

Technology applications can be used by RTAs to effectively mitigate trespasser and suicide fatalities and injuries. Agencies are increasingly considering innovative technologies for reducing trespassing and suicide incidents; however, while many RTAs are interested in applying technologies, they are concerned about the maturity, capabilities, availability, and effectiveness of these technologies as well as the costs associated with acquisition and deployment. Through a comprehensive technology scan, researchers identified existing and emerging technologies and provided responses to some of these concerns.

Promising Technologies for Trespassing Detection and Mitigation

Several existing and emerging technologies and applications could be used for trespassing detection and prevention, including aerial drones, detection sensors, video analytics, airbags on locomotives, connected and automated vehicle (CAV) technology, and artificial intelligence (AI). Aerial drones, or unmanned aircraft systems (UAS), could assist in monitoring and enforcing trespassing on rail transit ROW in a large-scale deployment. Via a loudspeaker attached to a drone, the drone pilot can ask trespassers to leave the rail transit ROW. Detection sensors and radar could be employed to automatically detect trespassers, and such systems could be enhanced by prerecorded voice messages warning violators.

Both onboard and rail-side detections systems are useful for trespassing detection and prevention. CAV technology could be further explored and applied to detect and warn trespassers and rail transit operators, and AI technologies can be applied to trespass detection algorithms and installed on mobile platforms such as UAS. Video analytics-based solutions are valuable at railroad crossings and on tracks for detecting trespasser activity and other disruptions. Algorithms can be created that detect, identify, and categorize various types of events that occur along rail transit ROW.

Promising Technologies for Suicide Prevention and Mitigation

Various technologies used to successfully mitigate suicides on rail transit include platform screen doors, blue lights (proven effective in other countries, but limited data to confirm the effectiveness of this method in the U.S.), and onboard detection systems. Platform edge doors serve as good physical barriers to restrict unauthorized access to the tracks and help with service disruptions. Although expensive, platform edge doors may be a worthy investment for new station construction and retrofits of existing stations. Half-height platform edge doors are another plausible solution for station retrofits. Integrated onboard and wayside detection systems that use a combination of sensors—including lidar, stereo vision, thermal vision, night vision, camera systems, and laser scanners—are also promising technologies for detecting and mitigating suicide attempts on rail transit ROW, stations, and facilities. One Japanese study showed the effectiveness of blue light applications in reducing suicide rates at stations; their calming effect on people deterred suicidal thoughts and they are associated with the presence of police officers. However, this study has not been replicated elsewhere.

Summary

This research project focused on mitigation strategies and countermeasures that may be used by RTAs to reduce trespasser and suicide fatalities and injuries. It provides useful information, valuable insights, RTA practices, and practical and promising strategies and countermeasures. This report can serve as a toolbox for RTAs providing (1) mitigation strategies identified from literature review and employed by RTAs, including the 11 case study agencies in this research; (2) promising existing and emerging technology applications to detect and/or prevent rail transit trespassing and suicides; and (3) key research findings for mitigating injuries and fatalities associated with trespassing and suicide events.

Although suicide and trespasser safety events were the focus of this study, it is important to recognize there are security elements related to trespassers that pose a significant concern for RTAs. Passenger rail systems are vulnerable to terrorist acts because the systems are openly accessible and offer confined environments with large numbers of passengers. Improvised explosive devices (IEDs) activated onboard a train, in a station, or on a platform can lead to mass fatalities from explosive concussion, fire or smoke, and chemical or biological agent release. Such security issues may warrant future consideration and research. Although security enhancement is not within the scope of this effort, the researchers will identify technologies that are complementary to both security enhancement and trespasser and suicide prevention.

Introduction, Event Examination, and Literature Review

Introduction

In response to the Moving Ahead for Progress in the 21st Century (MAP-21) Act and its successor, the Fixing America's Surface Transportation (FAST) Act, FTA established the Safety Management Systems (SMS) framework as the basis for its National Public Transportation Safety Program. Key aspects of this framework include building on existing safety foundations to detect and correct safety problems earlier and holistically by analyzing safety data to ensure that resources are applied effectively to mitigate risks. One such risk faced by the transit industry is the growing number of suicide and trespasser fatalities and injuries occurring on rail transit system properties throughout the United States.

Suicide is the leading cause of rail transit related fatalities in the United States. Based on NTD data reported to FTA, between 2011 and 2019 there were 595 rail transit fatalities due to suicides and 209 fatalities due to trespassing (NTD 2019), which accounts for 52% and 18% of all rail transit fatalities in that period, respectively. Approximately 70% of all rail transit related fatalities are the result of suicide and trespassing. Trespassing along railroad ROW is the leading cause of freight and commuter rail fatalities in the United States. According to FRA data, more than 500 trespassing fatalities and 1,000 casualties (fatalities and injuries) have occurred each year since 2017. Between 2011 and 2019, fatalities associated with trespassing and suicide events during that period accounted for 45% and 26% of fatalities along railroad ROW, respectively.[3] Approximately 71% of all freight and commuter rail related fatalities are the result of trespassing and suicides.

Recognizing the importance of mitigating fatalities and injuries from suicide attempts and reducing preventable fatalities and injuries from trespassing on rail transit properties, this research focused on the mitigation of suicide and trespasser fatalities and injuries. Through detailed RTA suicide and trespassing data analysis, an extensive literature review, and case studies, this research sought effective and promising strategies, practices, and technologies that may mitigate suicide and trespasser fatalities and injuries.

Definition and Entries for Trespassers and Suicides

This section explores the definition and data for trespassers and suicides, including definitions from the NTD and FRA, and the change in definitions and data entries of FTA.

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[3] FRA Office of Safety Analysis, Railroad Accident/Incident Reporting System (RAIRS), 2011–2019.

As of 2008, NTD no longer uses the term "trespasser" as a classification of person type; additional person types were introduced that constitute trespassing behavior such as "pedestrian not in crossing," "pedestrian crossing tracks," and "pedestrian walking along tracks." However, prior to 2008, those person types were not necessarily categorized as trespassers but were classified in the "other" category. The "pedestrian crossing tracks" classification was eliminated in 2016.[4]

In the NTD data analysis, pedestrians not in crossings, crossing the track, and walking along track are considered "trespassers." Additionally, if the description of "other" labels the person type as trespasser or describes trespasser or suicidal behavior (such as laying on the tracks), those fatalities are considered trespassers. Pedestrians using the crosswalk and bicyclists are not considered trespassers. "Suicide" is its own classification; attempted suicides are "suicides resulting in non-fatal injuries" and "completed" suicides are "fatalities."

FRA defines trespassers as persons illegally on private railroad property without permission; they most often are pedestrians who walk across or along railroad tracks as a shortcut to another destination. Some trespassers are loitering; others are engaged in recreational activities such as jogging, hunting, bicycling, snowmobiling, or operating off-road all-terrain vehicles (Federal Railroad Administration 2020a).

According to an FRA report describing trespass event risk factors (Stanchak and daSilva 2014), a person on a highway-rail grade crossing should not be classified as a trespasser (Class E) unless:

- He/she passes through a closed, protected gate or other similar barriers, or
- He/she attempted to pass over, under, or between cars or locomotives occupying the crossing.

A person or vehicle that enters a crossing without a physical barrier (e.g., gates in a lowered position) is not classified as a trespasser, even when the highway-rail grade crossing lights are activated, or other warning systems are functioning; they would be classified as a non-trespasser.

In most states, trespassing is a property crime and a general offense. A list of state-by-state rail trespassing laws is available in FRA's Compilation of State Laws and Regulations Affecting Highway-Rail Crossings.

FTA and FRA both provide data quantifying the extent and nature of rail-related suicide and trespassing incidents. Title 49 CFR 225.5 states:

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[4] https://www.transit.dot.gov/ntd/national-transit-database-ntd-glossary#B.

Suicide data are data regarding the death of an individual due to that individual's commission of suicide as determined by a coroner, public police officer or other public authority; or injury to an individual due to that individual's attempted commission of suicide as determined by a public police officer or other public authority (US. Government Regulations, 2022).

Reporting is required in both cases using the FRA Railroad Injury and Illness Summary reporting form 6180.55a.

Trespassers and suicides may be related but are not synonymous. Although not all trespassers have suicidal intentions, some countermeasures addressing the challenges prohibiting the vulnerability of trespassing are likely to complement the prevention of suicide. Access to awareness and educational treatment measures, along with community-based collaboration and technological deployment (detection and tracking), can also help prevent suicides.

Examination of Trespassing and Suicide Events and Trends

This section analyzes trespassing and suicide-related events and trends in detail based on NTD data from FTA. The detailed analysis on trespassing and suicide events and trends using FRA data is provided in Appendix A. It is important to note that NTD data is the reporting platform for RTAs, while FRA data is reported by FRA regulated properties, such as freight and commuter rail agencies.

Rail Transit Trespassing and Suicide Trends[5]

Based on NTD data, between 2011 and 2019 there were 595 rail transit fatalities due to suicide, which accounted for 52% of all rail collision and suicide fatalities in that period. During the same period, the number of annual suicides was between 57 and 80, and there were 209 fatalities due to pedestrians not in a crossing, walking along the tracks, crossing the tracks, or trespassing. Similar analysis over this time revealed that the number of annual trespasser fatalities was between 8 and 41. Figure 1-1 shows that RTA reported fatalities due to trespassing and suicide combined account for more than 70% of all fatal collisions reported between 2011 and 2019.

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[5] Current analysis of FTA data does not include all Commuter Rail (CR) and Alaska Railroad (AR) modes, Heavy Rail (HR) service reported for Port Authority Trans Hudson (NTD ID: 20098), Hybrid Rail (YR) service for the Tri-County Metropolitan Transportation District of Oregon (NTD ID: 00008), and Hybrid Rail (YR) service for Capital Metropolitan Transportation Authority (NTD ID: 60048).
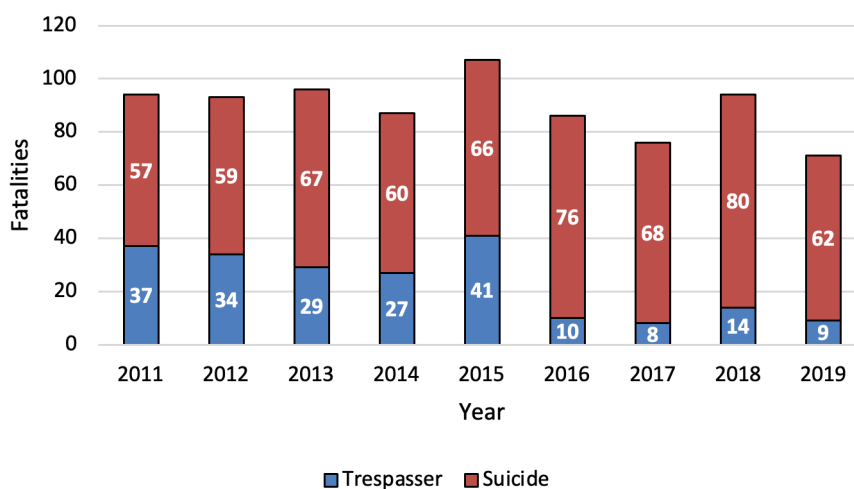
Source: NTD Safety and Security Time-Series Data

Figure 1-1 *RTA reported fatalities due to trespassing or suicide*

Between 2011 and 2019, there were 653 non-fatal rail injuries sustained due to attempted suicide and 322 injuries sustained by pedestrians not in a crossing, walking along the tracks, crossing the tracks, or some other form of trespassing (see Figure 1-2). Other forms of trespassing include laying, sleeping, or standing on tracks, and suspected trespassing as defined in the person description. Attempted suicides and trespassing events accounted for 975 non-fatal injuries from 2011 to 2019, which is 20% of all rail collision related injuries.
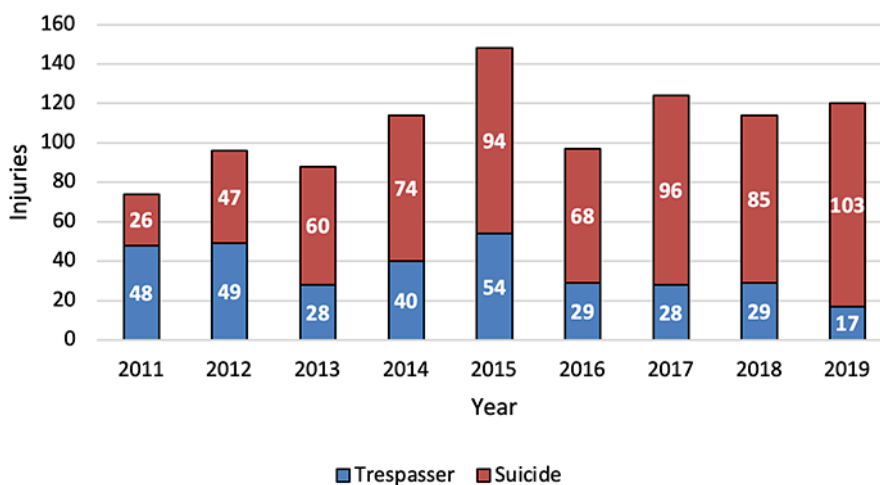
Source: NTD Safety and Security Time-Series Data

Figure 1-2 *RTA reported non-fatal rail injuries due to trespassing or suicide*

Trespasser injuries and fatalities reported by RTAs are shown in Figure 1-3. There were more trespasser injuries than fatalities; trespasser casualties peaked in 2015, and both injuries and fatalities significantly reduced after 2015. Figure 1-4 shows suicide injuries and fatalities reported by RTAs. There were more suicide fatalities than injuries, and there was an uptrend in suicide casualties from 2011 to 2015. The number of suicide casualties stabilized at around 120 after 2017.
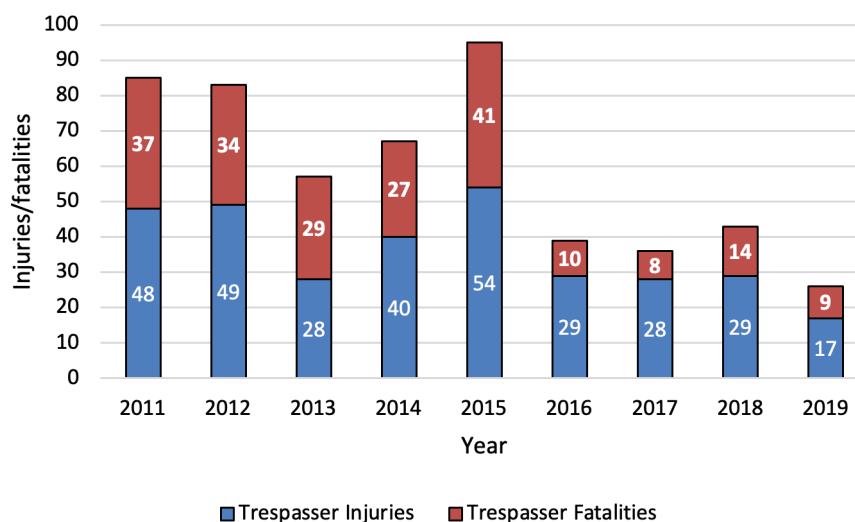
Source: NTD Safety and Security Time-Series Data

Figure 1-3 *RTA reported trespasser injuries and fatalities*
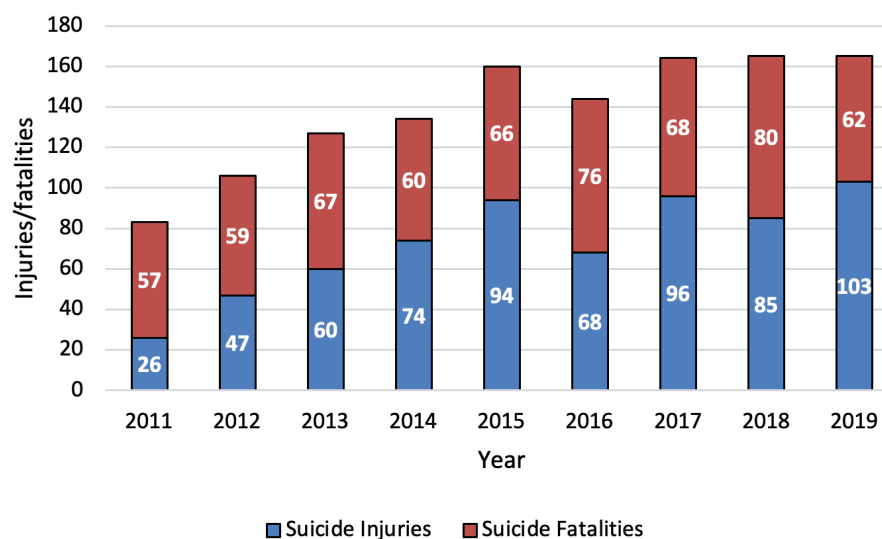
Source: NTD Safety and Security Time-Series Data

Figure 1-4 *RTA reported suicide injuries and fatalities*

Further analysis of NTD data for 2011–2019 (see Figure 1-5) reveals a higher number of suicide incidents than trespassing incidents leading to injuries or fatalities. Suicides have accounted for at least 44% of all annual RTA fatalities since 2011, except during 2019. In recent years (2016–2019), the incidence of suicide fatalities was at least five times greater than trespasser fatalities.
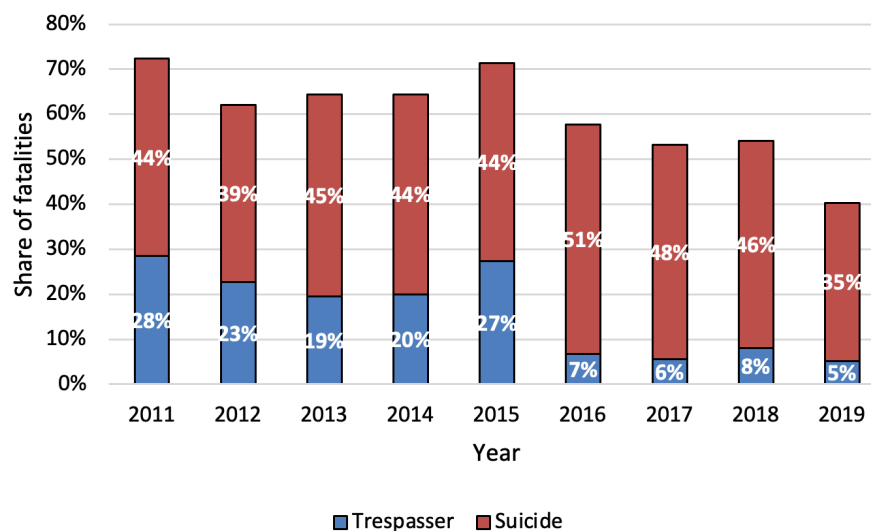
Source: NTD Safety and Security Time-Series Data

Figure 1-5 *RTA suicide and trespassing share of total fatalities*

Comparing rail suicide fatalities by mode (Figure 1-6) reveals that much higher numbers of suicide fatalities occurred on heavy rail (HR) than light rail (LR) or any other mode. In 2018, there were 67 suicide fatalities sustained on heavy rail, the highest annual suicide fatalities between 2011 and 2019.
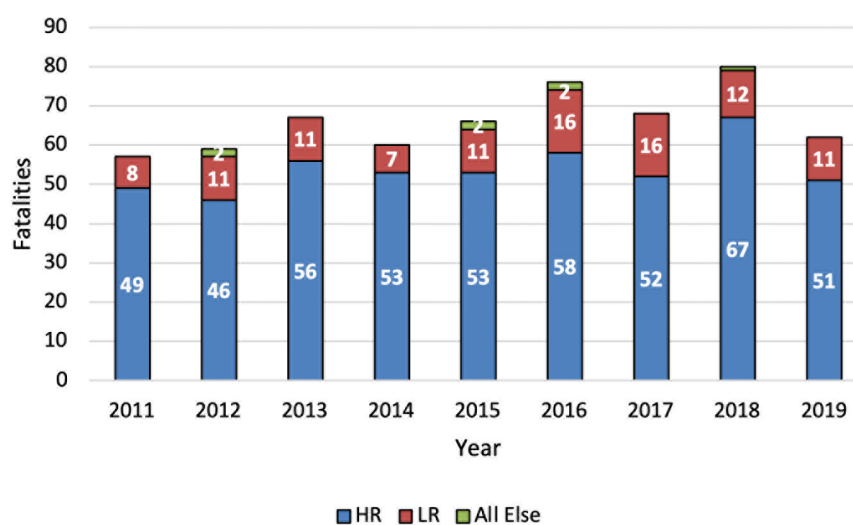
Source: NTD Safety and Security Time-Series Data

Figure 1-6 *Suicide fatalities by rail transit mode*

Overall, heavy rail accounted for about 82% of all suicide fatalities between 2011 and 2019 (Figure 1 7), followed by light rail (17%); all others constituted the last 1%. Heavy rail is also the most common mode for trespasser fatalities.
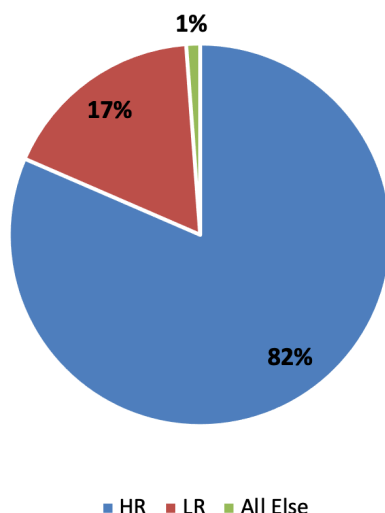
Source: NTD Safety and Security Time-Series Data

Figure 1-7 *Suicide fatality percentage by rail transit mode, 2011–2019*

It is worth noting again that trespasser activity is included as a person type description; thus, the analysis of such data is cumbersome at best. The quality and potential use of the NTD data collected might be improved if there was a trespasser indicator to define the type of activity that would constitute a trespasser classification. The comparison of rail transit trespasser fatalities by mode in Figure 1-8 indicates that generally higher numbers of trespasser fatalities occurred on heavy rail with a couple of exceptions.
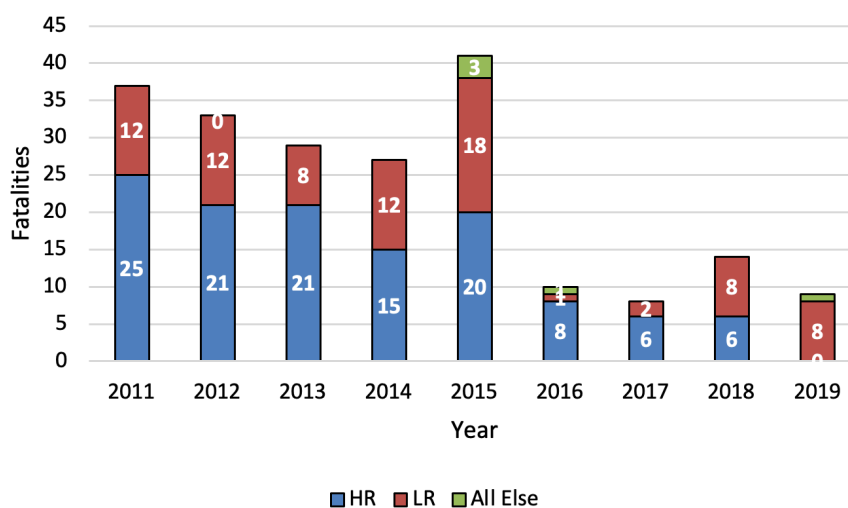
Source: NTD Safety and Security Time-Series Data

Figure 1-8 *Trespasser fatalities by rail transit mode*

Figure 1-9 reveals that heavy rail accounted for 59% of all trespasser fatalities between 2011 and 2019, while light rail also accounted for a significant share at 39%.

■ HR ■ LR ■ All Else
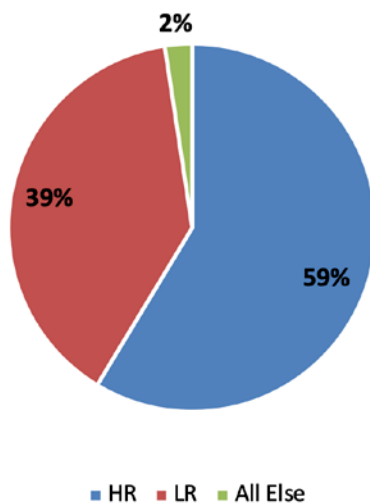
Source: NTD Safety and Security Time-Series Data

Figure 1-9 *Trespasser fatality percentage by rail transit mode, 2011–2019*

When the trends of rail trespasser and suicide fatalities are combined, the fatality trends slightly improve over time. Additionally, if the share of trespasser and suicide fatalities is compared with total rail collisions and suicide-related fatalities, the trends also improve. In 2015, trespassers and suicides accounted for 81% of all rail transit collision and suicide fatalities; by 2019 that share decreased to 48% (Figure 1-10).

□ HR □ LR □ All Else —●— Share of all collision+suicide fatalities
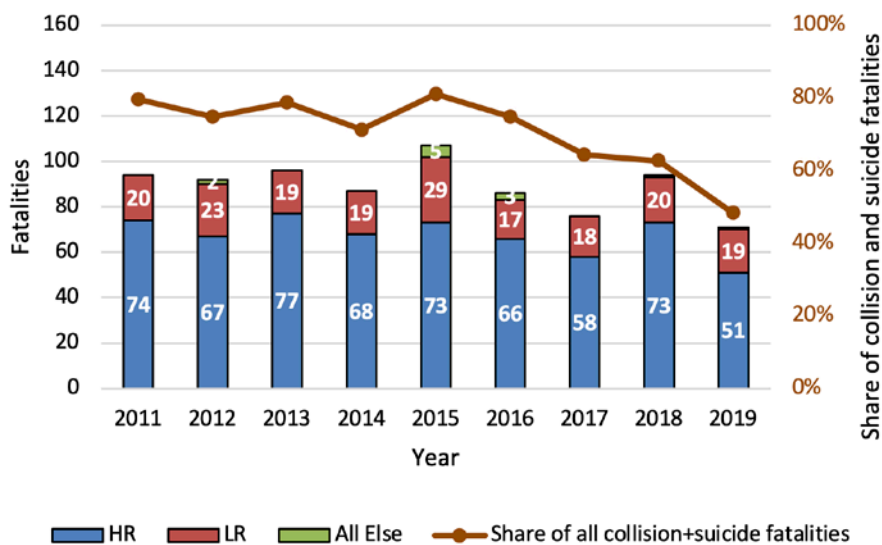
Source: NTD Safety and Security Time-Series Data

Figure 1-10 *RTA combined rail trespasser and suicide fatalities, 2011–2019*

Comparing the share of rail collision and suicide fatalities by each mode, trespassing and suicide fatalities on heavy rail accounted for a larger share of overall heavy rail fatalities (Figure 1-11).
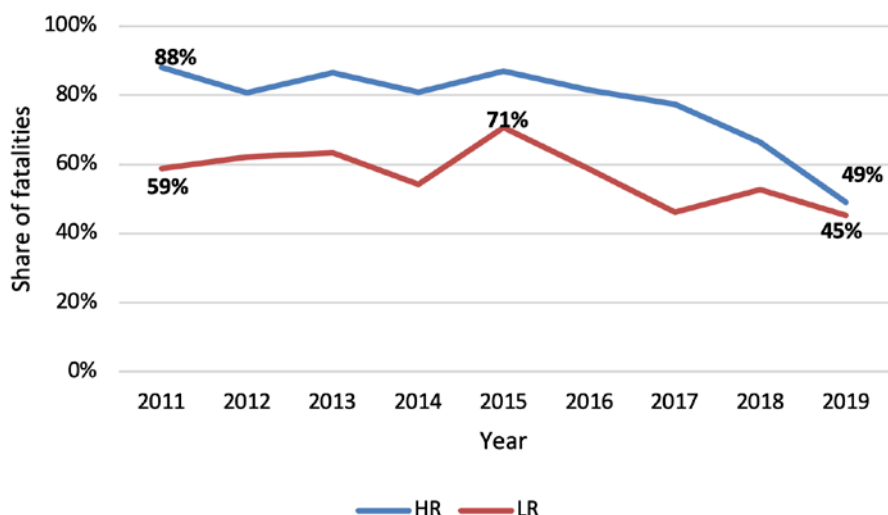
Source: NTD Safety and Security Time-Series Data

Figure 1-11 *Share of all FTA reported collision and suicide fatalities*

Similarly, when rail transit suicide fatality trends are compared by location, it is evident that the majority (78%) occurred at a revenue facility such as a transit station, parking facility, or other similar facility, and 21% of all suicide fatalities occurred on the ROW (Figure 1-12).
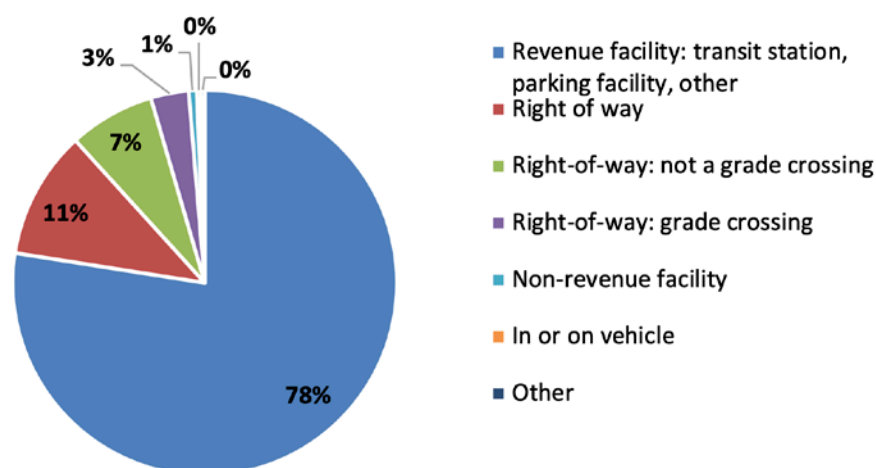
Source: NTD Safety and Security Time-Series Data

Figure 1-12 *Suicide fatalities by location type for RTAs, 2011–2019*

Unlike suicide fatalities, trespasser fatalities are more likely to occur on the ROW (63%), with almost half (48%) occurring on ROW that is not a grade crossing. About 36% of trespassing fatalities occurred at a revenue facility (Figure 1-13). It is important to note that some activity categorized as "suicide," such as laying on tracks, is included as "other" trespasser, so trespasser data may include instances of suspected suicide that were not officially classified as suicide.
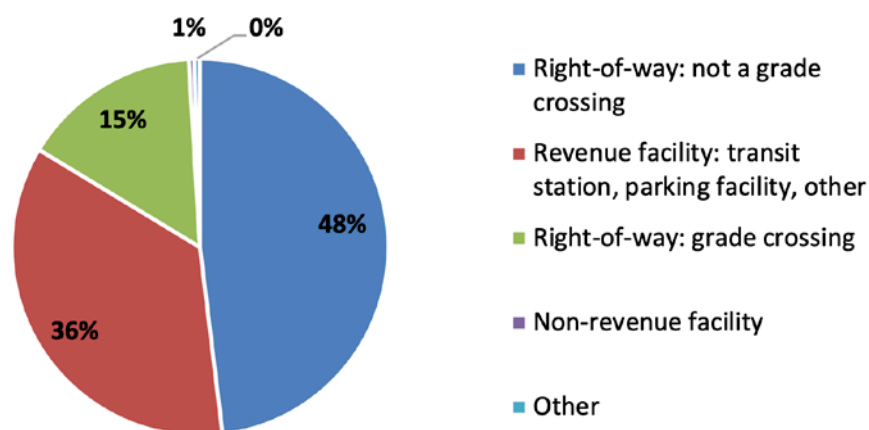
Source: NTD Safety and Security Time-Series Data

Figure 1-13 *Trespasser fatalities by location type for RTAs, 2011–2019*

Major Statistics and Risk Factors for Trespass and Suicide Fatalities and Injuries

Approximately 70% of all rail transit fatalities in the United States are the result of trespassing (18%) and suicide (52%). In the European Union (EU), trespassing and suicide incidents account for 89% of all rail-related fatalities (European Railway Agency 2016) with a high percentage of suicides. This section provides a summary of vital statistics and trends of trespasser and suicide fatalities and injuries based on the analysis of NTD data from FTA, and it identifies associated risk factors based on the data analysis and literature review. Understanding these statistics, trends, and associated risk factors will help RTAs and researchers identify specific problems, recognize challenges, and seek effective techniques and countermeasures and implement them to significantly mitigate trespasser and suicide fatalities and injuries.

Major Rail Transit Trespasser Statistics

- On average, there were roughly 23 cases of trespassing fatalities between 2011 and 2019; trespassing-related fatalities have been declining since the peak year of 2015 with 41 fatalities.

- A similar trend was observed for trespassing-related injuries; non-fatal rail injuries due to trespassing have been declining since the peak year of 2015 when there were 54 cases.

- The trespassing share of total rail fatalities has been declining since 2015; the trespassing-related share of rail fatalities declined by 70% for 2016–2019 in comparison to the preceding analysis years of 2011–2015.

- For 2011–2019, heavy rail (59%) and light rail (39%) constituted the major share of trespasser fatalities; 2015 was an especially bad year for trespassing, with the highest number of fatalities and injuries along all rail modes (NTD Safety & Security Timeseries Data).

- It was found that 48% of all trespass fatalities for 2011–2019 occurred along the railroad ROW (not including grade crossings). Revenue facilities such as transit stations and parking facilities were second (36%), followed by railroad ROW at grade crossings (15%).

Major Rail Transit Suicide Statistics

- On average, there were 66 suicide fatalities for 2011–2019; suicide-related fatalities have been increasing since 2014.

- A similar trend was observed for suicide-related injuries; non-fatal rail injuries due to suicides have been increasing since 2014.

- The suicide share of total rail fatalities has been increasing since 2014 (Figure 1-5).

- For 2011–2019, heavy rail constituted a significant share of trespasser fatalities (82%), followed by light rail (17%).

- In total, 78% of all rail suicide fatalities in 2011–2019 occurred at a revenue facility such as a transit station or a parking facility. Additionally, 11% of suicide fatalities occurred along a railroad ROW that was not a grade crossing, with 7% occurring along the ROW at grade crossings.

- FTA data show suicide fatalities and injuries from suicide attempts fluctuating between agencies reporting for 2008–2017 at 15 transit agencies (Federal Railroad Administration 2020a). See Appendix B for details.

- FTA data show that the New York Metropolitan Transportation Authority (MTA) had on average the most suicide fatalities each year relative to other transit agencies.

- FTA data show that the New York MTA, Massachusetts Bay Transportation Authority (MBTA), and Utah Transit Authority (UTA) had steady increases in suicide attempts with injuries from 2013 to 2016.

Rail Transit Suicide Risk Factors

Risk factors for suicide were analyzed from the NTD incident level for 2008–2017:

- The majority (78%) of RTA reported suicide casualties occurred on heavy rail systems.
- Suicide casualties occurred most frequently midday between 11:00 AM and 1:00 PM and in the evening hours from 5:00 PM to 11:00 PM, with 5:00 PM to 6:00 PM being the peak for suicide casualties.
- Suicide fatalities and injuries showed little variance with respect to season, with only a slight elevation in the spring for suicide fatalities.
- Geographic mapping of suicide casualties holds great promise for identifying potential factors that may influence where or when these incidents occur, although with limited data currently available the full potential may be realized later.
- Investigating the correlation between suicides at railroad facilities, ROW, and the mental distress of those who committed suicide could be useful for seeking potential countermeasures. The correlation between psychological distress (data extracted from the Centers for Disease Control and Prevention) over time was examined with suicide rate from historical data for different regions of the United States (Northeast, Midwest, South, and West); however, no specific correlation was found.

Trespassing and Suicide Risk Factors based on FRA Data Analysis

FRA data analysis shows that trespassing casualties occurred within 1,000 ft of a grade crossing, 82% of trespassers were male, and most were of low socioeconomic status. According to the study referenced in Mishara and Bardon (2016) and several others (Rådbo and Andersson, 2012; Rådbo et al., 2005; Tseloni et al., 2011), the mean age of railroad suicide victims is consistently 39 to 45 years. Based on the study by Berman, et al. (2014), 96% of freight rail suicide incidents occurred on areas of the track that did not have a barrier to restrict ROW access. The study also indicated that individuals who commit suicide are likely to have psychiatric disturbance and comorbidity (mostly alcohol related). Of the 37% of suicide decedents in the United States who had been drinking at the time of death, a substantial percentage (94%) had blood alcohol levels above 0.08, 96% were identified as having a mental health disorder, and 47% had been prescribed medications with only 19% adherent to the medication regime.

Framework to Reduce Trespasses and Suicides

To effectively mitigate the identified problem areas and challenges to prevent and reduce trespassers and suicides on railroad property, a framework for the reduction of rail-related trespassers and suicides would serve as a beneficial support structure for detailed strategies and countermeasures. A

countermeasure decision-making flowchart to mitigate trespassing and suicides and a problem-solving model are introduced below. These can assist RTAs in establishing customized frameworks to develop strategies, countermeasures, and an evaluation process.

Considering the number of problem areas and challenges, some studies (e.g., Beiler et al., 2019 and Havârneanu et al., 2017) indicate a need for research efforts on predominant factors. Incidents, time and day, pre-crash actions, victim demographics, location, cultural, sociopolitical organization, economics, and the nature of the problem were considered. A simple and practical countermeasure decision-making flowchart proposed by Beiler et al. (2019) is shown in Figure 1-14. The study also emphasized the collection of the following items to improve incident data analysis: station distance, safe crossing distance, highway-rail grade crossing accidents, suicide prevention infrastructure, darkness, operational and communication error, environmental conditions, maximum train speed, vandalism of on-track equipment, weather, and temperature.
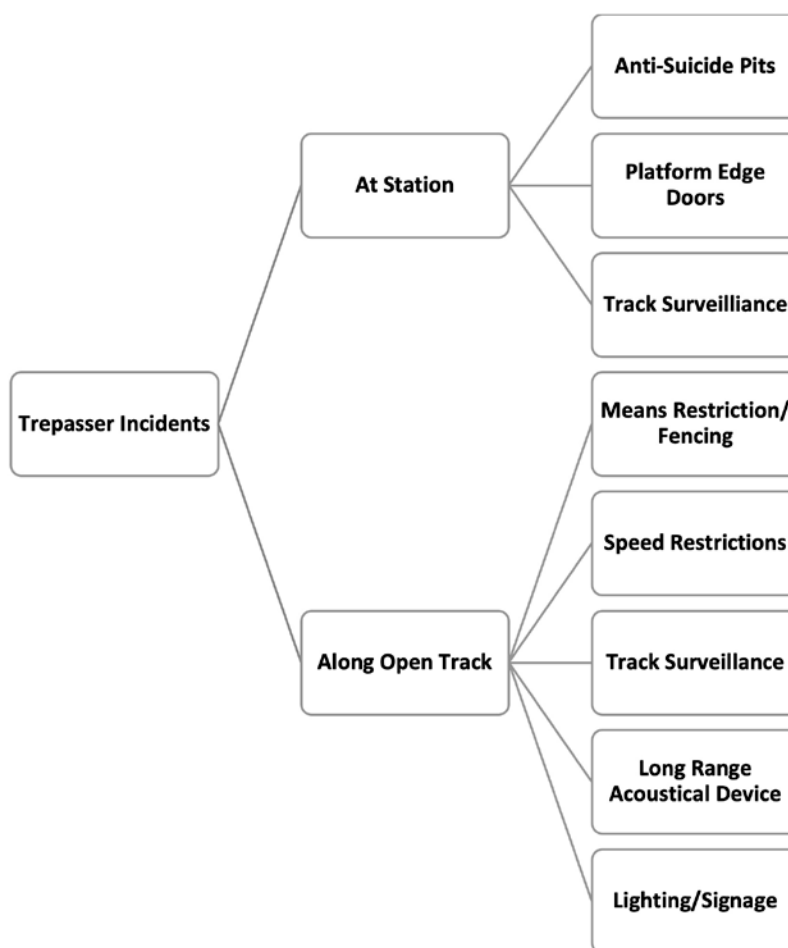
Source: Adopted from Beiler et al., 2019

Figure 1-14 *Countermeasure decision-making flowchart*

The RESTRAIL[6] study in Europe by Havârneanu et al. (2017) indicated the magnitude of the problems in their context and attempted to provide some solutions from a holistic perspective:

- Annually, about 3,000 suicides and 800 trespassing accidents occur, representing 89% of all fatalities within the EU railway system (European Railway Agency, 2014).

- Most of these incidents occurred at stations on open lines and level crossings, resulting in more fatalities than train derailments and collisions combined.

- There is limited empirical data or research on preventing railway suicide and trespassing, although previous studies have sufficiently emphasized effective countermeasure implementation.

- The literature survey concluded that current studies are insufficient to properly address the problem of suicide and trespassing as follows:

  – Guides and research are specific to a single problem, either prevention of railway trespass or prevention of suicide.

  – Existing guidance on suicide is not railway-specific, as it addresses the problem more generally from a mental health perspective.

  – Recommendations often concern only a single type of intervention (e.g., planning, implementation, and evaluation of education measures).

  – The transferability of recommendations is questionable; each document researched is based on context-specific problems and possible countermeasures.

  – Currently there are no guidance documents for railway undertakings and infrastructure managers, station managers, and other decision-makers that concern both suicide and trespass prevention in an integrated fashion.

The RESTRAIL study proposed the RESTRAIL Problem-Solving Model (RPSM), which can be transferrable across countries and communities and flexible for adaptation to the problem, analysis, and evaluation from a local context. Successful implementation of measures depends on the following factors:

- Cultural issues
- Sociopolitical organization
- Division of skills and responsibilities
- Demographics
- Economics
- Nature of the problem (type of incident, motives, location characteristics)

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[6] RESTRAIL was a three-year EU FP7 collaborative research project with 17 partners from 12 countries. The interdisciplinary consortium included rail infrastructure managers, research institutes, universities, and small and medium industries (Havârneanu et al. 2017).

The proposed RPSM endorses a system-integrated approach by considering a wide variety of contributing factors and decisions leading to a train-pedestrian collision. The model considers different motives behind suicidal and non-suicidal intent and the potential need for different types of measures that influence the decisions to commit these acts.

The model supports the analysis of the problem and encourages decision-makers to use the traditional approaches on preventive measures, especially evidence about the various effects leading to suicide and trespassing incidents. Finally, the RPSM highlights the importance of evaluation and the collection of evaluation data before and after implementing selected measures. By incorporating detailed information, specific assessment methods can be extended and used to evaluate the effects of different types of preventive measures. Figure 1-15 shows the working mechanism of RPSM.
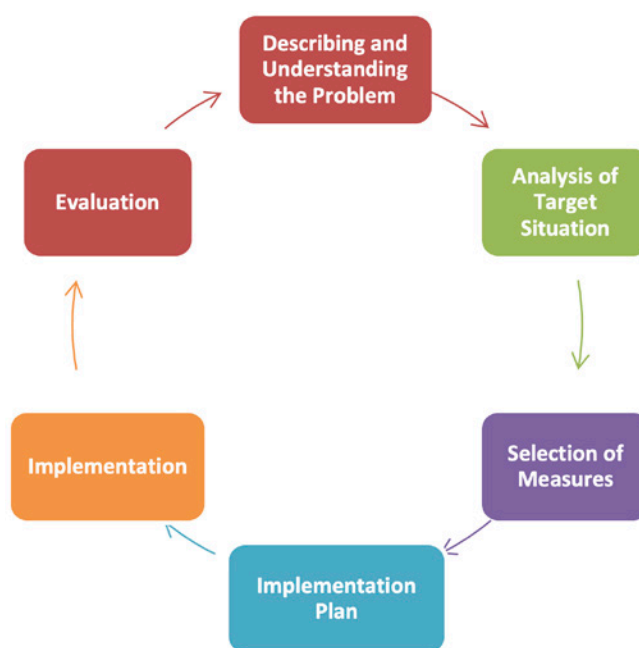
Source: Adopted from RESTRAIL study by Havârneanu et al., 2017

Figure 1-15 *General overview of RESTRAIL Problem-Solving Model (RPSM)*

Mitigation Strategies and Countermeasures for Trespassing and Suicides

RTAs may have different trespassing and/or suicide problems and challenges due to various factors including the nature of the problem (e.g., mental health aspects of suicides, rail system characteristics, ridership, demographics,

cultural difference, infrastructures, and economic situations). Strategies and countermeasures will be developed according to the needs of an individual RTA. Based on the literature review, this section highlights the key mitigation strategies and associated countermeasures on trespassing and suicides for RTAs to consider. Some strategies and/or countermeasures are common for both trespassing and suicide prevention and mitigation, and some are trespassing or suicide specific.

Trespasser Mitigation Strategies and Countermeasures

The literature review identified common strategies and associated countermeasures to detect and prevent trespassing on railroad ROWs, train stations, and other railroad facilities. These strategies and countermeasures focus on but are not limited to community outreach, rail infrastructure modification, procedural modification of rail agency operations, rail operator and agency employee training, enforcement, and the implementation of new technologies. The identified countermeasures cover engineering, education, enforcement, and technologies.

The strategies and/or countermeasures for effectively reducing trespasser fatalities and injuries can be divided to two categories: preventing trespassing occurrence and mitigating trespassing incidents, injuries, and fatalities when trespassing occurs. Based on the literature review, the key strategies and supporting countermeasures for both categories are summarized below.

Trespassing Prevention

- Community outreach on danger and violation of railroad trespassing
  - Rail safety campaigns and educational outreach to the general public
  - Railroad safety education among school children
  - Distribution of railroad safety educational materials
  - Distribution of railroad safety educational posters and flyers
  - Public safety announcement (PSA) and social media outreach
  - Partnerships with railroad safety advocates and/or stakeholders in a community
- Signage Installation
  - Placement of trespassing prohibition signs at train stations
  - Placement of trespassing prohibition signs at highway-rail crossings and along railroad tracks up to 1,000 ft from a crossing
- Fencing and Barriers
  - Design and installation of fencing or barriers along railroad ROWs, especially for new rail lines, to eliminate or reduce trespassing incidents

    – Design and installation of inter-track fencing or barriers at train stations to eliminate or reduce trespassing incidents

- Rail Infrastructure Modification
  – Installation of fencing or barriers at known areas or hotspot locations of trespassing on railroad ROWs
  – Installation of inter-track fencing or barriers at train stations to prevent pedestrians from crossing undesignated
  – Installation of swing gates and pedestrian gates at railroad grade crossings, and end-of-platform gates at train stations
  – Installation of platform edge (screen) doors at train stations
  – Installation of underground pass or pedestrian bridges if deemed necessary

Trespassing Mitigation

- Rail Operator and agency employee training on:
  – Recognizing errant behaviors and trespassing behaviors
  – Identifying risky areas for trespassing
  – Reporting trespassing incidents
  – Responding to trespassing incidents
- Procedural Modification
  – Addition on near-miss trespasser fatality and injury reporting requirement
  – Increase of patrols along the railroad ROW
  – Increase of communication between transit agency operators and transit police or local police department on trespassing incidents
  – Addition on trespassing incident reporting requirement from specific rail transit personnel such as rail operators, cashier attendants, workers, and employees
  – Consistent and uniform reporting among RTAs on trespasser incidents, injuries, and fatalities
- Speed Restriction
  – Reduction of train speeds on approach to grade crossings, especially at locations with many trespassers or known trespassing incidents, to ensure a higher operator reaction time and better anticipation of trespasser behavior
- Law Enforcement
  – Regular patrol by rail transit police on railroad ROW, especially on known trespassing hotspots
  – Quick response to locations with critical reported trespassing activities
  – Successful prosecution of trespass law

- Implementation of New Technologies
  – Trespasser detection through:
  – On-track surveillance using various detection technologies and systems
  – Guideway intrusion detection
  – Onboard detection
  – Grade crossing obstacle detection
  – Long-range acoustic devices to deter trespassers through verbal warnings
  – Drone patrol to detect trespassers and loudhailers attached to the drone to warn trespassers to leave railroad ROW
  – Artificial Intelligence (AI) applications to the trespasser detection and warning systems identified above

Suicide Mitigation Strategies and Countermeasures

The literature review shows there are multiple preventive strategies and countermeasures for suicides in railroad ROWs or train stations. Most are targeted to reduce suicides by influencing individuals with suicidal thoughts and by making it difficult for the public to cross or directly access railroad property through a crossing or any open area along the track.

Suicide prevention efforts can take various forms. Some mitigation strategies are engineering based, "physically restricting access to the rail system through the installation of equipment" (FRA, 2019), and others aim to educate people and encourage them to seek help for their mental health. Practical preventive strategies or countermeasures for suicide attempts may include but are not limited to the following (each of these strategies are further discussed and illustrated in Section 2):

- **Fencing and barriers** – Adequate fencing or barriers could be placed in known areas of trespassing incidents or suicides on railroad ROWs to reduce access to the rail line. To prevent damage and vandalism, proper monitoring is needed.

- **Refuge space** – Installing refuge spaces under railroad tracks at transit stations can effectively prevent suicides on the tracks by creating a larger gap between the ground and the tracks, enabling a person who attempts to commit a suicide to fall below the wheelbase and avoid being struck.

- **Signage and digital displays** – A broad area of geographical space can be covered to communicate suicide prevention signage and hotline information.

- **Suicide prevention events and education** – When implemented by RTAs to facilitate community involvement in suicide prevention, these events and campaigns can educate the community about suicide warning signs and help someone who is suicidal.

- **Social services/crisis intervention programs** – Partnering with local suicide prevention groups, social services, and crisis intervention programs to prevent suicides on rail transit agency properties.
- **Law enforcement** – Working with the rail transit agency police department or local law enforcement agencies to patrol ROW, respond to incidents, and prevent suicides.
- **Detection and monitoring** – In-person monitoring can be a deterrent but is limited in scope. Technology-based monitoring "can overcome some of the human limitations of in-person monitoring" ; however, this method could use an "unreasonable amount of resources" (Federal Railroad Administration 2018). Although drone technology for specific applications is beneficial, drones can pose privacy and data storage challenges. Detection and monitoring technology can be done along railroad ROW, at train stations, or near railroad grade crossings.
- **Training for railroad employees and authorities** – The most common training for railroad employees and authorities helps to identify behavioral indicators of individuals, especially among trespassers, passengers, and employees of transit agencies.
- **Installation of platform screen door** – Studies such as Gabree et al. (2014) indicate that the installation of platform edge doors can fully eliminate or significantly reduce suicide attempts at train stations.
- **Implementation of technologies** – Various existing and emerging technologies (e.g., thermal, infrared, lidar, drone) could be applied to detect trespassers, unusual trespassing behaviors, and suicide behaviors. Installation of blue lights at train stations also shows potential for deterring suicidal thoughts (Matsubayashi et al., 2013). However, the results of the Japanese study have not been replicated elsewhere.
- **Improvement of data collection** – The quality, accuracy, and consistency of suicide data collection could be improved to support accurate assessments of implemented strategies and countermeasures.

Figure 1-16 illustrates the informative sequence of suicide events and associated preventive strategies (Gabree et al. 2014) from the beginning of suicidal thoughts to committing the act. The preventive strategies include:

- Reduction/prevention of suicidal thoughts
- Reduction of perceived viability of railroad right-of-access as means of suicide
- Prevention of access to the ROW
- Increased ability to avoid a train-person collision
- Reduced lethality of a train-person collision
- Improvement of data collection

Sequence of Events

Preventive Strategies

Considering Suicide
(Suicidal Ideation)

Reduction/ Prevention of Suicidal Ideation:
- Blue lights
- Gatekeeper training
- Public awareness
- Signage
- Training of mental health providers

Railroad ROW seen as a
Viable Means of Suicide

Reduction of Perceived Viability of Railroad ROW as Means for Suicide:
- Media guidelines/media training
- Public awareness campaigns

Trespass on ROW with
Self-Harm Intent

Prevention of Access to ROW:
- Means of restrictions/fencing
- Platform edge doors

Collision between Trespasser and
Train

Increased Ability to Avoid Train-Person Collision:
- Refuge spaces
- Long range acoustic devices
- Speed restriction
- Track surveillance

Outcome of Collision Fatal

Reduction of Lethality of Train-Person Collision:
- Train modification

Completed Suicide on ROW

Improvement of Data Collection:
- Training coroners/medical examiners or others to determine suicidal intent more consistently

Source: Adopted from Gabree et al., 2014

Figure 1-16 *Event sequences preventive strategies for suicide on railroad properties*

Suicide sequence events and associated preventive measures are described as follows:

- **First Sequence of Events** – At the initial stage of suicidal thought that leads to considering a railroad as a viable means of suicide, preventive measures could be introduced to mitigate further thoughts. These preventive measures such as blue lights, gatekeeper training, public awareness, signage, and training of mental health providers are essential (as noted, the results of blue lights based upon a Japanese study have not been replicated elsewhere).

- **Second Sequence of Events** – After moving ahead with the suicidal thought of railway as a viable means, the individuals think about

trespassing into the ROW with the intent of self-harm. Essential and proactive strategies that could mitigate further steps include media guidelines or media training and public awareness campaigns.

- **Third Sequence of Events** – At this stage when an individual is thinking of colliding with a train, preventive measures that could mitigate a person-train collision include means of restriction with fencing and platforms with edge doors.

- **Fourth Sequence of Events** – When a possible fatal outcome is perceived to be imminent from such collision, preventive strategies can reduce the odds of fatal injuries and even some sustained injuries. These include anti-suicide pits, long-range acoustic devices, speed reduction of oncoming train, and track surveillance.

- **Final Sequence of Events** – At the stage of an individual committing suicide, strategies to prevent future possible incidents must be considered. It is important to collect and improve data quality and locational information for each responsible agency and to understand the characteristics of those trespassing and who have suicidal thoughts. Then, concrete measures can be taken to influence any potential trespassing for suicide attempts.

This section presented the trends and statistics of trespassing and suicide fatalities and injuries based on NTD data from FRA. The associated risk factors of trespassing and suicides based on the NTD data were analyzed and discussed. The key findings on trespassing and suicide risk factors based on FRA data were also mentioned. Considering the trends and risk factors, researchers provided strategies and associated countermeasures identified from literature review to mitigate rail transit trespasser and suicide fatalities and injuries. These strategies and countermeasures have been widely used and found effective in the United States and Europe. The following section summarizes the survey and interview results of 11 RTAs in the United States and discusses their preventive countermeasures and experiences to address and mitigate trespassing and suicide incidents.

Rail Transit Agency Case Studies

In total, 11 RTA and FRA-regulated agency case studies were conducted in this research to summarize their success, practices, and experience in addressing rail transit trespasser and suicide injuries and fatalities. The case study agencies represent various sized RTAs and FRA-regulated properties. Table 2-1 describes the major system characteristics of these systems:

- Bay Area Rapid Transit (BART, San Francisco)
- Brightline (South and Central Florida)
- Capital Metro (Austin, Texas)
- Houston METRO
- Los Angeles County Metropolitan Transportation Authority (LA Metro)
- Metropolitan Atlanta Rapid Transit Authority (MARTA)
- Massachusetts Bay Transportation Authority (MBTA)
- Metra (Chicago)
- Pittsburgh Regional Transit (PRT), Pittsburgh, PA
- Southeastern Pennsylvania Transportation Authority (SEPTA)
- Washington Metropolitan Area Transit Authority (WMATA)

Table 2-1 *System Characteristics of Case Study RTAs*

Rail Agency	# of Lines	# of Route Miles	# of Stations	Annual Ridership (millions)	On-Time Performance (System-Wide)	Peak Line Frequency (Most Frequent/ Other)	Off-Peak Line Frequency (Most Frequent/ Other)
BART	7	120	48	118 (2019)	93% (2018)	2-8 min	15-24 min
Brightline	1	60	3	0.9 (2018)		60 min	115 min
Capital Metro	1	32	9	0.6 (2018)	91% (2018)	30 min	60 min
Houston METRO	3	23	44	18.3 (2017)	92% (2017)	6-12 min	12-20 min
LA Metro	6	98	93	1.1 (2018)		6-12 min	10-20 min
MARTA	4	48	38	72 (2017)	94% (2018)	10 min	20 min
MBTA	14	388	138	35 (2019)	89% (2017)	20/25-50 min	40/60-120 min
Metra	11	488	241	76 (2018)	96% (2016)	20/30-120 min	60/90-180 min
PRT	3	26.1	53	9.2 (2018)	83% (2018)		
SEPTA	13	224	155	34 (2018)	86% (2017)	15/20-40 min	15/30-120 min
WMATA	6	118	91	182 (2019)	84% (2016)	4-8 min	12-20 min

This section includes observations and findings on trespassing detection and prevention, and observations and findings specific for detection and mitigation of suicides on rail transit property. Case study insights present an overall understanding of the trends as well as agency strategies and efforts on mitigating trespasser and suicide fatalities and injuries. These 11 case studies offer valuable practices and informative countermeasures. The findings also include success stories and lessons learned (Appendix C provides detailed case study narratives). Figure 2-1 shows the geographic coverage of the 11 case study agencies across the United States.
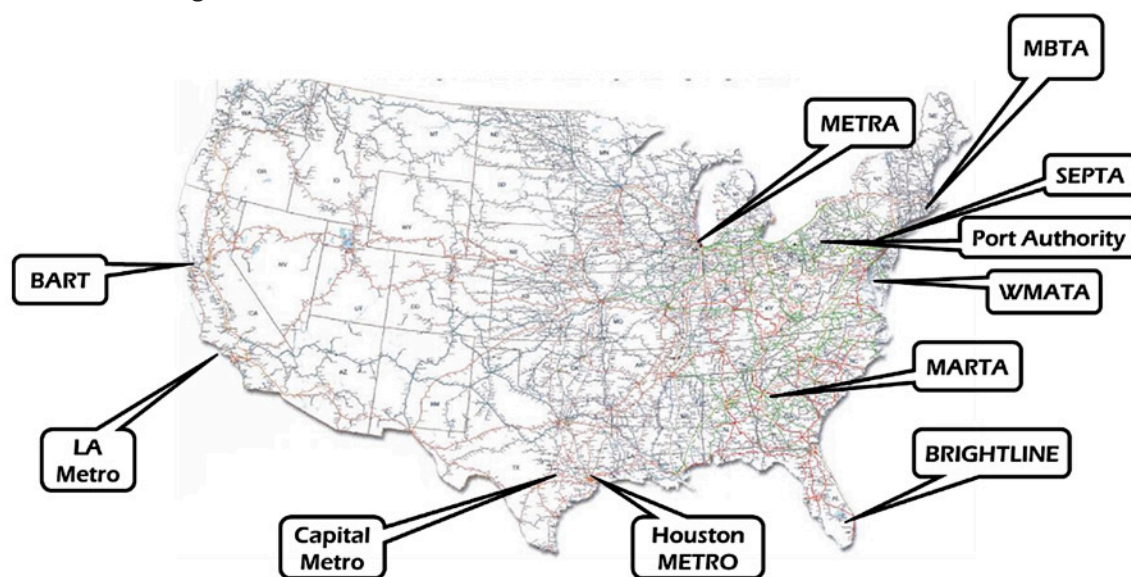
Figure 2-1 *Location of case study agencies*

In November and December 2019, the research team from the Center of Urban Transportation Research administered a web-based survey to obtain information from case study agencies on their efforts and activities that focused on reducing/mitigating trespasser and suicide injuries and fatalities. The survey comprised an introductory section to obtain baseline information from each agency and a major section aimed at collecting information on agency strategies/efforts to address trespasser and suicide injuries and fatalities, including (1) community outreach efforts, (2) infrastructure modifications, (3) procedural modifications, (4) signage installations, (5) operator training, (6) coordination with social service and crisis intervention centers, and (7) new technologies. (Appendix D provides the survey instrument.)

The findings from the literature review showed the seven strategies and associated countermeasures were of great interest for this research project, so they were included in the survey. The survey also collected self-identified successes from each case study agency in their endeavor to address trespasser and suicide injuries and fatalities.

In January 2020, follow-up teleconference calls were held with each responding agency to discuss survey responses and to gather additional information on strategies/efforts to prevent trespasser and suicide injuries and fatalities. Figure 2-2 shows the overall data collection framework. Observations and findings on trespassing and suicide prevention and mitigation strategies from the case studies are presented in subsequent sections.
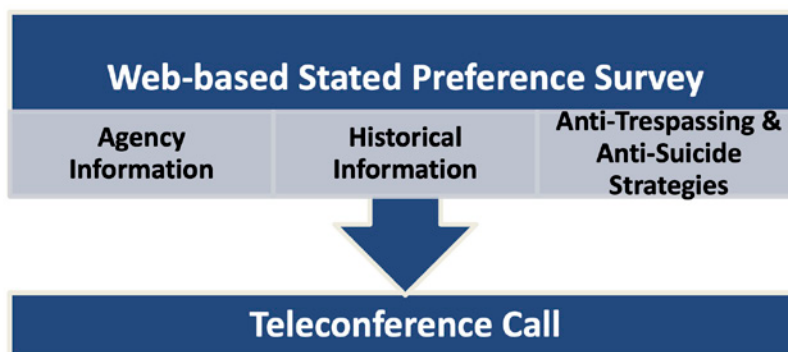
Figure 2-2 *Data collection framework*

Based on the survey results, most strategies yielded positive outcomes in mitigating trespassing, suicide incidents, injuries, and fatalities. Agencies self-reported success in the following areas:

- Installation of signage and fencing
- Fostering collaborations with law enforcement agencies
- Community outreach efforts, active advocacy, and partnerships
- Rail infrastructure modifications and procedural modifications
- Social media communications and campaigns emphasizing rail safety
- Rail operator and agency employee training and rail safety education
- Instituting suicide prevention campaigns, interventions, and mental health awareness training
- Collaboration with social services and crisis intervention groups on suicide prevention
- Application of existing technologies
- New technology adoption
- Instituting rail safety committees and think tanks promoting and prioritizing rail safety

Observations and Findings on Trespassing Prevention, Detection, and Mitigation

This section provides detailed observations and findings on trespassing prevention, detection, and mitigation strategies employed by case study

agencies based on their responses to a web-based survey. These findings are valuable to all RTAs looking to strategize and prioritize trespasser injury and fatality prevention or mitigation along their ROW.

Trends and analysis of trespassing incidents, fatalities, and injuries of the surveyed agencies for 2012–2018 are presented along with an outline of agency strategies and approaches to mitigate the problems. These strategies and approaches cover five areas: (1) community outreach programs, (2) rail infrastructure modifications, (3) procedural modifications, (4) rail operator and agency employee training, and (5) new technologies.

Trespassing Incident Trends

Table 2-2, Table 2-3, and Table 2-4 show the trends for trespassing incidents, fatalities, and injuries of the case study agencies for 2012–2018. Analysis of these data provides insights into the prevalence of trespassing. At the outset, there are two major points to consider:

- Analyses of trespassing incidents revealed non-homogeneous data retention policies among case study agencies. Some (such as SEPTA and LA Metro) did not retain data prior to 2016; therefore, these data were unavailable for analysis.
- Discussions with case study agencies revealed the varying nature of the definition of trespassing incidents. These non-homogenous definitions, agency size, and operating environment may have contributed to the widely differing numbers of incidents recorded for each rail agency. The self-reported numbers in Tables 2-2, 2-3, and 2-4 are used for reference, not for comparison.

Table 2-2 *Survey Responses on Trespassing Incidents, 2012–2018*

Rail Transit Agency	2012	2013	2014	2015	2016	2017	2018
BART	45	43	47	34	54	43	44
Brightline						2	38
Capital Metro					90	180	134
Houston METRO							
LA Metro					6	16	13
MARTA	65	69	66	122	114	128	140
MBTA		13	16	12	13	30	22
Metra	25	33	34	29	27	32	23
PRT	4	4	4	4	4	4	4
SEPTA					224	359	393
WMATA	94	66	77	116	116	182	171

SEPTA, WMATA, and MARTA reported a high number of trespassing incidents during the analysis period. Pittsburgh Regional Transit (PRT) reported a low number of incidents. Houston METRO does not define a person on the tracks as a trespasser and does not define or track trespasser incidents due to the operating environment of their light rail system (on shared-used and mixed-use roadways). If tracked, the number of trespasser incidents could be very large but may not be useful or meaningful.

Table 2-3 *Survey Responses on Trespasser Fatalities, 2012–2018*

Rail Transit Agency	2012	2013	2014	2015	2016	2017	2018
BART	0	0	2	1	0	0	1
Brightline						2	12
Capital Metro	0	1	0	0	0	0	1
Houston METRO	0	0	0	1	1	1	0
LA Metro					3	9	7
MARTA	2	0	0	0	0	0	0
MBTA		11	12	12	13	27	20
Metra	25	23	27	23	24	28	16
PRT	0	0	0	0	0	0	0
SEPTA	5	5	5	6	6	7	9
WMATA	5	2	2	2	0	1	1

Metra and MBTA recorded a high number of trespassing fatalities for 2012–2018. For Metra, there was a consistently high number of trespassing fatalities (>20 every year except 2018) that posed a significant challenge to the agency. Brightline reported 12 trespasser fatalities in 2018. PRT reported zero trespasser fatalities during the analysis period. Most remaining case study agencies (BART, Capital Metro, Houston METRO, MARTA, WMATA) reported low numbers.

Table 2-4 *Survey Responses on Trespasser Injuries, 2012–2018*

Rail Transit Agency	2012	2013	2014	2015	2016	2017	2018
BART	0	0	0	0	0	1	
Brightline							13
Capital Metro							
Houston METRO							
LA Metro					3	7	6
MARTA	8	11	11	15	22	19	17
MBTA		2	4	0	0	3	2
Metra	0	10	8	6	3	4	7
PRT	0	0	0	0	0	0	0
SEPTA					12	8	13
WMATA	8	7	6	8	15	8	15

Brightline, MARTA, SEPTA, and WMATA reported a high number of trespasser injuries. PRT recorded zero trespasser injuries for 2012–2018. The remaining case study agencies either reported low numbers or did not have available data to report.

The number of trespassing incidents reported by MBTA and Metra was equal to the sum of trespassing fatalities and injuries. Five agencies, including BART, Capital Metro, MARTA, SEPTA, and WMATA, reported large differences between the number of reported trespasser incidents and the sum of trespassing fatalities and injuries, which indicates that incidents were either alleviated or/and did not lead to injuries or fatalities.

In general, rail agencies that either experienced higher levels of ridership (WMATA, MARTA, and SEPTA) or had greater exposure of their ROW to the public (Brightline and Metra) experienced higher numbers of trespassing incidents. In addition, agencies who operate both commuter rail and other transit modes experience more trespassing incidents due to the frequency of crossings and higher operating speeds.

Strategies and approaches for community outreach programs, rail infrastructure modifications, procedural modifications, rail operator training, and new technologies used by the 11 case study agencies to mitigate trespassing are discussed next. Although these strategies and approaches focus on trespassing, most techniques are also applicable to mitigating suicide incidents.

Community Outreach Programs

In total, 8 of the 11 respondents (73%) indicated their agency was involved in conducting community outreach to raise awareness on rail safety and prevent trespassing attempts. Figure 2-3 shows these rail agencies.

Figure 2-3 *Rail agency respondents involved in community outreach programs*

Collaboration with organizations such as Operation Lifesaver (OLI) to conduct rail safety campaigns was the most common community outreach practice for case study agencies. Figure 2-4 shows a campaign poster from Operation Lifesaver.
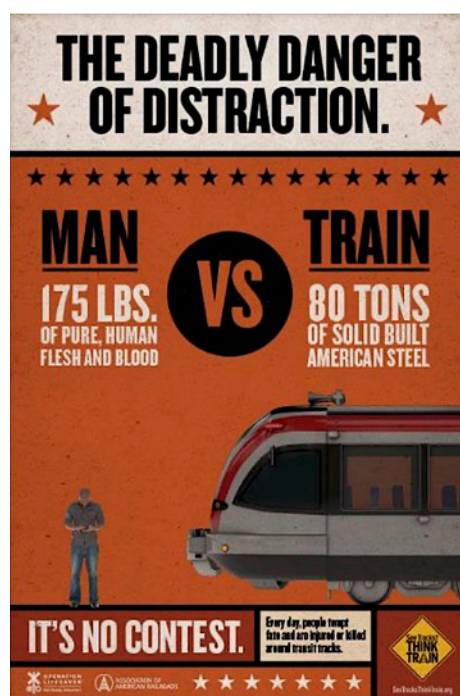
Source: OLI

Figure 2-4 *Operation Lifesaver campaign resource*

Six of the eight agencies that conducted community outreach programs leveraged resources and forged collaborations with Operation Lifesaver during their campaigns. The target demographics for most of the initiatives are age/income/ethnic subgroups, transient populations, school students, older adults, and people who live near the railroad tracks. These outreach initiatives are often held during a specific month. BART and MBTA are also developing evaluation tools to assess the effectiveness of the outreach programs. The major strategies related to agency-led community outreach efforts and the agencies involved in these efforts include:

- Reaching out to schools near the rail tracks to raise awareness and organizing poster contests on rail safety (Figure 2-5) (LA Metro, Metra)
- Distributing rail safety pledge cards among school children in the vicinity of the railroad ROW (Capital Metro, Brightline)
- Sending pamphlets emphasizing rail safety to invested stakeholders
- Running a special excursion train to spread the message of rail safety (Capital Metro)
- Out-of-the-box initiatives such as the Buzz Boxx (a mobile barber shop for low-income patrons where customers are educated on rail safety) (Figure 2-6)

SEPTA has organized initiatives such as Respect the Train (since 2013), Community Safety Day (since 2013), and Monthly Station Blitzes (since the 1990s), and MBTA has organized Watch, Samaritans, Transit Police Community Outreach Program, OLI Pro-Active Committees, and station safety programs.

Source: LA Metro

Figure 2-5 *LA Metro community outreach program with school children*

Source: West Palm Beach PD, Twitter

Figure 2-6 *Brightline community outreach program – Buzz Boxx*

Rail Infrastructure Modifications

In total, 8 of the 11 agencies (73%) were involved in conducting rail infrastructure modifications to prevent trespassing events. Figure 2-7 shows these agencies.
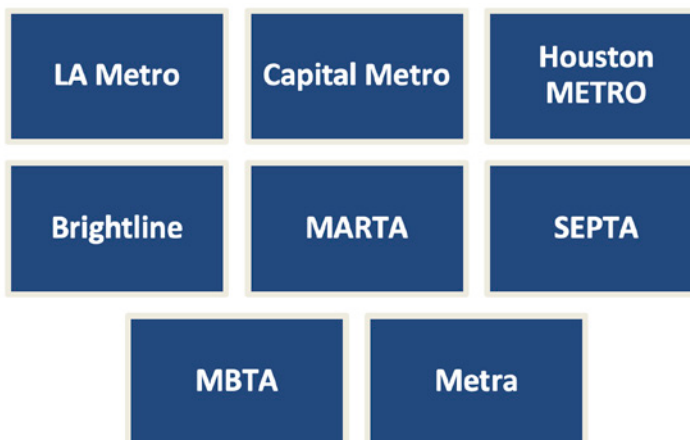
Figure 2-7 *Rail agency respondents undertaking infrastructure modifications*

The most common practice for agencies undertaking rail infrastructure modifications is to add or improve fencing to restrict access to part or all railroad ROW (5 of 8 agencies do this). Other infrastructure modifications and strategies include:

- Developing new design criteria for grade crossings with the installation of swing gates, pedestrian gates, and end-of-platform gates (LA Metro, SEPTA)
- Installing rail grade crossing incursion opposing upgrades, pedestrian grade crossing incursion opposing upgrades, and engineering hazards on low-level and high-level platforms (MBTA)
- Initiating the extension of audible bells that continue to ring when the gates are down and instituting wayside horns on a pilot basis (Houston METRO)
- Upgrading many crossings to exceed FRA standards with special focus on four-quadrant gates (Brightline)
- Constructing underpasses and inter-track fencing to prevent crossing of tracks at non-designated areas (MARTA) (Figure 2-8)
- Installing platform screen doors (Figure 2-9)

Source: MARTA

Figure 2-8 *MARTA rail infrastructure modification – fencing*

Source: International Railway Journal, Munich, Germany

Figure 2-9 *Rail infrastructure modification – platform screen doors*

Procedural Modifications

In total, 5 of the 11 respondents (45%) revealed their agencies had initiated some procedural modifications to prevent trespassing attempts. Figure 2-10 shows the agencies involved in conducting this intervention.
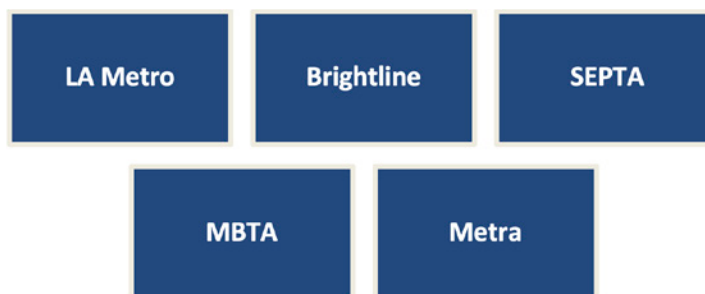
Figure 2-10 *Rail agency respondents undergoing procedural modifications*

Procedural modifications vary by agency and consist of the following:

- Increasing of patrols along the railroad ROW (Figure 2-11) and working closely with transit police and local police departments (Brightline, SEPTA, MBTA)
- Initiating changes to operating reporting requirements and cashier attendant reporting requirements (SEPTA)
- Instituting the creation of near-miss reports for performance assessment and evaluation (Metra)

- Reducing speed on approach to grade crossings to ensure a higher operator reaction time and better anticipation of trespasser behavior (e.g., reducing speed to 25 mph along certain corridors) (LA Metro); these modifications are often considered a fine balance between safety and efficiency

Source: West Midlands Police, Flickr

Figure 2-11 *Procedural modification – increased patrolling*

Rail Operator Training

In total, 8 of the 11 responding agencies (73%) conducted rail operator training programs with the aim to prevent trespassing. This is a common practice among many agencies. Figure 2-12 shows the agencies conducting this intervention.

Figure 2-12 *Rail agency respondents involved in rail operator training*

The most common practice for rail agencies undertaking rail operator training has been to institute procedures for reporting trespassing incidents and to provide resources that increase operator (new and existing) awareness on how to effectively respond to a crisis. Various strategies for training have been adopted by RTAs:

- Teaching modules for both new and existing operators from the Train Operator Certification textbook that focus on responding to incidents involving death and injury on trackways (BART)
- Making rail operators (both new and existing) complete a form when faced with errant behavior during work; the forms are given to law enforcement agencies to conduct "sting" operations at the noted locations (LA Metro)
- Hiring experienced engineers and conductors to teach on potentially risky areas for trespassing activities; training often takes eight weeks in class and a minimum of five weeks on-the-job (Brightline)
- Using campaigns (such as Samaritan) and training resources from the Volpe Center to teach safety, transportation, and management employees (MBTA)

New Technologies

In total, 5 of the 11 responding agencies (46%) reported introducing or deploying new technologies to reduce/mitigate trespassing. Figure 2-13 shows the agencies involved in this area. The survey and follow-up interviews indicate that rail agencies are interested in new technologies. However, implementation of technologies to reduce or mitigate trespassing incidents is not widespread yet due to agency concerns about their effectiveness, maturity, and cost. Although it is early to comment on the effectiveness of specific technologies employed by agencies, there is growing evidence that future mitigation strategies will likely involve the use of new and emerging solutions in surveillance, detection, and notification to produce more favorable outcomes.
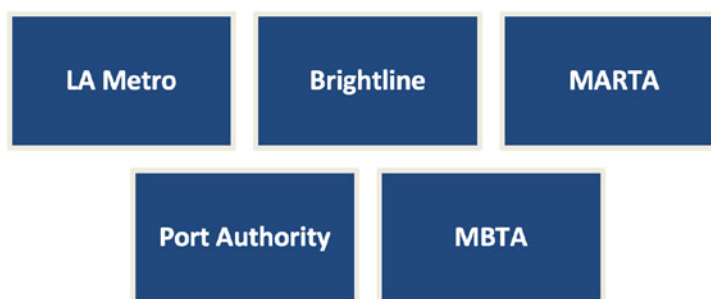
Figure 2-13 *Rail agency respondents involved in testing/deployment of new technologies*

The following technologies have been deployed to mitigate trespassing incidents:

- Using end-of-platform gates installed with visual and audio alarms, fiber optics systems installed along ROW, and camera analytics systems that raise an alarm when any object/pedestrian falls onto the railroad track at stations (LA Metro)
- Encouraging the public to use apps such as See & Say by MARTA and MBTA (Figure 2-14)
- SEPTA Transit Watch app and BART Watch app to report trespassing or suspicious activity
- Using data analytics to focus the presence of law enforcement agencies in safety hot-spot areas (MARTA)
- Using technology that consists of emergency trip stations to quickly shut down power to the third rail in case of an incident (MARTA)
- Testing and deploying flashing lights at platforms to indicate the arrival of a train (MARTA, WMATA)
- Installing laser intrusion detection systems in tunnels of the rail system that send an alarm to law enforcement when an intrusion is detected (PRT)
- Embracing digital billboards to relay agency-related information and safety messages to the public (MBTA)
- Exploring the use of drones (Figure 2-15) to fly over an area of trespasser detection by roadside sensors to visualize and report potential incidents to law enforcement agencies for investigation (Brightline)
- Applying intrusion detection systems for trespasser detection and surveillance (SEPTA, BART)
- Applying video analytics technology to detect trespassers (Capital Metro)
- Using electronic billboards to display various railroad safety messages to mitigate trespassing and suicide incidents (Metra)
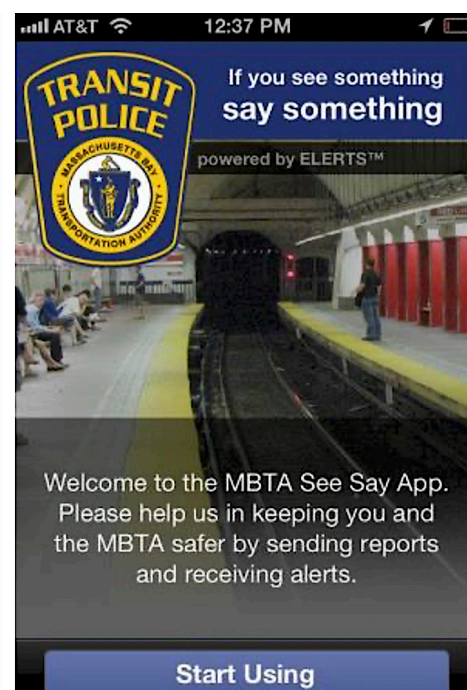
Source: MARTA Police, MBTA Police

Figure 2-14 *See & Say app – MBTA*

Source: Edie

Figure 2-15 *Drone technology*

Observations and Findings on Suicide Prevention and Mitigation

This section provides detailed observations and findings on suicide prevention and mitigation strategies employed by RTAs. They are based on the responses by 11 agencies to a web-based survey and follow-up interviews. These

observations and findings are valuable to all RTAs looking to strategize and prioritize suicide prevention along their ROW.

Trends and analyses of suicide incidents, fatalities, and injuries of the surveyed agencies for 2012–2018 are presented and their strategies and mitigation approaches are outlined. The strategies and approaches on suicide prevention and mitigation cover the following six areas: (1) signage installations, (2) social services/crisis intervention programs, (3) community outreach programs, (4) rail infrastructure modifications, (5) procedural modifications, and (6) rail operator training.

Suicide Incident Trends

Table 2-5, Table 2-6, and Table 2-7 show the trends for suicide incidents, fatalities, and injuries among the case study agencies for 2012–2018. Analysis of these data offers insights into the prevalence of suicides on RTAs.

Tracking suicide incidents or unsuccessful suicide attempts can be challenging and time consuming. Some agencies may not have reporting options in place to collect data related to attempted/suspected suicides that do not result in an injury or fatality. Several agencies do not track suicide incidents. SEPTA, MBTA, and Capital Metro do not track suspected or unsuccessful suicide attempts. The self-reported numbers in Tables 2-5, 2-6, and 2-7 are used for reference, not for comparison.

Table 2-5 *Survey Responses on Suspected Suicide Attempts, 2012–2018*

Rail Agency	2012	2013	2014	2015	2016	2017	2018
BART	7	5	12	12	6	10	5
Brightline							
Capital Metro							
Houston METRO							1
LA Metro					3	7	6
MARTA	69	76	98	103	116	102	109
MBTA							
Metra	15	10	4	10	10	25	14
PRT	0	0	0	0	0	1	1
SEPTA							
WMATA	7	7	7	13	6	7	11

MARTA reported a high number of suspected suicide attempts during the analysis period, reaching more than 100 each year from 2015 to 2018. Port Authority and Houston METRO reported the lowest number during the analysis period.

Table 2-6 *Survey Responses on Suspected Suicide Fatalities, 2012–2018*

Rail Agency	2012	2013	2014	2015	2016	2017	2018
BART	4	5	6	11	4	4	5
Brightline						2	5
Capital Metro							
Houston METRO	0	0	0	1	0	1	4
LA Metro					3	4	1
MARTA	2	0	0	1	1	0	1
MBTA		9	8	6	9	17	14
Metra	15	10	4	10	10	22	12
PRT	0	0	0	0	0	0	1
SEPTA	1	2	3	4	4	5	5
WMATA	3	3	3	2	1	2	4

BART, MBTA, and Metra recorded high numbers of suicide/suspected suicide fatalities for 2012–2018, while Port Authority reported a low number during the analysis period.

Table 2-7 *Survey Responses on Unsuccessful Suicide Attempts/Injuries, 2012–2018*

Rail Agency	2012	2013	2014	2015	2016	2017	2018
BART	3	0	6	1	2	6	0
Brightline						0	0
Capital Metro							
Houston METRO							
LA Metro					0	2	1
MARTA	3	5	8	7	5	5	6
MBTA							
Metra	0	0	0	0	0	3	2
PRT	0	0	0	0	0	1	0
SEPTA							
WMATA	4	4	4	11	5	5	7

BART, MARTA, and WMATA reported high numbers of unsuccessful suicide attempts on their railroads. Brightline reported zero unsuccessful suicide attempts for 2017–2018.

In cases in which suicide incident data were being collected by the agencies, the number of incidents collected from BART, Metra, Port Authority, and WMATA was equal to the sum of fatalities and the number of unsuccessful suicide attempts along the railroad.

Overall, rail agencies with either higher levels of ridership (MARTA, Metra, MBTA, and BART), greater exposure of their ROW to the public (Brightline), or higher operating speeds (Brightline) experienced higher numbers of suicide fatalities and the lowest number of unsuccessful suicide attempts.

Strategies and approaches to reduce suicide on railroad properties are discussed next. They include signage installations, social services/crisis Intervention programs, community outreach programs, trail infrastructure modifications, procedural modifications, and rail operator training. It is important to note that some of the practices highlighted for suicide could also be useful to mitigate/deter trespassing.

Signage Installations

In total, 9 of the 11 of the responding agencies (82%) reported signage installations aimed at mitigating suicides and trespassing. Figure 2-16 shows the agencies involved in conducting this intervention.

Figure 2-16 *Rail agency respondents involved in installing signage*

The most common practice for enhancing signage has been to provide distressed users with resources that direct them to a suicide hotline. The current National Suicide Prevention Lifeline number is 1-800-273-TALK or 1-800-273-8255. The Lifeline provides 24/7 free and confidential support for people in distress, prevention and crisis resources to help people, and best practices for professionals. The U.S. Congress has approved the adoption of 9-8-8, the new

three-digit number for the National Suicide Prevention Lifeline to be completed by July 2022.

Several agencies pointed out the effectiveness of these strategies in terms of increasing calls made specifically in reference to the railroad (LA Metro, BART). Enhanced signage on station premises as well as ROW has also been an effective way to reduce the number of trespassing incidents. For example, some agencies have installed "No Trespassing" or "Stay Off Train Tracks" signs to indicate the rail line is live at rail crossings and along tracks (at locations less than 500 ft from the crossing), at the end of station platforms, at entrances to railroad tunnels, at the ends of passenger platforms, and at locations where there is no fencing (Figure 2-17).

Source: Wesley Fryer, Flickr

Figure 2-17 *"No Trespassing"/anti-suicide signage*

Analysis of agency-led efforts to improve signage revealed the following interventions:

- Installing suicide-prevention signage at train stations (Figures 2-18, 2-19, 2-20, and 2-21) encouraging those who are struggling to call the National Suicide Prevention Lifeline (1-800-273-TALK) or access other resources (BART, LA Metro, SEPTA, MBTA)
- Installing signage along the rail line, crossings (Brightline, Capital Metro), entrances to tunnels (Port Authority), ends of platforms (Port Authority, WMATA, BART, Metra), and areas without fencing (Capital Metro)

Figure 2-18 *BART anti-suicide signage*

Source: MTA

Figure 2-19 *Suicide Prevention Lifeline*

Source: MCES, Twitter

Table 2-20 *SEPTA suicide prevention signage*

Source: Samaritans

Table 2-21 *MBTA Samaritans signage*

Social Services/Crisis Intervention Programs

In total, 6 of the 11 surveyed agencies (55%) reported coordinating with social services/crisis intervention programs to decrease suicides in their jurisdiction. Figure 2-22 shows the agencies involved in conducting this intervention.

Table 2-22 *Rail agency respondents coordinating with social services/
crisis intervention programs*

The most common practice for coordinating with social services/crisis
intervention programs is to engage in enhanced staff training by collaborating
with suicide prevention groups or helplines. Four of the six agencies (BART,
LA Metro, Brightline, SEPTA) have coordinated with social services/crisis
intervention programs to achieve better outcomes. Other strategies used by rail
agencies in working with social services/crisis intervention include:

- Providing National Suicide Lifeline wallet cards at stations and printing the
  Suicide Lifeline number on paper tickets (BART)
- Initiating training classes for service attendants by coordinating with
  suicide prevention groups (SEPTA, Metra)
- Instituting initiatives such as a suicide prevention task force to campaign
  on recognizing suicide risks, and promoting suicide awareness training
  programs aimed at prevention (SEPTA) (Figure 3-23)
- Coordinating with organizations such as Samaritans and receiving input
  from the U.S. Department of Transportation in efforts to reduce suicides
  along premises (MBTA)
- Engaging in various interventions via mental health suicide awareness
  training and outreach efforts with county health departments, promoting
  knowledge sharing and transfer through conferences and symposiums
  focused on mental health and well-being (Metra)

Figure 2-23 *SEPTA – Regional Suicide Prevention Task Force*

Community Outreach Programs

The community outreach programs previously highlighted for trespassing are also useful in mitigating suicide incidents. Some community outreach and campaigns on suicide prevention focus on mentally distressed groups. In addition to those indicated previously, outreach initiatives specific to suicide that have been conducted by rail agencies include:

- Suicide prevention campaigns with an aim to prevent/reduce suicide incidents (MARTA)
- Activities and events around Annual Suicide Prevention Day (SEPTA)

Although some of these programs are targeted events for specific demographics, most are year-long programs for the general population.

Rail Infrastructure Modifications

Most infrastructure modifications employed by the surveyed agencies focus on trespassing prevention. As was evident in the case of community outreach

programs, several rail infrastructural modifications are also effective against suicide prevention and a reduction in incidents and fatalities.

In addition to the noted strategies, a rail infrastructure modification specific to suicide is the installation of refuge spaces under platforms, also known as drainage or anti-suicide pits (Figure 2-24). These spaces can effectively prevent suicide fatalities on train tracks by creating a 3-ft gap between the ground and the railway tracks, enabling victims to fall below the wheelbase and prevent being struck. Although these spaces span the entire station platform and were originally intended for platform drainage purposes, they have reduced the mortality rates for accidental and suicidal victims. Results from a study of the London Underground showed that stations with drainage pits reduced the mortality rate by about half. Data analysis of historical MARTA suicide fatalities and injuries indicates significantly fewer fatalities than injuries due to the design of their refuge spaces (Figure 2-25). It is worth noting that the retrofit of existing train stations with refuge spaces is expensive; therefore, it would be cost-effective to include refuge spaces in new station designs.
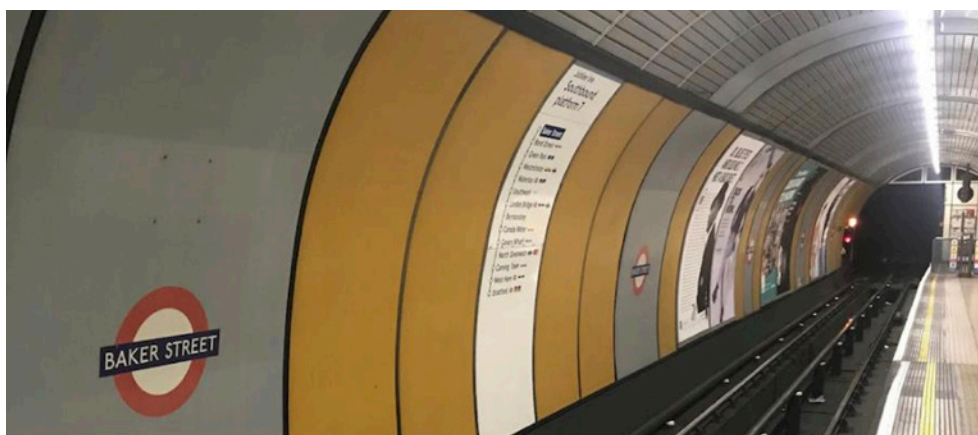
Table 2-24 *Rail infrastructure modification—refuge space under platforms, London*
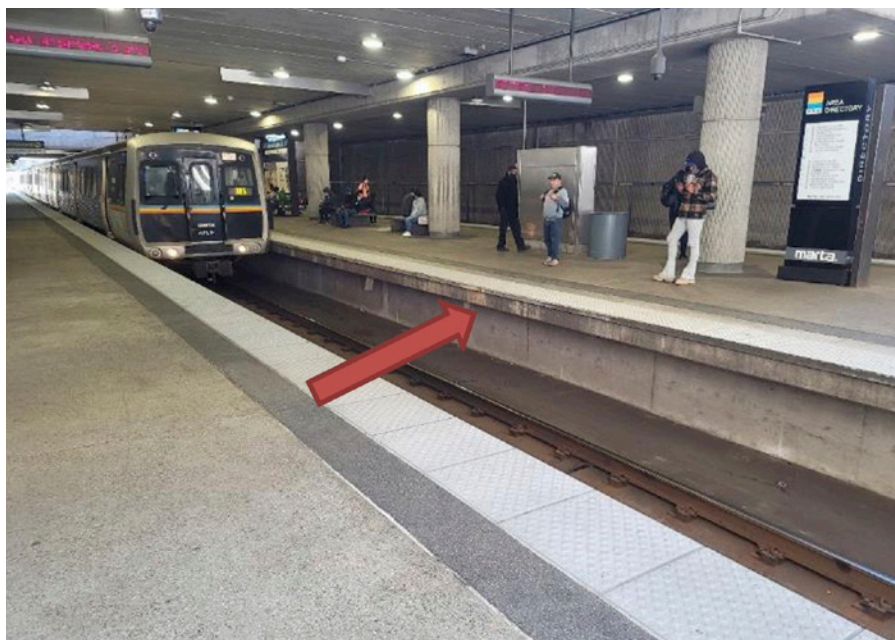
Figure 2-25 *Refuge space on MARTA*

Procedural Modifications

Limited procedural modifications were made for suicide mitigation by case study agencies. A noted modification is suicide awareness training for train crews to equip operators and other employees to report suspicious behavior and incidents promptly and diligently to enforce preventive action by law enforcement (SEPTA).

Rail Operator Training

Several operator training processes explored by the agencies were discussed in the previous section. Many of these modifications were found to be useful for combatting both trespassing and suicides along railroads. A few operator training processes were created to reduce rail-related suicides and include:

- Conductor training on using frank and sincere language onboard to discourage "copy-cat" suicide attempts (MBTA)
- Suicide awareness modules specifically in new operator training (Capital Metro, SEPTA, Brightline).
- The Question Persuade Refer (QPR) program (Figure 2-26) for training new and existing operators (Metra)

Figure 2-26 *QPR program logo*

Summary of Findings—
Mitigating Trespassing and Suicides

The findings from the 11 case study agencies that employ various strategies and countermeasures to mitigate trespassing and suicide show their challenges, solutions, and successes. Community outreach programs, rail infrastructural modifications, and new technologies are employed as strategies for trespasser detection and prevention along rail transit ROW. On the other hand, signage installations, social service/crisis intervention programs, and community outreach initiatives are employed for mitigating suicide incidents and fatalities. The survey results and findings from these 11 RTA and FRA-regulated agencies offer valuable insight, information, and experience to address rail transit trespassing and suicide problems.

The next section looks at the existing and emerging technology applications based on intensive technology review to mitigate trespasser and suicide fatalities and injuries.

Applications of Technologies

RTAs can significantly mitigate trespasser and suicide fatalities and injuries using various technology applications. Most RTAs are interested in applying technologies, but the uncertainty on maturity, capabilities, availability, and effectiveness, and the costs associated in acquiring and deploying the technologies have affected agency decisions to implement them. A comprehensive review of existing and emerging technologies could provide some answers and valuable information to RTAs for future technology deployment. This section describes the technology review process and then presents technologies identified for trespassing detection and prevention, and those identified for suicide prevention and mitigation.

Technology Review Process

The technologies reviewed have been deployed for trespasser detection and suicide prevention and mitigation on railroads. Emerging technologies that have the potential to mitigate trespassing and suicide are also described. RTAs are increasingly considering innovative technologies such as heightened surveillance and enforcement efforts to mitigate negative externalities across rail transit ROW. An extensive web-based review on the use of technologies to prevent rail trespassing and suicide incidents across the world was conducted. Information also was obtained directly from RTAs on strategies they have deployed across the United States.

It is important to note that some technologies used to prevent trespassing could also reduce suicide incidents. Integrating various technologies may lead to better outcomes. An example of an integrated technology is a commercial-off-the-shelf system that integrates video cameras, motion detectors, infrared illuminators, speakers, and central processing units. If a system detects an intruder, it alerts the monitoring station by sending audible and visual signals, which are then validated by live images. The security agent monitoring the system subsequently warns the trespasser(s) via speakers and notifies law enforcement (Topel et al., 2019).

Existing Technology Applications for Trespassing Detection and Mitigation

The technologies and systems described below are currently used in the United States and in other countries to mitigate trespassers on rail tracks. These systems are currently available to be deployed either off-the-shelf or by customization of services by the manufacturer or distributors. They have been widely used or used and studied with proven results to serve as countermeasures for trespassers.

Guideway Intrusion Detection Systems

Guideway intrusion detection systems (GIDS) have been used to support the public and operational safety of railroads. They are located primarily at train stations, at the edge of the platform in cases where platform screen doors are not used. These intrusion systems are most often used with unmanned train operations (e.g., Vancouver Sky Connect trains), not with manual or semi-automatic train operations. Intrusion detection systems are also placed along other infrastructure such as tunnel entrance/exits, level crossings and facilities such as yards.

Figure 3-1 shows a platform intrusion emergency stop (PIES) system in operation at the Kuala Lumpur Kelana Jaya line, an automated driverless light rail in Malaysia. Detection is based on the weight of a person walking on the area and on the tracks. The system can have false positives from items such as garbage bags, skateboards, and from detections arising from shock/vibrations. A visual verification of the intrusion detection can help verify if the detection is a person or some other object.
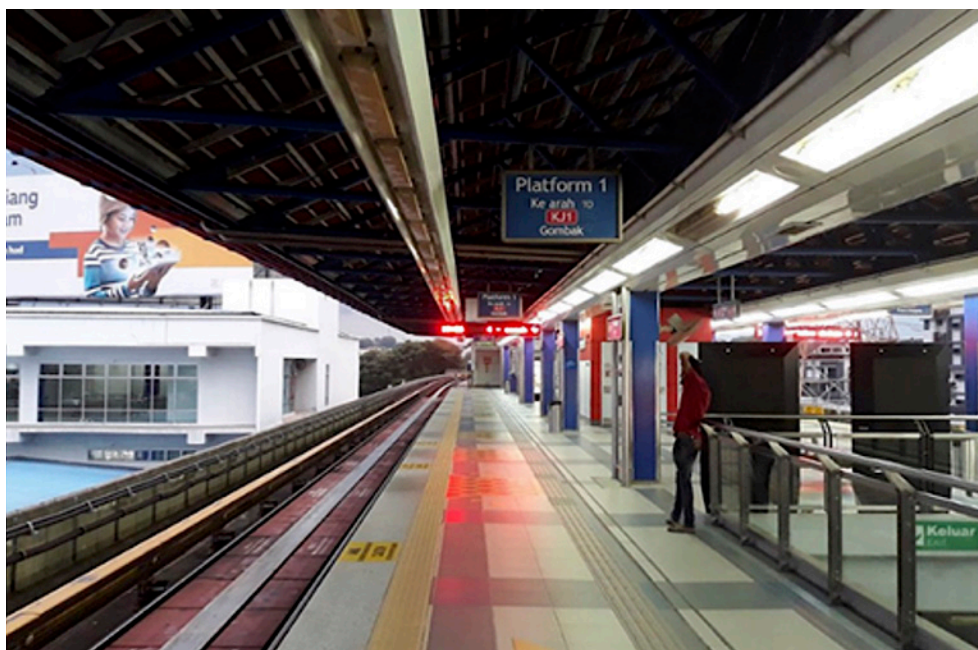
Figure 3-1 *PIES system, Kuala Lumpur, Malaysia*

Another example of a guideway intrusion system has been deployed in Vancouver, BC, on an automated driverless light rail line where optical sensors detect obstructions at stations (Figure 3-2). This system uses optical instead of pressure sensors to detect when an object enters the track area. Similar to the system in Malaysia, the Canadian system also suffers from instances of false positives from items such garbage bags, plastic bags, and so on.
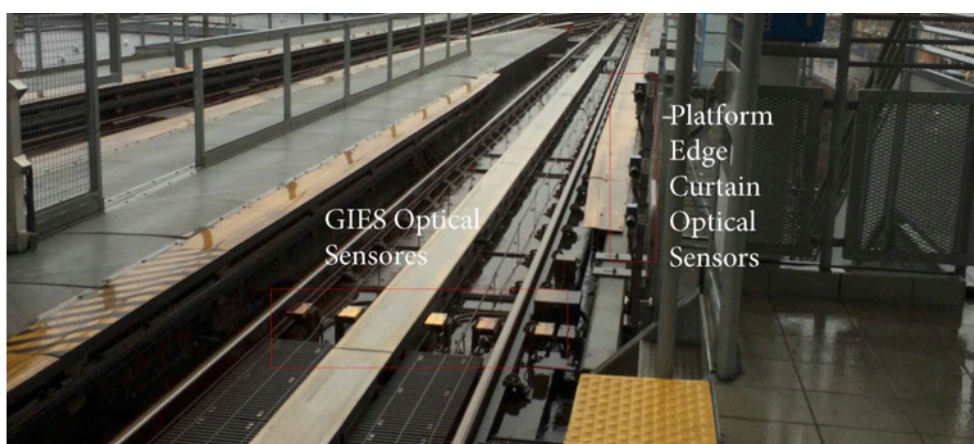
Figure 3-2 *Optical sensor-based intrusion system, Vancouver, BC*

A third type of GIDS uses optical and radio frequency (RF) sensors to create a virtual screen above the tracks to detect an object passing through the screen when no train is present. This type of system is deployed in Nuremberg, Germany and alerts the train dispatch center when a person is detected. Figure 3-3 shows the system at the train station.
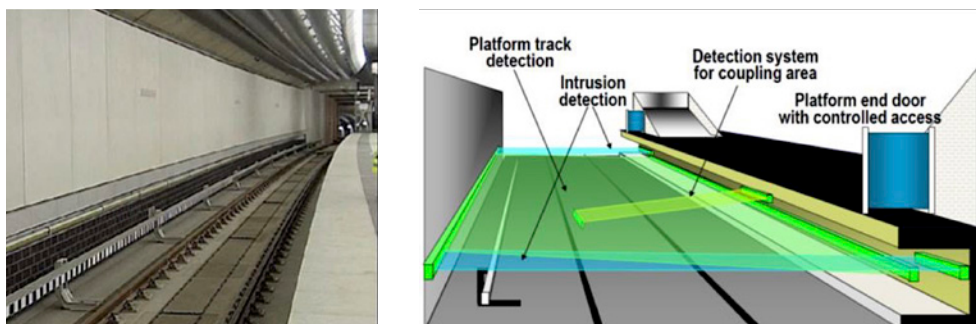
Figure 3-3 *Optical and RF sensor–based guideway intrusion system, Nuremberg, Germany*

Anti-trespass Guards or Grids

Many technologies for trespassing include anti-trespass guards or landscaping rock treatments. These technologies have been used in Europe and the United States and are installed at the end of a platform and at-grade crossings to deter pedestrians from walking on the tracks. The effectiveness of these technologies for reducing trespassing is being evaluated by agencies (Ngamdung and daSilva, 2020; Topel et al., 2019). Similar systems are anti-trespass grids, or "anti-trespass panels" or "cattle grids" (Figure 3-4), which consist of pyramidal or cone-shaped rubber panels placed on the ground to create barriers for pedestrians to cross (Bonneau & Havârneanu, 2014).

Figure 3-4 *Trespasser detection – anti-trespass grids*

Another kind of system for trespasser detection uses cables to sense intruders (trespassers) where they are not expected. Buried sensors in the form a long cable along a track can provide monitoring and alerts when intruders are detected. Different kinds of technology are used and deliver similar results. An example of such a system is a one that converts a standard single-mode telecommunication fiber optic cable into an array of distributed sensors. These sensors allow railway owners and operators to understand trespasser incidents across the entire length of their critical infrastructure, enabling them to deter the activity. Three major types of sensor systems are typically used for detection purposes:

- **Seismic sensors system** – Seismic sensors are buried underground and recognize vibrations in the ground, detecting and locating intrusions.
- **Leaky coax system** – A buried leaky coax cable creates an electromagnetic volumetric detection field; controllers monitor this field to detect and locate variation caused by an intrusion.
- **Fiber optic system** – A central controller transmits signal pulses and analyzes the reflections and disturbances to detect and locate intrusions.

Figure 3-5 shows a schematic of a fiber-based sensor device used to detect personnel activity. Fiber-based systems improve surveillance over longer stretches of a route and reveal activity hot spots to improve the focus of complementary security measures. The location delivery of these systems is accurate within 30 ft, and a single trackside installation can cover up to 60 miles.

Figure 3-5 *Trespasser detection – fiber-based sensor device*

Infrared Sensors

Infrared sensors are also used for automatic detection and warning. They detect trespassers at the location at which they are installed, similar to the operation of elevator doors. The sensors can detect any kind of object passing the virtual screen, including large animals and debris. The infrared sensor can activate a prerecorded voice message asking the violators to immediately leave the ROW. When tested in a study by Topel et al. (2019), the system resulted in a 44% reduction in trespassing occurrences 60 days post-installation.

Emerging Technology Applications for Trespassing Detection and Mitigation

The technologies and systems presented in this section have been developed and used in other industries with great success for some time, but their application in rail trespassing is what makes them interesting. Some of these technology applications have been piloted or proven for trespassing and some need further development or customization to render them successful and suitable for deployment in the rail industry. They all, however, have great potential to help mitigate trespassers and suicides at railroad tracks.

Applications of Artificial Intelligence on Trespasser Detection

An emerging area is the use AI and machine learning techniques in analyzing available data to identify patterns and categorize incidents. FRA is examining how AI technologies can be applied to detect trespassers in real time and develop trespass detection algorithms that can be used on both stationary (near the tracks) and mobile platforms (UAS, drones). The results of this research will

enable FRA to develop tools that will assist the railroad industry and community in identifying hot spots and significantly improve trespasser detection.

An AI algorithm known as Mask R-CNN has been successfully used in analyzing big video data of railroad trespassing (Zaman, Ren, and Liu, 2019). This AI provides a platform for automatically gathering information from railroad live feeds to leverage manual labor in collecting massive data on railroad trespasses. The AI technology helps rail agencies with the laborious task of reviewing the extensive closed-circuit television (CCTV) surveillance. The framework can automatically gather previously inaccessible data on trespassing to inform long-term strategic education, enforcement, and engineering solutions. Appendix E illustrates the AI framework for railroad trespass detection.

Another emerging technology can provide multiple services to rail agencies using a suite of video analytics-integrated solutions (Figures 3-6 through 3-9). Possible services include:

- People counting
- Overcrowding detection
- Crossing the yellow line on platforms
- Crossing rail tracks
- Smoke and fire detection
- Objects on rail tracks and platforms
- Trespassing detection
- Empty carriages detection
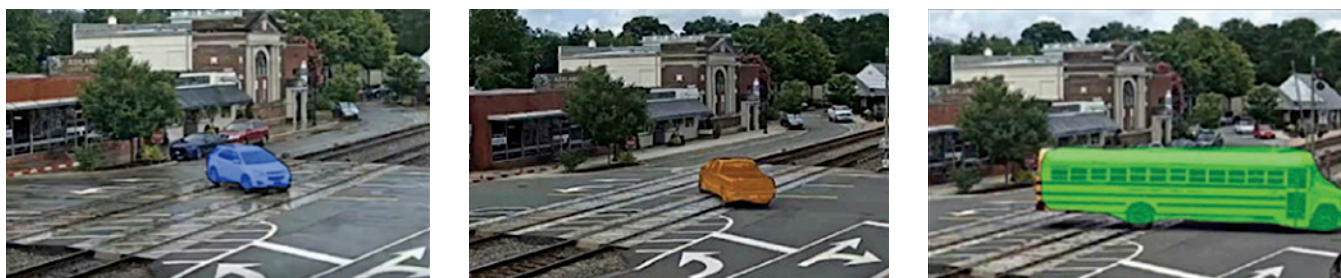
Figure 3-6 *Trespassing vehicle detection – AI-based detecting algorithm*
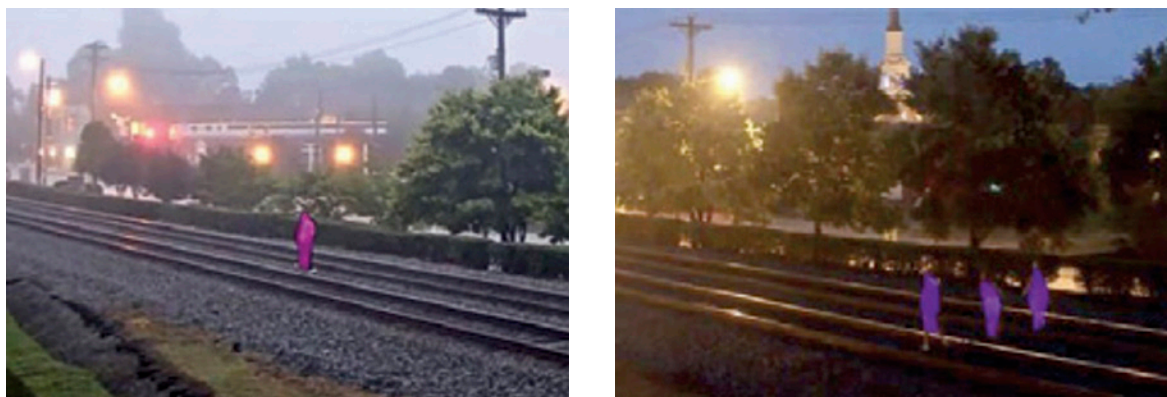
Figure 3-7 *Trespasser detection – obstruction on railroads using AI-based detection algorithms*

Figure 3-8 *Trespasser detection – activity on rail track at railroad station*

Figure 3-9 *Trespasser detection – track surveillance with laser beam in United Kingdom*

Video analytics-based solutions have been employed at railroad crossings and tracks to detect trespasser activity as well as other disruptions. Algorithms are created that detect, identify, and categorize various types of events that occur along rail tracks. Table 3-1 provides a summary of track surveillance.

Table 3-1 *Summary Table – Track Surveillance*

Target Population	Benefits	Known Issues	Summary
Individuals trespassing on ROW	May impact trespass and suicide	Requires constant surveillance. False alarms from animals and debris. Must have specific plan for intervention and/or enforcement.	Monitoring ROW (or sections of track) to identify individuals trespassing on or loitering near ROW. Track surveillance may allow railroads to identify individuals who are trespassing. For it to be effective at reducing suicides, railroads and/or law enforcement must be committed to dealing with individuals once identified

Source: Gabree et al., 2014

Unmanned Aircraft Systems

Unmanned aircraft systems (UAS) or aerial drones have been used recently in the rail industry. Drones have become more prevalent in monitoring and enforcing trespassing on railroads (Association of American Railroads 2020; Morris 2015; Murfin 2018). During agency interviews, officials from Brightline discussed extensive use of drone technology to monitor their ROW (Lyons and Boryga 2019). Once the drones detect any unusual activity, law enforcement agents are alerted to investigate the incident at the reported location. Drones are also being used in a pilot in Brunswick, Maine (Byrne 2017), to monitor and identify trespassers on railroads. Figure 3-10 shows the use of a drone at a BNSF Railway line for track inspection. Aerial drones have also been used in conjunction with loudspeakers to warn and alert persons identified as trespassers. Figure 3-11 shows two other examples of drone applications, one is to warn a surfer of rip currents and the other is to warn a motorcyclist not wearing a helmet.

Figure 3-10 *Trespasser detection – aerial drones*

Figure 3-11 *Examples of aerial drone applications with loudspeaker to warn surfer and motorcyclist*

Long-Range Radar and Applications

Several radar-based applications can be employed to detect and prevent trespassing along railroads (Figure 3-12). Many of these applications have been used in power utility and substation security, military installation security and intruder detection, water reservoir security, airport security and intruder detection, and UAS detection. Trainable target classifications can be done for people, birds, small animals, vehicles, and drones. The integration of proven radar systems with existing video and alert notification and management systems can create effective trespasser detection and notification systems with high effectiveness (Spotter RF 2020).

Figure 3-12 *Trespasser detection – long-range radar*

Onboard Detection Systems

The most recent and advanced systems involve integrated onboard detection systems that use a combination of sensors—including stereo vision, thermal vision, night vision, and laser scanners—to detect, categorize, and warn train operators of imminent threats ahead on a track. These systems work similarly to those on autonomous vehicles and can alert operators of not only trespassers on the tracks, but also any object that could be dangerous for train cars. Onboard detection systems are being piloted in Europe and the United States but have not been widely used at this time. Figures 3-13 through 3-15 show examples of views from such systems.

Figure 3-13 *Onboard detection system – SeeFar*

Figure 3-14 *Onboard detection system – Shift2Rail*

Source: TR News, 2019

Figure 3-15 *Onboard detection system – Positive Train Control (PTC)*

Connected Vehicle Technologies

The approach to mitigate trespassing/suicide attempts with detection/sensors using connected vehicle (CV) technology is still in the research phase. With the recent implementation of CV technology at at-grade crossings, Havârneanu et al. (2017) aimed to develop a data-driven learning-based sensor system integrating the detection of approaching trains and road users at grade crossings to provide system warnings and guidance.

Figure 3-16 shows a conceptual illustration of the sensor system provided by University of South Florida (USF) professor Xiaopeng Li containing three components for detecting and predicting approaching trains, detecting road users (e.g., vehicles and pedestrians) at the crossing, and synthesizing sensor information for safety risk analysis and navigation, respectively.

Source: http://cee.eng.usf.edu/faculty/xiaopengli/
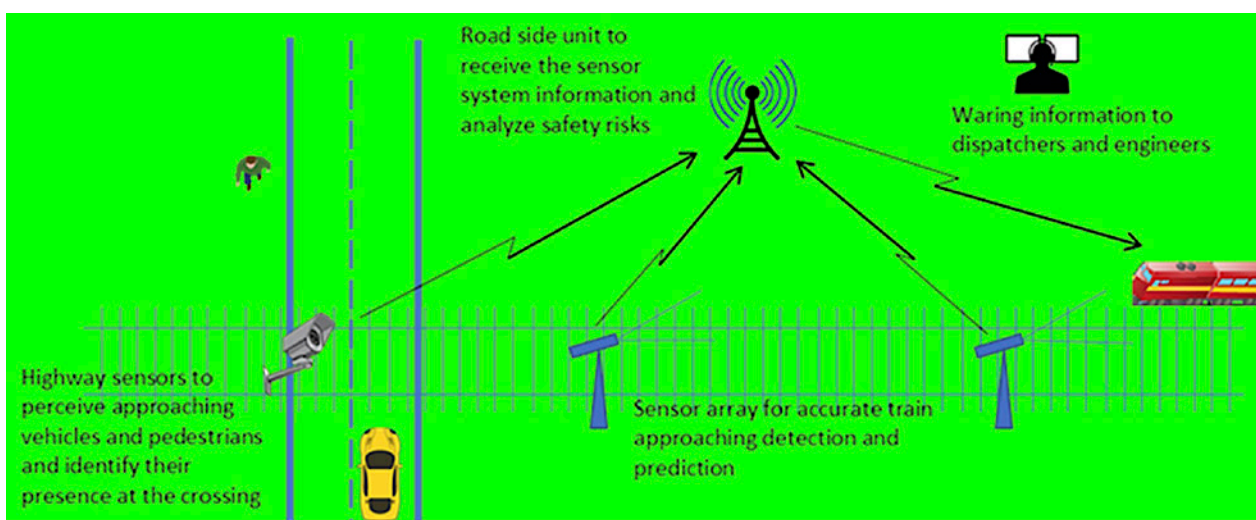
Figure 3-16 *General illustration of highway and grade-crossing sensors on train arrival*

The first trackside sensing component contains an array of sensors (e.g., lidar or radar) along the upstream railway. Each sensor provides streaming data on the train's instantaneous location and speed as well as other features (e.g., train types, length). Deep-learning models integrate train kinematics to predict the train's arrival and departure times accurately, and speeds at the grade crossing from the online and historic streaming data are proposed.

The second component integrates highway sensors (e.g., video, lidar, CV) to detect approaching road users and their closeness to the grade crossing and uses a deep-learning road user identification tool that identifies stopped road users on and near the crossings.

The third component uses CV technologies (e.g., roadside unit receiving information from all sensors) to analyze safety risks (e.g., crossing clearance and

time-to-collision). Train engineers and dispatchers receive the analysis results in real time to help them take preventive actions and warn of possible collisions. In the future, warning information could be issued to highway devices to warn road users of possible collisions and guide connected autonomous vehicle driving.

With the above-mentioned technology and models, it is useful to develop evaluation measures to assess their effectiveness in the mitigation of trespassing/suicide attempts. A study by Ryan et al. (2018) described applying a method to identify and evaluate wide-ranging preventive measures for rail suicide and trespass fatalities. Evidence from literature and industry sources was collated and reviewed to achieve consensus among experts. Multiple evaluation criteria were used to examine the measures from different perspectives. The following indicate some challenges with evaluation that can be implemented with better likelihood of success in the future:

- Practicalities or limitations of measures
- Potential negative impacts of measures
- Identification of new measures
- Problems applying the methodology

To effectively implement appropriate countermeasures, correctly determining the intent behind a trespass or suicide attempt is critical. To assist railroads in making these determinations, FRA developed Trespass Intent Determination and Evaluation (TIDE) criteria. Using 2009–2017 incident data, TIDE criteria were proven to be close to the official suicide determination (official fatality 71% vs. TIDE fatality 72%) (Federal Railroad Administration 2020c).

Technologies and Other Countermeasures for Suicide Mitigation

As noted, many suicides are trespassing incidents that end in the casualty of the trespasser. Many technologies used for trespassing detection can be used for suicide mitigation and prevention as well.

Platform Edge Doors

Platform edge doors can be installed at the edge of a platform to serve as a physical barrier between passengers waiting at a station and the train tracks, restricting unauthorized access to the tracks (Figure 3-17 and Figure 3-18). Several studies have been conducted on the effectiveness of platform screen doors in reducing the number of suicides along railroad ROW, with results showing a 60–80% decline in the five-year average number of suicides (Law and Yip, 2011; Law et al., 2009), among other benefits such as a reduction in service disruptions and enhanced savings in passenger-years. As with many

other technologies, these barriers are effective only at train and railway stations that have the space to add the screen doors at the edge of the platform. The doors can be full-height or half-height, requiring less expensive and obtrusive installation. Studies documenting the effectiveness of half-size barriers (Ueda et al. 2015) do not show them to be as effective in reducing suicide incidents on railroads as full-size barriers. Table 3-2 lists the benefits and issues of full-size platform screen doors.

Source: Gabree et al., 2014 (left); Sherry, 2016 (right)

Figure 3-17 *Suicide prevention – full-height platform edge doors*

Source: Gabree et al., 2014

Figure 3-18 *Suicide prevention – half-height platform edge doors*

Table 3-2 *Summary Table – Platform Edge Doors*

Target Population	Benefits	Known Issues	Summary
Individuals with suicidal intent on train station platform	• Completely or significantly restricts access to ROW in station • Can keep individuals from falling onto ROW • Can keep debris off ROW and manage temperatures in station	• Very high cost • Some existing stations may not support added weight • Only effective at stations	Installation of platform edge doors (PEDs) that block access to ROW at stations until train has stopped in place, at which point access to train is granted. PEDs are likely to be effective, but they are costly and can be implemented only at stations.

Source: Gabree et al., 2014

Blue Lights

Blue light installations have been introduced at several subway stations in Japan to understand their effectiveness in reducing suicidal behavior at railroad stations (Figure 3-19). A study by Matsubayashi et al. (2013) reported that suicide levels dropped by 84% at 11 railroad stations that had installed blue lights. Another study by Matsubayashi et al. (2014) showed that suicide numbers may have transferred from stations with blue lights to those with no blue lights, indicating that even though blue lights were an effective measure in suicide reduction, they did not reduce overall suicide rates. The effect of blue lights on reducing suicides may be attributed to the following reasons: blue lights have a calming effect upon people, and they are associated with the presence of police officers, suggesting it is an area of law enforcement. However, it must be noted the results based upon the Japanese study were not replicated elsewhere. More studies or pilot testing are needed.

Source: Gabree et al., 2014 (left); NextCity.org (right)

Figure 3-19 *Suicide prevention – blue LED lights in Japan railroad station platforms*

Refuge Spaces

Several studies have assessed the effectiveness of refuge spaces in reducing suicides along railroads (Coats and Walter 1999; O'Donnell and Farmer 1994). Fatal suicide incidents in stations with refuge spaces were much lower than in those without refuge spaces (from 66% to 45%), showing that they reduced the lethality of suicide incidents on railroads. Table 3-3 summarizes the benefits and issues of refuge spaces.

Table 3-3 *Summary Table – Refuge Space*

Target Population	Benefits	Known Issues	Summary
Individuals who enter ROW at station	Provide last-minute way to avoid contact with train once on ROW. May reduce fatal incidents by knocking into pit below train instead of under wheels.	Impacts not well known. High cost to modify existing stations. Only effective at stations.	Gap underneath elevated track in station that provides location for person to avoid contact. Provide last-minute place for individual to escape collision with train. In event of train-person collision, individual less likely to be taken under wheels of train where additional injury likely to occur.

Source: Gabree et al., 2014

Air Bags on Locomotives

Railroad agencies are evaluating the use of air bags on locomotives to mitigate trespassing. This system is at the concept stage and intends to use air bags similar to those used in the automotive industry, but that are larger and installed at the front of a locomotive to reduce injury if a train collides with a

trespasser or a person trying to commit suicide. The system could mitigate the effects of level crossing and trespassing accidents on vehicles and pedestrians (Topel et al. 2019).

Remarks and Recommendations

The use of technologies and applicable systems to mitigate trespassers and suicides has been shown and proven over time. Technological advances have greatly improved rail safety by detecting the presence of trespassers and people laying on the tracks and mitigating trespasser and suicide fatalities and injuries. As technology advances, so should the use and deployment of appropriate systems to effectively address rail transit trespassing and suicide incidents.

The industry is benefiting from unprecedented computing power and innovation, making this the appropriate time to deploy and rely on technological processes to improve the detection, identification, awareness, and notification of rail transit trespassers. Many systems exist that can detect, identify, and alert agencies about trespassers. As shown in RTA interviews in Section 2, some technologies have been used with variations of success.

The technology applications presented in this section can inform RTAs of their options in the immediate and future deployment of technologies for mitigating rail transit trespassing and suicide incidents. Several applications have been used in other industries or in other transportation context, several are a compilation of existing technologies, and others are new configured systems that need to be piloted and studied more or customized to suit the needs of transit agencies. All, however, have the potential to improve safety on rail transit and reduce trespassing and suicide incidents. These technology applications have different deployment timelines and cost, and RTAs that want to be in the forefront of technology and innovation can work with system manufacturers, researchers, and vendors to deploy, pilot, and evaluate the systems to prove their potential.

Section 4　Findings and Conclusions

The focus of this research was to identify effective and promising mitigation strategies and countermeasures to support RTA efforts to reduce trespassers and suicide fatalities and injuries. Researchers analyzed FTA NTD data and FRA data, performed an extensive literature review, conducted RTA and FRA-regulated agency case studies, and examined existing and emerging technologies. This section summarizes (1) trespasser and suicide fatality and injury statistics, trends, and risk factors, (2) findings from the literature review on mitigation strategies and countermeasures, (3) findings based on the 11 case studies, and (4) findings from the technology review.

Overall Statistics, Trends, and Risk Factors

Approximately 70% of all rail transit fatalities in the United States were the result of trespassing (18%) and suicides (52%). For RTAs, more suicide fatalities occurred than trespasser fatalities (74% vs. 26%).

Based on NTD Safety & Security Time Series Data, the majority of suicides (80%) were on heavy rail systems. Suicide casualties occurred most frequently midday between 11:00 AM and 1:00 PM and in the evening hours from 5:00 PM to 11:00 PM with 5:00 PM to 6 PM having the peak of suicide casualties. FTA data show MTA (New York) had the most suicide fatalities each year relative to other transit agencies. MTA (New York), MBTA (Massachusetts), and UTA (Utah) showed steady increases in suicide attempts with injuries from 2008 to 2017 (Gabree et al. 2019).

For RTA trespassing events, on average there were 23 cases of trespassing fatalities per year between 2011 and 2019; trespassing-related fatalities have been on a decline since the peak year (2015), where there were 41 fatalities. A similar trend was observed for trespassing-related injuries. For 2011–2019, heavy rail (59%) and light rail (39%) constituted the major share of trespasser fatalities, and 48% of all trespasser fatalities during 2011–2019 occurred along the railroad ROW that did not constitute a grade crossing. Revenue facilities such as transit stations and parking facilities were second (at 36%), followed by the railroad ROW that constituted a grade crossing at 15%.

Based on the analysis results from FRA data, 74% of trespassing casualties (fatalities and injuries) occurred within 1,000 ft of a grade crossing, 82% of trespassers were male, and most were of low socioeconomic status. For railroad suicides, according to a study by Mishara and Bardon (2016), the mean age of victims is consistently 39–45. Based on a study by Berman et al. (2014), 96% of freight rail suicide incidents occurred on areas of track that did not have a barrier to restrict ROW access. The study also indicated that individuals who commit suicide are likely to have psychiatric disturbance and comorbidity (mostly alcohol-related). Of the 37% of decedents in the United States who

had been drinking at the time of death, a substantial percentage (94%) had blood alcohol levels above 0.08; 96% were identified as having a mental health disorder; and 47% had been prescribed medications, but only 19% were taking them.

Literature Review on Trespass Mitigation Strategies and Countermeasures

The literature review identified major strategies and associated countermeasures to detect and mitigate trespassing on rail transit ROWs, train stations, and other facilities. They cover engineering, education, enforcement, and technologies.

- **Engineering**
  - Signage Installation – Placement of "No Trespassing" and suicide prevention life-line signs at train stations, highway-rail crossings, and along railroad tracks up to 1,000 ft from a crossing.
  - Fencing and Barriers – Design and installation of fence or barrier along rail transit ROWs especially for new rail lines, and installation of inter-track fencing or barriers at new train stations.
  - Rail Infrastructure Modification – Modification or addition of rail transit infrastructure besides fencing such as landscaping, end-of-platform gates, platform edge (screen) doors, underground pass, or pedestrian bridge at train stations.
  - Speed Restriction – Reduction of train speeds on approaches to grade crossings, especially at locations with many trespassers, known trespassing incidents, or serious concerns to allow train operator more time to react.

- **Education**
  - Community Outreach – Rail safety campaigns and outreach through collaboration with organizations such as Operation Lifesaver to educate the public on the dangers associated with railroad trespassing; distribution of educational materials, posters, flyers, and social media posts to improve railroad safety.
  - Rail Operator and Station Employee Training – Teaching personnel how to recognize errant and trespassing behaviors, identify risky areas for trespassing, and report incidents.
  - Procedural Modification – Adding a near-miss trespasser fatality and injury reporting requirement, increasing patrols along the railroad ROW, requiring consistent and uniform reporting to closely monitor trespassing activity, and improving data quality.

- **Enforcement**
  - Law Enforcement – Regular patrol by rail transit police or local law enforcement on rail transit ROW, especially known trespassing hot spots, and quick responses to locations where trespassing activity has been reported.
- **Technology**
  - Implementation of New Technologies – Applying various detection technologies and systems such as guideway intrusion, onboard detection, grade-crossing obstacle detection, rail-side detection, and drone patrols to surveil and warn trespassers.

Literature Review on Suicide Mitigation Strategies and Countermeasures

Some mitigation strategies for suicide prevention are engineering based to physically restrict access to the rail system, while others are education based to encourage people to seek mental health help and increase law enforcement patrol of rail transit ROW. High-level strategies to mitigate suicide fatalities and injuries include:

- Reduction/prevention of suicidal thoughts
- Reduction of perceived viability of railroad ROW as a means for suicide
- Prevention of ROW access
- Increased ability to avoid a train-person collision
- Reduced lethality of a train-person collision

From the literature review, major mitigation strategies and countermeasures include engineering, education, enforcement, and technology:

- **Engineering**
  - Fencing and Barriers – Installation of adequate fencing or barriers in known areas of incidents on railroad ROWs to eliminate or reduce access.
  - Refuge Space – Installation of refuge space under railroad tracks to enable a person who attempts suicide to fall below the wheelbase and avoid being struck.
  - Signage and Digital Displays – Installation and display of suicide prevention signage and suicide hotline messages encouraging those with suicidal thoughts to seek help.
- **Education**
  - Suicide Prevention Events and Education – Facilitation of community involvement in suicide prevention.

- Social Services/Crisis Intervention Programs – Partnership with local suicide prevention groups and social services and crisis intervention programs.
- Training for Railroad Employees and Authorities – Training employees to identify behavioral indicators of suicide among trespassers, passengers, and employees of transit agencies.
- Data Collection – Improvement of suicide data collection quality and accuracy by standardizing definitions of suicide incidents (suspected suicide attempts, suspected suicide fatalities, and injuries) to better assess strategies and countermeasures.

- **Enforcement**
  - Law Enforcement – Partnership with rail transit agency police or local law enforcement agencies to patrol, respond, and prevent suicides.
- **Technology**
  - Detection and Monitoring – Implementation of technology-based detection and monitoring along railroad ROW, train stations, or near railroad grade crossings to overcome human limitations of in-person monitoring.
  - Platform Edge Door – Installation of platform edge doors to significantly reduce suicide attempts at train stations.
  - Blue Lights at Train Stations – Consideration of installing blue lights at train stations to potentially deter suicidal thoughts. However, it must be noted that the effectiveness of blue lights is not proven.

Rail Transit Agency Case Studies

The interviewed case study agencies find it challenging to reduce rail transit trespasser and suicide fatalities and injuries due to many factors, some of which are beyond the agency's control. Based on survey and interview results, many strategies and associated countermeasures either yielded positive outcomes or showed potential. Agencies self-reported success include the following areas:

- Installation of signage and fencing at strategic and hot spot locations
- Fostering collaborations with law enforcement agencies
- Community outreach efforts, active advocacy, and partnerships
- Rail infrastructure and procedural modifications
- Social media communications and campaigns emphasizing rail safety
- Rail operator and agency employee training and rail safety education
- Instituting suicide prevention campaigns, interventions, and mental health awareness training
- Collaboration with social services and crisis intervention groups on suicide prevention

- Application of existing technologies
- New technology adoption
- Instituting rail safety committees and think tanks promoting and prioritizing rail safety

Effective and Promising Practices for Trespassing Detection and Mitigation

Case study agencies are exploring and adopting many strategies to detect and mitigate trespassing fatalities, injuries, and incidents. The effective and/or promising practices they have identified include the following:

- Fencing rail transit ROW to reduce trespassing especially at hot spots and areas with serious concerns and using cameras for monitoring.
- Conducting community educational outreach activities via collaboration with Operation Lifesaver, rail safety campaigns such as Respect the Train, and targeted campaigns to vulnerable populations.
- Training rail transit operators and employees on how to properly handle various trespassing scenarios.
- Deploying smartphone apps such as See Say and Transit Watch (ELERTS Corp) and encouraging passengers to install the apps to help report trespassing or suspicious activities.
- Patrolling by collaborating with rail transit police or local law enforcement to respond to reported and reduce trespassing incidents.
- Installing flashing lights at train stations to indicate train arrival and warn passengers and trespassers.
- Initiating the extension of audible bells at train stations to indicate train arrival and warn passengers and trespassers.
- Applying technology such as drones and intrusion detection systems to detect trespassers.

Drones could help agencies conduct a large-scale patrol of rail transit ROW as long as Federal Aviation Administration (FAA) regulations are followed. If possible, incorporating exclusive rail transit ROW and/or highway-rail grade separation into new rail line designs can prevent or significantly reduce trespasser fatalities and injuries.

Additionally, it is crucial to train new and existing rail transit operators and employees to ensure they are always current with the latest tools and standard operating procedures to assist them in mitigating trespassing incidents.

Effective and Promising Practices for Suicide Prevention and Mitigation

RTA case studies revealed that several strategies for mitigating trespassing are also relevant in reducing suicide incidents and fatalities. Effective and/or promising practices they identified include the following:

- Installing signage with suicide hotline messages to provide distressed users with resources such as the National Suicide Prevention Lifeline, 1-800-273-TALK, or 1-800-273-8255.
- Coordinating with social services/crisis intervention programs and organizations such as Samaritans, forming a suicide prevention task force, and enhancing staff training on suicide prevention.
- Installing refuge spaces under railroad tracks at rail transit stations to enable a person attempting suicide to fall below the wheelbase.
- Conducting rail operator and agency employee training to teach suicide awareness modules and use the Question Persuade Refer (QPR) program for training new and existing operators.
- Enhancing community outreach initiatives by using resources from organizations such as Operation Lifesaver and Samaritans and collaborating on community efforts targeting specific at-risk demographics.
- Preventing access to railroad ROW by restrictions/fencing and platform edge doors at train stations at hot spot locations or areas of serious concern.

One of the most effective practices observed across RTAs is enhanced signage with suicide prevention hotline information that effectively communicates available resources for distressed persons. Significant increases in hotline calls after signage installation by SEPTA, BART, and Metra, as examples, potentially saved many lives. When comparing the number of suspected suicide fatalities and the number of suicide attempts/injuries (1-to-8 ratio), refuge space or anti-suicide pits used by MARTA effectively reduced suicide fatalities. Other innovative solutions include Buzz Boxx, a mobile barber shop for low-income patrons where customers are educated on rail safety (adopted by Brightline), and excursion trains that spread the message of rail safety (implemented by Capital Metro). Training railroad operators by collaborating with suicide prevention groups or helplines has also proved beneficial.

Technology Review

Most RTAs are interested in applying technologies but are concerned about the uncertainty of their maturity, capabilities, availability, effectiveness, and acquisition and deployment costs. Through a comprehensive literature review, researchers identified existing and emerging technologies used for the mitigation of trespasser and suicide fatalities and injuries.

Promising Technologies for Trespassing Detection and Mitigation

Several existing and emerging technologies and applications could be used for trespassing detection and prevention, including aerial drones, detection sensors, video analytics, air bags on locomotives, connected and automated vehicle (CAV) technology, and artificial intelligence (AI) applications. Aerial drones, or unmanned aircraft systems (UAS), could be useful in monitoring and enforcing trespassing on rail transit ROW in a large-scale deployment. Via a loudspeaker attached to a drone, the drone pilot can ask trespassers to leave the rail transit ROW. Detection sensors and radar could automatically detect and warn against trespassers; these systems could be more effective if associated with prerecorded voice messages.

Both onboard and rail-side detection systems are also promising. CAV technology could be further explored and applied to detect and warn trespassers and rail transit operators, and AI technologies can be applied to trespass detection algorithms and installed on UAS. Video analytics-based solutions are valuable at railroad crossings and tracks to detect trespasser activity and other disruptions. Algorithms can be created that detect, identify, and categorize various types of events that occur along rail transit ROW.

Promising Technologies for Suicide Prevention and Mitigation

Successful or promising technologies targeted to mitigate suicide on rail transit include platform screen doors, blue lights (not proven), and onboard detection systems.

Platform screen doors serve as physical barriers restricting unauthorized access to the tracks and can also help with service disruptions. Although expensive, they could be valuable investments for new designs or stations. Half-height platform screen doors are another plausible solution.

Blue lights have shown to be effective in Japan for reducing suicide rates at stations. They have a calming effect upon people and are associated with the presence of police officers, suggesting an area of law enforcement. However, the effectiveness of blue lights is not proven, and the Japanese study results have not been replicated. More studies or pilot testing are needed.

Integrated onboard and wayside detection systems that use a combination of sensors, including lidar, stereo vision, thermal vision, night vision, camera systems, and laser scanners, are also promising technologies for detecting and mitigating suicide attempts on rail transit ROW, stations, and facilities.

Conclusions

This research focused on mitigation strategies and countermeasures to reduce rail transit trespasser and suicide fatalities and injuries. Researchers conducted detailed NTD and FRA data analysis, performed an extensive literature review, conducted 11 RTA and FRA-regulated agency case studies, summarized approaches implemented by the agencies, and explored existing and emerging technology applications for RTAs to consider.

Results from detailed FTA's NTD data analysis indicate that suicide is the leading cause of rail transit-related fatalities in the U.S. Suicides and trespasser fatalities account for 52% and 18% of all rail transit related fatalities from 2011 to 2019, respectively. Approximately 70% of all rail transit related fatalities are the result of suicide and trespassing. The detailed NTD data analysis provided RTAs with key statistics, trends, and associated risk factors.

The survey and interview results from the 11 case study agencies show that RTAs and other rail agencies have different trespassing and/or suicide challenges due to various factors such as rail system characteristics, levels of exposure (ridership or share of open spaces along ROW), demographics, cultural differences, infrastructure, and economic situations.

The case study agencies are engaged in a variety of strategies and countermeasure to mitigate trespassing and suicide incidents, injuries, and fatalities depending on the type and magnitude of the challenge. Many strategies have yielded positive outcomes in responding to and mitigating trespassing and suicide incidents on railroad properties. Key agencies self-reported successes for trespassing and suicide mitigations include the following:

- Installation of signage at strategic locations and fencing at trespassing hot spot locations
- Community outreach efforts, active advocacy, and partnerships
- Rail operator and agency employee training and rail safety education
- Instituting suicide prevention campaigns, interventions, and mental health awareness training
- Collaboration with social services and crisis intervention groups on suicide prevention
- Social media communications and campaigns emphasizing rail safety
- Fostering collaborations with law enforcement agencies
- Rail infrastructure modifications, and procedural modifications
- New technology adoption
- Instituting rail safety committees and thinktanks promoting and prioritizing rail safety

The top three most popular and adopted strategies for reducing trespassing and suicides based on the case studies are (1) signage installations for suicide prevention hotline and warning against trespassing, (2) community outreach programs, and (3) rail transit operator and employee training. Peer RTAs looking at employing similar strategies can review the results of the case studies in Section 2 to determine which strategies may be suitable for them.

Applications of technologies could support RTAs in significantly mitigating trespasser and suicide fatalities and injuries. The literature review in Section 3 identified existing and emerging technology applications to consider for future implementation.

This final report can serve as a toolbox for RTAs on (1) trespassing and suicide data analysis, (2) strategies identified from literature review or employed by RTAs in mitigating trespassing and suicide incidents, injuries, and fatalities, (3) 11 RTA case studies, (4) existing and emerging technology applications to detect and/or prevent railroad trespassing and suicides, and (5) key research findings in the mitigation of trespassing and suicide incidents.

Findings

The major findings from this research project are provided below:

- RTAs can benefit from reviewing the statistics, trends, and risk factors associated with trespassing and suicides to identify specific problems and implement effective strategies and countermeasures.
- Strategies with examples illustrated in the RTA case studies can be adopted or customized by transit agencies to mitigate trespassing and suicide problems.
- Technology applications may present effective countermeasures to mitigate trespasser and suicide injuries and fatalities.
- Most RTAs interviewed for this research were interested in applying technologies, but with some concerns. These concerns could be eased by providing guidance or otherwise educating transit agencies on aspects including technology maturity, capabilities, availability and effectiveness of technologies, and the costs associated with acquisition and deployment.
- RTAs could review the promising technology applications identified here and explore the applications of interest for future adoption or pilot testing.
- Collaboration with organizations such as Operation Lifesaver to conduct rail safety campaigns and with Samaritans on suicide prevention targeting at-risk demographics were the most common and effective community outreach practices for case study agencies.
- Installing "No Trespassing" signage at strategic or trespassing hot spot locations is cost-effective and popular for RTAs.

- Also, cost-effective and popular is the installation of signage with suicide hotline messages to provide distressed users with resources such as the National Suicide Prevention Lifeline, 1-800-273-TALK, or 1-800-273-8255. This method is highly recommended for RTAs.

- Preventing access to rail transit ROW or stations by restrictions/fencing or platform edge doors is one of the most effective methods for eliminating or significantly reducing trespasser and suicide fatalities.

- The use of refuge spaces may prove effective in reducing suicide and other fatalities. The placement of refuge under railroad tracks cause a person attempting suicide to fall below the wheelbase, preventing a vehicle strike and potentially reducing fatality rates.

- If budget allows, infrastructure improvements or construction could be considered in conjunction with adding technology to detect and monitor trespassing activities.

- It is deemed an effective practice by RTAs to deploy smartphone apps to help report trespassing or suspicious activities from their passengers.

- Regular patrolling and collaboration with transit agency police or local law enforcement to respond to reported trespassing and reduce trespassing incidents have been successful.

- Aerial drones or UAS can assist in monitoring and enforcing trespassing on rail transit ROW in a large-scale deployment. With a loudspeaker attached to a drone, an agency or police drone pilot can warn trespassers to leave rail transit ROW.

- Blue lights have shown to be effective in Japan in reducing suicide rates at stations due to their psychological affects in deterring suicidal thoughts. However, the results have not been replicated elsewhere

- Certification programs are suggested to train rail operators and other personnel to report and respond to trespassing and suicide incidents.

- Connected vehicle technology could be further explored and applied to detect and warn both trespassers and rail operators. Future research is recommended to explore and develop connected train (CT) technology.

- To effectively perform safety risk assessment and management activities, it is beneficial for RTAs to have more granular, robust data associated with near-miss and trespassing events.

- Homogenous industry-wide standards to define trespass incidents and suicide attempts would help to fully understand the extent of the hazards associated with trespassing and suicide incidents.

Federal Roadway Administration Data Analysis and Findings

Trespassing and Suicide Trends— Federal Railroad Administration

According to the FRA Report to Congress *National Strategy to Prevent Trespassing on Railroad Property*, the annual number of trespassing-related pedestrian fatalities increased by 18% for 2012–2017, from 725 to 855.[7] FRA data indicate that the number of trespassing occurrences on railroad property far exceeded the number of fatalities and injuries that occurred each year. These statistics raise grave concerns about the potential for even more trespass incidents along rail.

Figure A-1 shows the most recent trespass fatalities (red dots) and injuries (blue dots) for 2011– 2020. As can be seen, there are concentrated clusters of casualties in New York, Illinois, California, Florida, and Pennsylvania.

Source: https://fragis.fra.dot.gov/Trespassers/
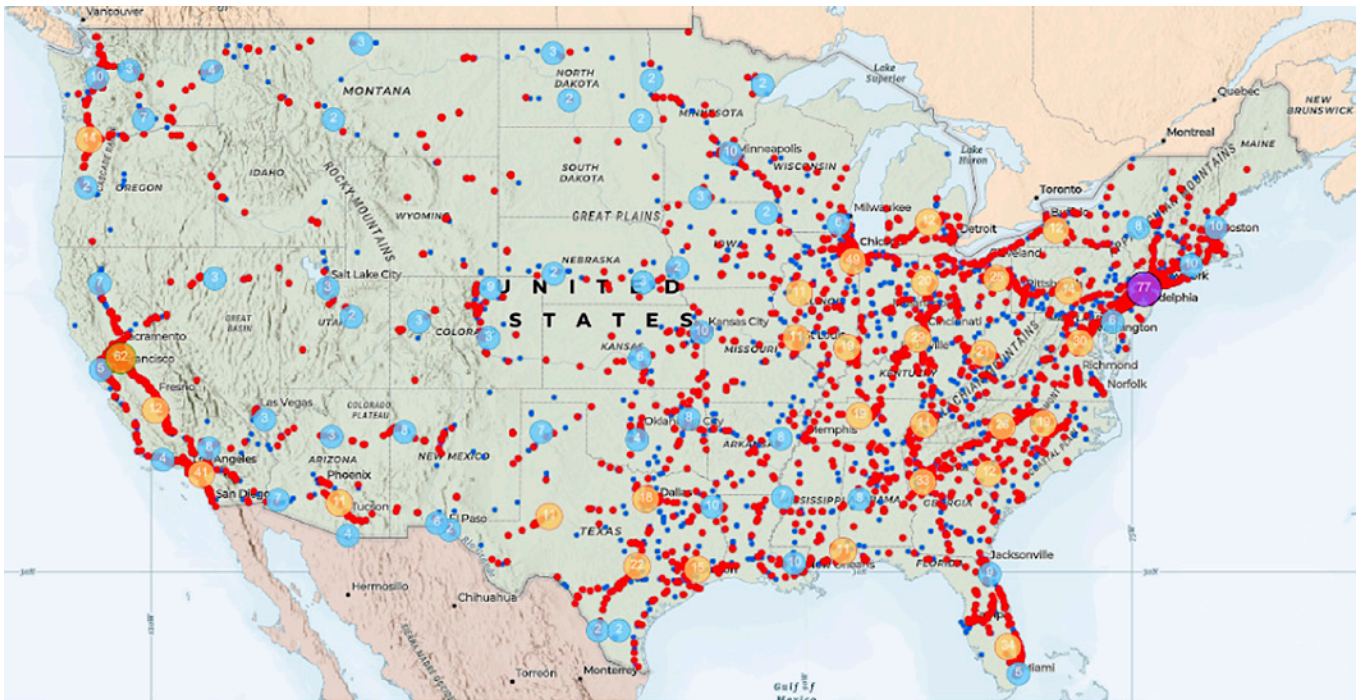
Figure A-1 *Trespass casualties in US, 2011–2020*

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[7] FRA Report to Congress - National Strategy to Prevent Trespassing on Railroad Property.

The fatalities, injuries, and casualties per million train-miles along railroad ROW are shown in Figure A-2. The overall temporal trend indicates that the fatality, injury, and casualty (fatality + injury) rates have increased since 2016 and are on an increasing trend.
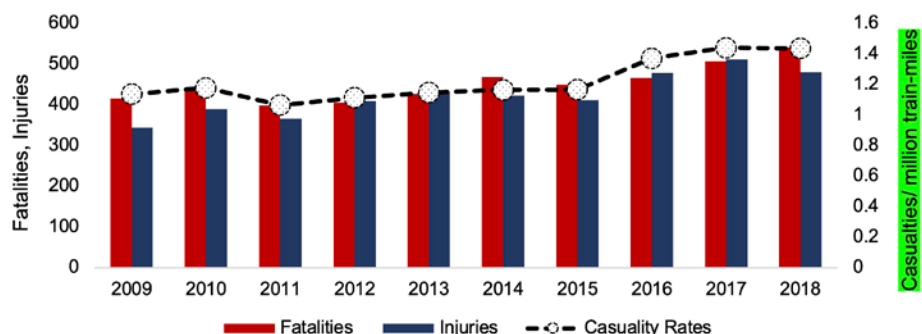
Source: FRA

Figure A-2 *Trespasser fatalities, injuries, and casualties per million train-miles, 2009–2018*

Figure A-3 shows age group distribution for trespassing fatalities by state for 2012–2018. The 40–59 age group was the most vulnerable in any state. Among all the states, California had the most trespasser fatalities (19.4%), followed by Texas with 7.1% and Florida with 6.1%.
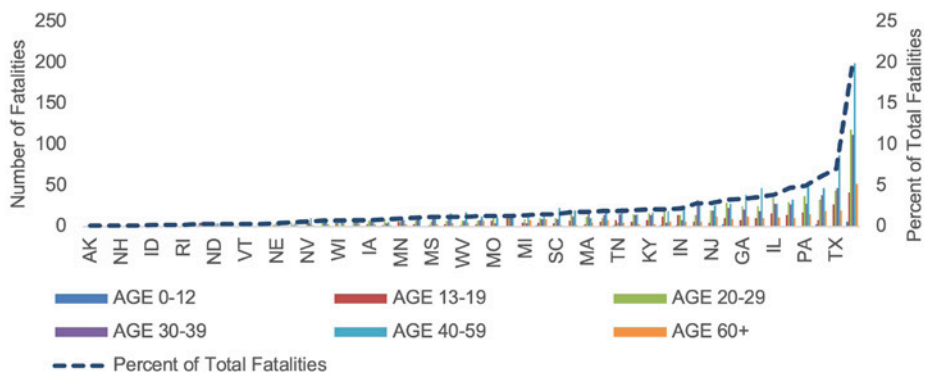
Source: FRA

Figure A-3 *Trespasser fatalities by age group and state with percent of total fatalities, 2012–2018*

Figure A-4 shows age group distribution for trespassing injuries by state for 2012–2018. Age group 40–59, followed by age group 20–29, were the most vulnerable relative to other age groups for many states. Among all states, California had the most trespasser injuries (14.9%), followed by Texas with 10% and Pennsylvania with 5%.
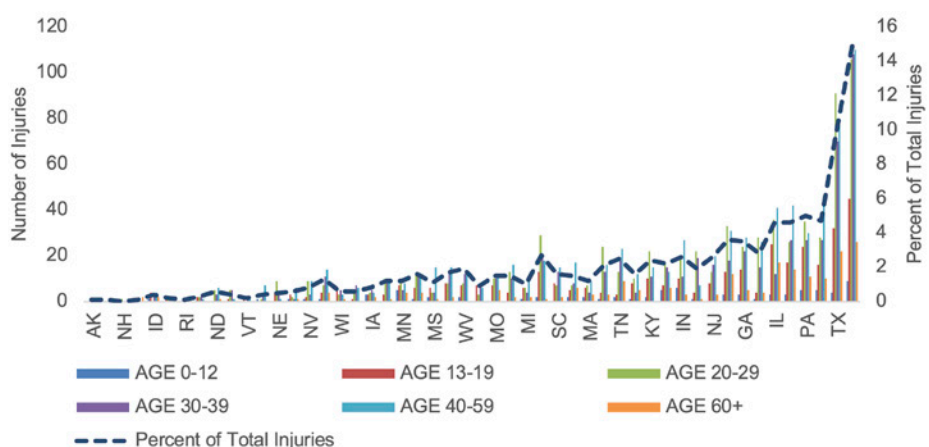
Source: FRA

Figure A-4 *Trespasser injuries by age group and state with percent of total injuries, 2012–2018*

Figure A-5 presents the age group distribution for trespassing fatalities and injuries at railroad crossings. The 40–59 age cohort accounted for 28% of total casualties, followed by ages 20–29 with 22% and ages 30–39 with 19%. Combined, 69% of all freight trespassing casualties were between ages 20 and 59.
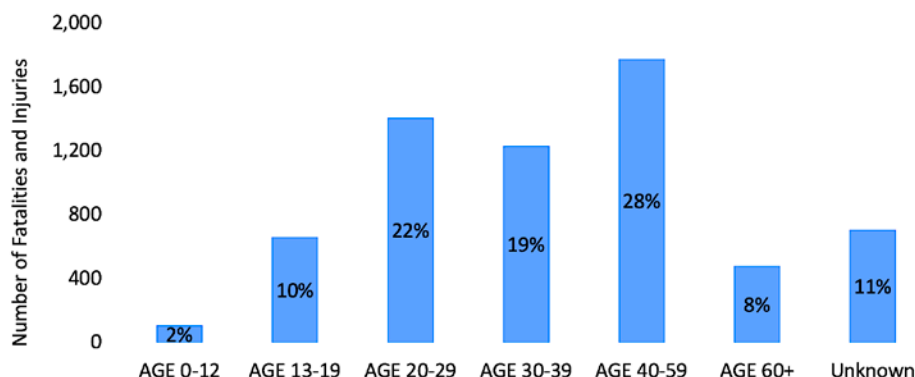
Source: FRA

Figure A-5 *Trespasser fatalities and injuries by age group, 2012–2018*

Distribution of trespasser casualties (fatalities and injuries) was determined for distance from a highway and railroad crossing. The results in Figure A-6 show that about 75% of trespasser casualties (excluding suicides) occurred within 1,000 ft of a crossing.
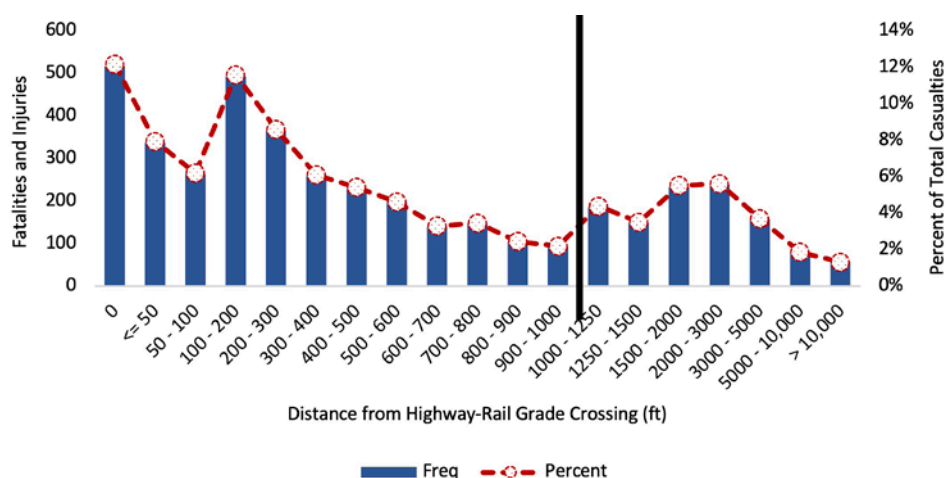
Source: FRA

Figure A-6 *Trespasser casualties (excluding suicides) by distance from highway and rail crossing, Nov 2013–Oct 2018*

According to the Volpe Center (FRA 2017), more than 40,000 people die every year in the United States from suicide. Less than 1% of those deaths happen within the rail system. Nevertheless, as with all suicides, rail suicides can have lasting, detrimental emotional effects on the victim's family and friends. With rail suicides, emotional stress extends to train crews, emergency responders, and bystanders. Identifying ways to limit these incidents will save lives, save money, reduce delays, and help families, train crews, and first responders avoid emotional distress. Additionally, when rail suicides happen, they often receive media attention, which can result in copycat suicide attempts.[8]

FRA began systematically collecting suicide data from U.S. rail carriers in 2011. Annual rail suicide fatalities for 2012–2019 were 274–328 per year.[9] According to the Volpe Center, the U.S. rail system experienced its highest recorded number of suicide incidents (358) in 2015 (328 fatalities, 30 injuries). Freight rail suicide fatalities trended downward between 2015 and 2019, though this figure remained above 200 year after year. Figure A-7 shows suicide causalities (fatalities + injuries) for 2012–2019, indicating that California, Illinois, New York, Florida, Texas, Pennsylvania, and New Jersey had 100 suicide casualties over 8 years.

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[8] Reporting of Suicide and Trespass Incidents by Online Media in the United States.
[9] FRA Office of Safety Analysis - Data.

Number of Records
1   470

Source: *https://cms8.fra.dot.gov/accident-and-incident-reporting/casualty-reporting/suicide-reporting*
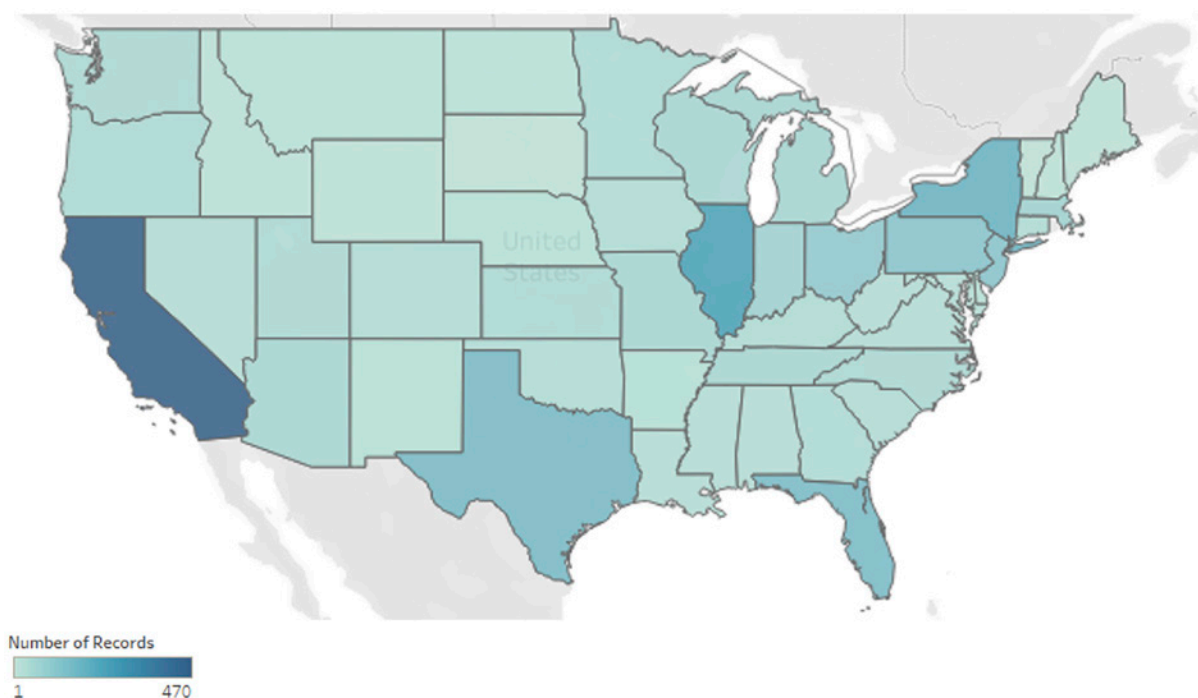
Figure A-7 *Suicide casualties in US, 2012–2019*

While trespasser and suicide safety-related events were the focus of this study,[10] it is also essential to recognize other elements of security related to trespassers that pose a significant concern for rail systems. Passenger rail systems are highly vulnerable to terrorist events, offering confined environments and many passengers. Explosive devices aboard a train, in a station, or on a platform, tampering of the train that can lead to derailments, and release of chemical/biological agents are security risks across the rail industry.

Major Trespasser Statistics – Results from FRA Data Analyses

- On average, each day during 2017 in the United States, three people were killed or injured while trespassing on railroad property, including more than 1,100 pedestrians.

- In the United States, trespassing is a more significant cause of rail fatalities than suicide; 43% of railroad-related deaths were due to trespassing, but only 17% of deaths in the EU were due to trespassing (ERA, 2016). In the

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[10] Trespassing and suicide definitions have undergone considerable changes in the NTD database. NTD converts the person type categories for all fatalities and injuries associated with suicide-related events to "Suicide" in the Safety & Security Time Series Data. Suicides and attempted suicides reported since 2016 are recorded as security events to maintain data continuity. As such, a passenger suicide in 2011 would be reported as a fatality in the "Suicide" column and would not be reported as a fatality in the "Passenger" column. In 2016, suicides are reported as an event type and as a person type.

U.S., trespassing is a more significant cause of rail fatalities than suicide, as opposed to the EU, where suicide causes more fatalities (European Railway Agency 2016).

- During 2012–2016, 50% of trespassers were fatally injured (Topel et al. 2019).

- FRA data show that 12% of trespassing pedestrian casualties, not including suicides, occurred at grade crossings; grade crossings accounted for only 2% (3,000 miles) of total U.S. freight rail miles.

- Of the approximately 3,100 counties and county-equivalents in the United States, approximately 14% of all trespasser casualties occurred in 10 counties in four states (Federal Railroad Administration 2018).

- In the top 10 counties over a period of four years (November 2013–October 2017), 300 pedestrian trespassers were killed, excluding suicides; including 169 suicides, that total increased to 469 (Federal Railroad Administration 2018).

- Over a period of four years (November 2013–October 2017), 6 of the top 10 counties for trespasser casualties were in California and accounted for 7.9% of the U.S. total (Federal Railroad Administration 2018).

- The county with the most trespasser casualties (110) was Los Angeles County, followed closely by Cook County (Chicago) with 109 casualties (Federal Railroad Administration 2018).

- In total, 74% of trespassing casualties occurred within 1,000 ft of a grade crossing (Federal Railroad Administration 2018).

- Slips, trips, and falls while trespassing caused 185 casualties, or 5% of trespassing casualties not at grade crossings (Federal Railroad Administration 2018).

- FRA (2018) conducted a "Costs and Effects of Railroad Trespassing" analysis for 2012–2016 for fatalities and injuries, which estimated that 4,291 reported trespasser fatalities equated to a statistical value of life over the five years of approximately $41.2 billion and 5,072 reported trespasser injuries equated to a statistical value of injury saving over the five years of approximately $2.0 billion.

Major Suicide Statistics – Results from FRA Data Analyses

- Rail suicide rates vary widely among countries—1.3% in Canada (Mishara, 2013), 12% in the Netherlands (Van Houwelingen et al., 2013), and less than 1% in the United States (FRA, 20120b.

- For 2012–2016, 90% of those involved in suicide attempts were fatally injured.

- The mean age of railroad suicide victims was consistently 39–45 over several studies (Mishara and Bardon, 2016).

- In total, 25–30% of fatalities occurring on a rail system resulted from an intentional act of suicide.
- Psychological autopsy data from 62 rail-related suicides revealed that approximately 77% of suicides in the rail system were in the freight system and 23% were in the transit system in the United States (Sherry, 2016).

Trespass Risk Factors

- *FRA Rail Trespasser Fatalities: Demographics and Behavior Profiles*[11] indicates that 82% of trespassers were male, equating to a male-to-female ratio of 4.6:1.
- Many trespassers that resulted in confirmed suicides were found wearing earphones or earbuds or talking on a mobile phone before the fatal incidents (Wali, Khattak, and Zhang, 2017).
- From the literature review, multiple studies indicated a higher trespassing incidence on a weekday afternoon and during the evening peak, roughly corresponding with peak railroad operation times.
- The most typical freight rail trespasser fatality involved a white male who possibly was intoxicated, with a mean age of 38 and a low socioeconomic status (FRA, 2013b); this study found that two-thirds of railroad trespassing fatalities were ages 20–49.
- Trespassing prevention efforts should involve the analysis of demographic characteristics including age, income, urban/rural classification, family composition, and life stages that focus on two suggested high-risk cohorts:
  - Younger, lower-income, urban renters in second-tier cities with railroads
  - Lower-income rural homeowners who are likely to be "empty nesters" or couples without children
- The number of pedestrian fatalities may be higher because U.S. mobile phone ownership increased from 35% in 2011 to 77% in 2016. Supporting these results is the 2017 trespassing injury severity study from the Southeastern Transportation Center at the University of Tennessee, which found that 55% of incidents that reported the trespasser to be wearing headphones or talking on a mobile phone resulted in fatal injury (Wali, Khattak, and Zhang 2017).
- An analysis for 2012–2017 showed that California (250), Illinois (138), New York (99), Florida (76), and Texas (69) consistently had the highest number of fatal trespasser strikes, regardless of intent (FRA ,2020a).
- Individuals are most likely to be ages 15–34 for all fatal strikes while trespassing (FRA 2020a).

[11] TR Circular E-C242: A Literature Review of Rail Trespassing and Suicide Prevention Research.

- At the time of a strike, trespassing most often involves an individual lying down or walking/stepping (FRA, 2020a).
- Freight trains are the most involved in fatal trespasser strikes (over 60% relative to 30–35% with passenger trains) (FRA , 2020a).

Suicide Risk Factors

- In total, 96% of freight rail suicide incidents occurred on areas of track that did not have a barrier to restrict ROW access (Berman et al. 2014):
  - 55% occurred in suburban areas, 25% in downtown/urban areas, and 20% in rural areas.
  - Individuals who commit suicide are likely to have psychiatric disturbance and comorbidity (mostly alcohol related); of the 37% of decedents in the United States who had been drinking at the time of death, a substantial percentage (94%) had blood alcohol levels above 0.08.
  - Decedents studied showed significant predisposing risk for suicide, with a high prevalence of severe mental disorder and substance abuse. In addition, several risk factors were commonly observed such as suicidal thoughts, hopelessness, anxiety, and anger.
  - 96% were identified as having a mental health disorder, and 47% had been prescribed medication but only 19% were taking the medication.
- Male-to-female rail suicide ratios were 3:1–3.5:1, which closely parallels the gender ratios in overall suicide statistics (Topel et al., 2019).
- The relative lack of access to a gun and the availability of railroad tracks to the victim's residence were significant factors in the choice of rail suicide (FRA, 2013a).
- Geographic areas of large wealth (high-income areas) and older age tend to have higher rates of railway suicide but lower general suicide rates in Belgium (Topel et al., 2019; Strale et al., 2017).

Annual Trends of Suicide
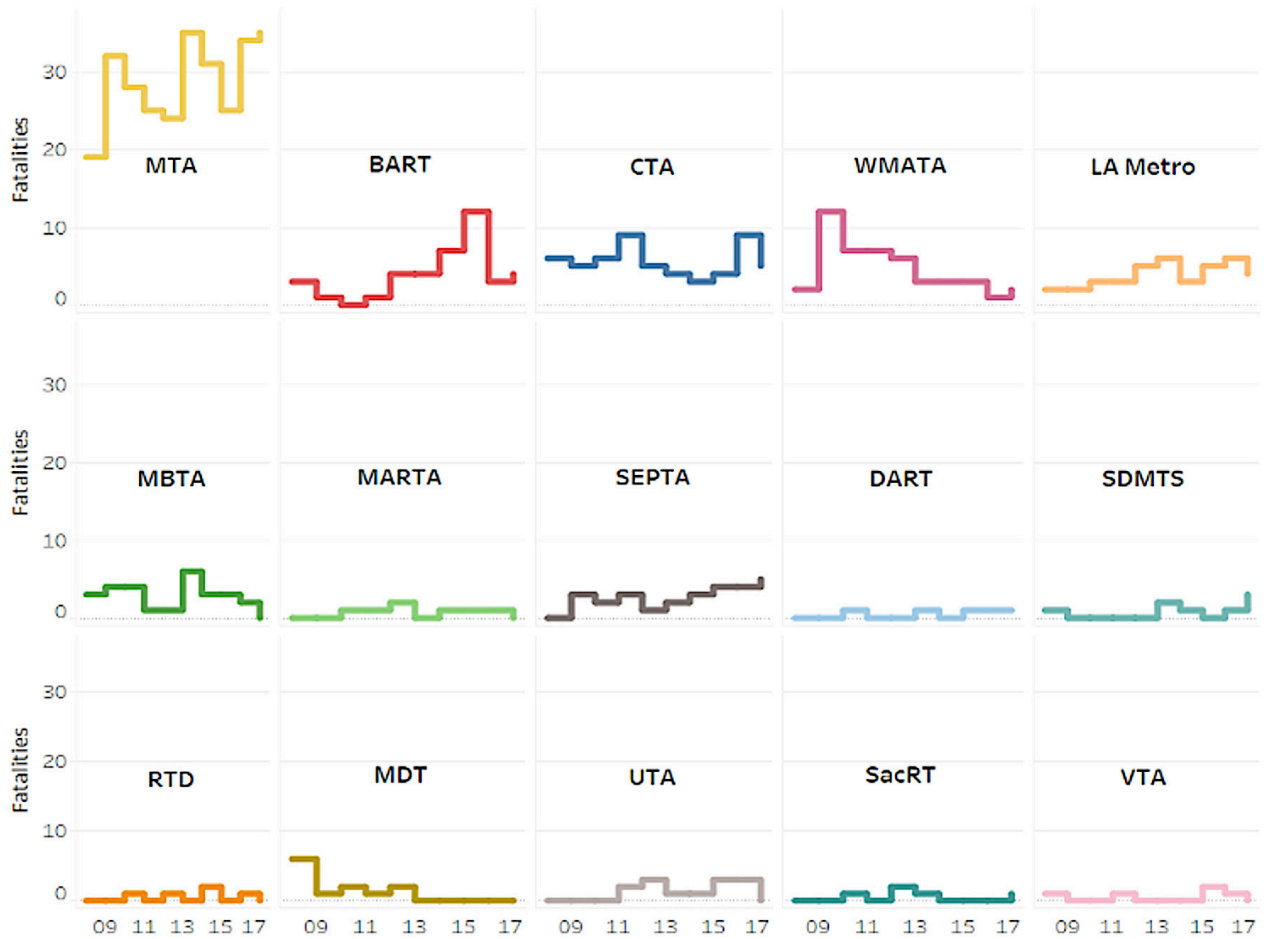
Source: NTD 2019

Figure B-1 *Suicide fatalities by transit agency and year (n = 582), 2008–2017*

Source: NTD 2019

Figure B-2 *Suicide attempt injuries by transit agency and year (n = 496), 2008–2017*

Case Study Narratives

BART

Rail Operator Training

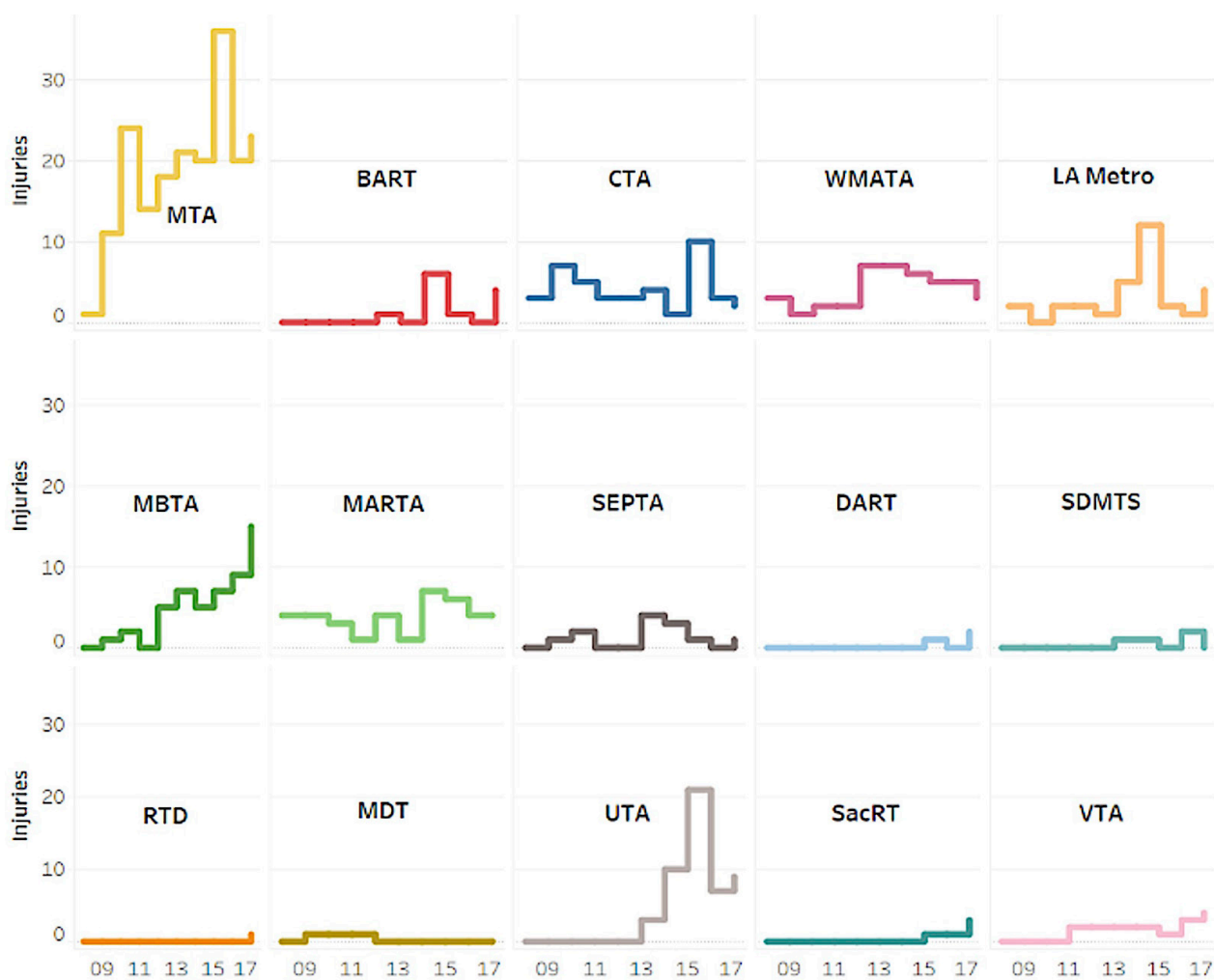Bay Area Rapid Transit (BART, San Francisco) operator training includes modules that focus on trespassing or suicide intervention or prevention. The training content consists of a lesson from the *Train Operator Certification* textbook that focuses on what to do and how to respond to incidents involving death, injury, and suicide on the BART trackway. Topics of trespassing and suicide are discussed in new and in refresher training. The *Train Operator Certification* textbook was first printed in 2011 and based on preceding documentation. The agency evaluated its driver training courses by testing trained drivers and obtaining ongoing feedback from train operators, workers, supervisors, and controllers. The certification program is well known in the industry. New hire trainees take nine performance evaluations (which include persons in the trackway) and eight written exams. Results from these are used to fine-tune the program.

Signage Installations

BART has installed signs to prevent trespassing and suicide on railroads since 2015. The sign states: "If you are struggling emotionally or thinking of suicide, call 1-800-273-TALK (1-800-273-8255). Free and confidential." The agency has installed about 160 signs since beginning the practice, which are on walls or structures near ends of station platforms. The estimated cost of the new signage installation was $530,000. BART evaluated the effectiveness of new installed signage by using call data to the National Suicide Prevention Lifeline (1-800-273-TALK). BART-related Lifeline calls increased annually—from 12 calls in 2013 to 53 (projected) in 2017.

Social Services/Crisis Intervention Programs

BART has coordinated with social services and crisis intervention programs to decrease suicides on its properties since 2015. The agency launched a multi-pronged, continuous crisis intervention campaign in partnership with the Bay Area Suicide and Crisis Intervention Alliance (BASCIA) in 2015. Station posters and signage direct troubled patrons to call the toll-free National Suicide Lifeline with the phrase "Suicide is not the route" included over the number. Frontline BART staff are trained to recognize and assist a person in crisis. National Suicide Lifeline wallet cards are provided at the Station Agent booths. One of the interventions involves the printing of the suicide Lifeline number on BART paper tickets. The agency interacts with social services and crisis intervention

programs about once a year and reviews call data to the National Suicide Prevention Lifeline (1-800-273-TALK).

Brightline

Community Outreach Programs

As many other agencies, Brightline (Florida) has held community outreach programs since 2016 and uses Operation Lifesaver (materials to use at events), Buzz Boxx (mobile barber shop for low-income), and rail safety pledge cards (school kids). Brightline Rail Safety Month occurs annually in September and Brightline also targets the beginning of the school year. Brightline has not noticed any monthly trends and has conducted more than 200 events since the onset of its programs. The organization has an annual budget of $300K–$400K and targets age group, income group, educational level, Spanish and Creole minorities, and others (location and proximity to tracks) in the design of its outreach programs.

Rail Infrastructure Modifications

Brightline had rail infrastructural modifications within the past 10 years to reduce trespassers or suicides that cost about $200M–$400M. Brightline upgraded all crossings to exceed FRA standards, including gate upgrades and additional signage.

Procedural Modifications

Brightline has implemented procedural modifications to reduce railroad-related trespassers and suicides, increased patrols along the ROW, and increased the use of signage. The estimated cost/expenditure for these procedural modifications is $2M–$3M. The procedural modifications included working with local or transit law enforcement to increase police presence or other enforcement tactics. Brightline has been evaluating its procedural modifications by holding monthly Executive Safety Committee meetings.

Rail Operator Training

Brightline introduced rail operator training prior to its revenue service. The process comprises hiring engineers and conductors with experience, with two months in class and five weeks of on-the-job training to make them aware of potentially risky areas. Content is covered in new rail operator modules and refresher modules for existing rail operators.

Signage Installations

Brightline has installed 700–900 new signs to prevent trespassers and suicides on railroads since 2016. Those signs were installed at highway-rail crossings, along railroad tracks less than 500 ft from a crossing, along railroad tracks 500–1,000 ft from a crossing; along railroad tracks 1,000–1,500 ft from a crossing, and along railroad tracks more than 1,500 ft from a crossing. Brightline is working with cities and the Florida Department of Transportation to evaluate the usefulness of the new signs.

Social Services/Crisis Intervention Programs

Brightline initiated working with social services and crisis intervention programs to decrease suicides in 2017. The agency has had 211 suicide prevention hotline calls. Brightline interacts with the social services and crisis intervention programs monthly.

New Technologies

Brightline began a drone program and camera analytics in 2019. The agency is in the process of evaluating the effectiveness of those new technologies. The roles of those new technologies are camera analytics to ensure surveillance, drones to check on people who are stuck for a while, and sensors to trigger a drone to fly to an area and report back to supervisors. These technologies are in the concept stage.

Capital Metro

Community Outreach Programs

Capital Metro (Austin, Texas) has been hosting community outreach events since 2009, with an annual budget of $5,000. The agency has employed Operation Lifesaver and has sent pamphlets and excursion trains to spread the message (media attention). Capital Metro celebrates Rail Safety Week in September, and the agency has not noticed any monthly trends.

Rail Infrastructure Modifications

Capital Metro employed rail infrastructure modifications in 2008 and 2018. The modifications were triggered by incidents. As part of the modifications, fencing has been added along with "No Trespassing" signs.

Rail Operator Training

Capital Metro is planning operator training that includes modules focused on trespassing or suicide prevention and mitigation. Herzog will be implementing this information in upcoming training.

Signage Installations

Capital Metro has installed new signage to reduce trespassing and suicides on railroads; the last signs were installed in 2019. The signs advise that the rail line is live and advise against trespassing. The signs were installed at highway-rail crossings, along railroad tracks less than 500 ft from the crossing, at locations where there is no fencing, and at the end of station platforms. The installed signage cost about $600.

New Technologies

Capital Metro has proposed the use of video analytics to prevent trespassing and is working out the bandwidth issues and targeting a few high activity centers for trespassing.

Houston METRO

Community Outreach Programs

Houston METRO has had community outreach activities since October 2017 with an annual budget of $30,000. The agency has partnered with Operation Lifesaver and has hosted about 50 events since 2017. Houston METRO does not target any specific month for campaigns and has not noticed any monthly trends. In the design of its outreach programs, Houston METRO considers age group, transient population, transitional homes, schools, students, and older adults.

LA Metro

Community Outreach Programs

LA Metro has conducted community outreach to prevent trespassers and suicide attempts for more than 20 years. Metro's Community Outreach Program is used by LA Metro to reach out to communities. The focus of LA Metro's Community Outreach Program has been to raise awareness at nearby schools and to address second train issues (the unanticipated arrival of a second train on the next rail track). LA Metro does not target any specific months for conducting outreach activities to prevent or mitigate trespassing and suicide incidents. Additionally, the organization is unaware of any specific trends during their outreach programs.

Rail Infrastructure Modifications

LA Metro has new design criteria for all grade crossings—swing gates and pedestrian gates. The agency also installed end of platform gates on the Red Line.

Procedural Modifications

LA Metro has implemented procedural modifications to reduce trespassers and suicides, including reduced speed on approaches to grade crossing for more reaction time by operators to anticipate trespassers, by making the maximum speed 55 mph and reducing speed to 25 mph at some crossings. The agency contended that these modifications slowed down the trains and decreased system efficiency, so they were not implemented to their full extent. A balance between safety and efficiency is being considered. The organization concluded that the incidents on the Blue Line triggered modifications and led to the search for trespassing mitigation solutions.

Rail Operator Training

LA Metro new and refresher operator training includes modules that focus on trespassing and suicide intervention and prevention. The training has operators complete a form once they notice errant behavior, which is sent to law enforcement to conduct investigations.

Signage Installations

LA Metro has installed new signage to prevent trespassers and suicides, which include penal codes and suicide prevention signs.

Social Services/Crisis Intervention Programs

LA Metro has coordinated with social services and crisis intervention programs to decrease suicides on their properties through the use of training classes for service attendants (suicide prevention groups).

New Technologies

LA Metro has introduced new technologies to reduce trespassers and suicides, such as platform screen doors for heavy rail, which were found to interfere with ventilation. The agency installed end of platform gates with audio and visual alarms, and tested technology that investigated pedestrians falling onto the track, but none of these have been particularly successful. Some additional explored technologies included a fiber optic system for ROW, a camera analytic system, and a 3D plane that alarms when something breaches the plane.

MARTA

Community Outreach Programs

MARTA (Metropolitan Atlanta Rapid Transit Authority) began suicide campaigns in January 2020. The organization did not reveal any other practices related to community outreach programs.

Rail Infrastructure Modifications

MARTA is in the design phase of rail infrastructural modifications to prevent and reduce trespassing and suicide incidents. Some modifications include fencing, refuge space under platforms, and power control if someone falls down.

Rail Operator Training

MARTA conducts operator training that includes modules on trespassing or suicide intervention or prevention. It brings attention to suicide attempts in the training department. Although not necessarily operational, MARTA includes it in new hire training. New operator training includes a suicide awareness module. Station agent training for new hires includes suicide signs to look for.

New Technologies

MARTA has used new technologies to prevent suicides and trespassing on railroads. For example, the agency deployed the See Say App to report trespassing or suspicious activities, data analytics to focus police presence in areas that are most concerning, an emergency trip station to shut down power to the third rail, closed circuit television, and flashing lights indicating train arrival. MARTA also considered PlatformSafe from Bombardier but has not yet tested or deployed it.

MBTA

Community Outreach Programs

MBTA has organized community outreach activities to prevent trespassers and suicide incidents since 2017 and held about 300 events since then. The agency's community outreach programs include Massachusetts (MA) Operation Life Saver, Samaritans, MBTA Transit Police Community Outreach, and an OLI Pro-Active Committee. MBTA targets September for its outreach activities. MBTA 2013–2018 person-to-train collision trends show that as the year progresses, incidents increase, with the highest number occurring between September and December. MBTA considers age group, gender, income-group, educational level, transient population, and mentally distressed groups when designing its outreach programs.

Rail Infrastructure Modifications

MBTA is currently making rail infrastructural modifications to mitigate trespassing and suicides. Modifications include fencing, rail grade crossing incursion opposing upgrades, and pedestrian grade crossing incursion opposing upgrades.

Procedural Modifications

MBTA applied procedural modifications to prevent and mitigate railroad related trespassing and suicide incidents in 2018 after a large increase in incidents in 2017. The modifications included establishing a commuter rail accident reduction committee in 2017–2018. The procedural modifications often involved working with local or transit law enforcement to increase police presence or other enforcement tactics when appropriate.

Rail Operator Training

MBTA began rail operator training focused on trespassing and suicide incidents in 2018. The MBTA contract requires conductor training on "candid" language to use onboard to avoid copycat suicide attempts. In addition, MBTA uses Samaritan and Volpe Center Training for MBTA safety, transportation, and management employees. The training covers new rail operator modules and refresher modules for existing operators.

Signage Installations

MBTA installed 1,400 new signs for reducing trespassing and suicide on railroads in 2018 and 2019 after a spike in suicide/trespasser strikes in 2017. Samaritan Signs have been posted at all commuter rail stations within the network. The signs were installed mostly at station platforms and high trespass areas identified on the ROW.

Social Services/Crisis Intervention Programs

MBTA worked with social services and crisis intervention programs to prevent suicides on their properties after a 2017 uptick in strikes. The social services/ crisis intervention programs include Samaritans and input from MassDOT's Suicide Prevention Program. MBTA holds monthly meetings with the social services and crisis intervention programs. The agency has evaluated its social services/crisis intervention during conference calls with Samaritans and assessed increases in the number of calls based on signs in stations and on the ROW. The social services and crisis intervention appear to have positive results.

New Technologies

MBTA introduced new technologies to reduce trespassing and suicide on their properties during its 2018 Rail Safety Week in September. For education, the agency has used highway digital billboards, messaging in the Registry of Motor Vehicles (RMV) offices, and digital boards in stations crossing blitzes. MBTA estimated the cost for these technologies to be up to $10,000 for printed materials, including train decals.

Metra

Community Outreach Programs

Similar to many case study agencies, Metra (Metropolitan Rail Corporation, Chicago) conducts outreach activities to prevent and mitigate trespassing and suicide injuries and fatalities. Although its campaigns do not have any target month, the agency has noticed trends in March, November, and December. Metra community outreach programs include Operation Lifesaver, Mental Health Awareness signs at all 241 stations with the National Suicide Prevention Lifeline and Crisis Text Line, a safety poster contest designed to engage school children in railroad safety, a station safety program promoting railroad safety to customers, trespasser enforcement with Metra police, "No Trespassing" signage, and audits to identify hot spots. Metra has an annual budget of more than $500,000. In the design of its community outreach programs, age groups and mentally distressed groups were considered.

Rail Infrastructure Modifications

Metra implemented rail infrastructure modifications several years ago. Underpasses have been built and inter-track fencing has been installed to prevent crossing tracks at non-designated areas. The pedestrian underpasses cost $8M–$15M.

Procedural Modifications

Metra has implemented procedural modifications to reduce trespassers and suicides, including near-miss reports and suicide awareness training for train crews. It introduced near-miss reports in 2015 and suicide awareness training in 2016. Agency procedural modifications include working with local or transit law enforcement to increase police presence or other enforcement tactics. Metra has collected data to evaluate the effectiveness of the procedural modifications and determined that the results vary and often depend on the situations.

Rail Operator Training

Metra began its operator training with modules focused on trespassing or suicide intervention and prevention in 2016. Metra uses the Question Persuade Refer (QPR) program for its training. The content covers new rail operator and refresher training for existing operators. The Metra training program is accredited, and the agency evaluates its driver training courses annually. Changes are based on QPR program administrators.

Signage Installations

Metra installed new signage to prevent trespassers and suicides in 2018. About 482 signs at 241 stations were installed at station platforms and include mental health awareness signs with the National Suicide Prevention Lifeline number and the Crisis Text Line text option. The estimated cost/expenditure for the new signage installation was $50,000.

Social Services/Crisis Intervention Programs

Metra coordinated with social services and crisis intervention programs to decrease suicides at various times in 2015. The social services and crisis intervention programs cover mental health suicide awareness training and outreach with county health departments. In addition, the agency hosts a biannual symposium bringing together mental health experts and transit agencies from the United States, Canada, and the United Kingdom. Depending on the organization, the agency interacts with social services and crisis intervention programs monthly or quarterly. Metra has tracked "interventions" through mental health awareness training and has monitored fatalities by demographic characteristics. It was successful in bringing 58 people to safety in 2017, 63 in 2018, and 62 in 2019 through interventions. Through the crisis text line, there have been 101 conversations with people who needed someone to talk to.

New Technologies

Metra has introduced new technologies to prevent trespassers and suicides such as electronic billboard systems.

Port Authority

PortAuthority

Signage Installations

Port Authority (Allegheny County, Pittsburg) has installed new signage to prevent trespassers and suicides at various times during the last several years. The agency has installed "No Trespassing" signs at various locations; most are simply replacing older faded signage. The signs were installed along railroad tracks less than 500 ft from crossings and others at entrances to rail tunnels and at ends of passenger platforms.

Social Services/Crisis Intervention Programs

Port Authority has not coordinated with social services and crisis intervention programs to reduce suicides.

New Technologies

Port Authority has introduced new technologies to prevent trespassers and suicides on railroads since 2012, including laser intrusion detection systems in tunnels on its light rail system that send an alarm to Port Authority police. Cameras at the location show police who was walking once the laser intrusion system detected the individual. The estimated cost/expenditure for the deployment of these new technologies was about $200,000 per tunnel.

SEPTA

Community Outreach Programs

Similar to LA Metro, SEPTA (Southeastern Pennsylvania Transportation Authority) has held community outreach programs to prevent trespassers and suicide attempts since the 1990s and conducted up to 500 events overall. Operation Lifesaver began in the 1990s; Respect the Train Campaign began in 2013; Community Safety Day began in 2013; Monthly Station Blitzes began in the late 1990s; Watch Their Step Campaign began in 2017; and Annual Suicide Prevention Day events. SEPTA community outreach events occur all year long with an annual budget of $8,000. SEPTA Community Safety Day occurs in May and the Suicide Prevention Day occurs in September. The agency would like to see more improvements as the results of their community outreach programs.

Rail Infrastructure Modifications

SEPTA made recent rail infrastructural modifications for reducing trespassers or suicides, including gates at the end of platforms, enhanced signage, and additional inter-track fencing. The agency introduced gates and inter-track fencing prior to 2012 and enhanced signage in 2013. Overall, these modifications did not lead to a notable decrease in trespassing and suicide incidents on the railroads.

Procedural Modifications

SEPTA began applying procedural modifications to address trespasser and suicide issues in 2017. Some of the modifications comprise operator reporting requirements and cashier attendant reporting requiring requirements.

Rail Operator Training

SEPTA has conducted operator training that includes trespassing intervention and prevention for more than 20 years. The new hire and refresher rail operator training comprise procedures for reporting trespassing. The training courses are evaluated as part of the triennial audit.

Signage Installations

Similar to LA Metro, SEPTA has installed signage to prevent trespassing and suicide on its railroads since 2013. Anti-trespassing signage and suicide prevention signs are placed on their properties. SEPTA installed around 2,000 signs at all its stations. The agency has evaluated their installed signage by reviewing calls to the Suicide Prevention Hotline and noticed a 30% increase in calls to the Hotline after signage installation.

Social Services/Crisis Intervention Programs

SEPTA has worked with social services and crisis intervention programs to decrease suicides since 2017. The social services/crisis intervention programs comprise a Regional Suicide Prevention Task Force of Southeastern Pennsylvania. SEPTA is an active member of the Task Force and has spent about $4,000 for social services/crisis intervention.

New Technologies

SEPTA has not deployed new technologies in an attempt to prevent trespassers or suicides on their properties. The agency has considered intrusion detection, trespasser detection, infrared platform passenger falling detection, and drone technology that runs ahead of trains to detect objects on track and send feedback.

WMATA

Signage Installations

WMATA (Washington Metropolitan Area Transit Authority) originally installed new signage in 2015 and updated its suicide prevention number in 2019. About 350 posted signs were directed at those in crisis, not specific to trespassers. Signs provide the National Suicide Prevention Hotline number. The new signs were installed at the end of each platform/track.

Appendix D Survey Instrument

1. Please complete the following information. We will only contact you if we have a question about your survey responses.

> Name
> Transit Agency/Company
> Address
> City/Town
> State/Province
> ZIP/Postal Code
> Email Address
> Phone Number

General Information

2. How many trespass incidents occurred each year (2012–2018)?
3. How many trespasser fatalities occurred each year (2012–2018)?
4. How many trespasser injuries occurred each year (2012–2018)?
5. How many suspected suicide attempts occurred each year (2012–2018)?
6. How many suicide/suspected suicide fatalities occurred each year (2012–2018)?
7. How many injuries (unsuccessful suspected suicidal attempts) occurred each year (2012–2018)?

Community Outreach

8. Is your agency conducting community outreach to prevent trespassers and suicide attempts?
9. Name and describe the community outreach program(s).
10. When was the program initiated?
11. Do you target any specific month?
12. Have you noticed monthly trends?
13. How many events have been conducted since the inception of the community outreach program?
14. What is the annual budget (or estimated cost/expenditure) for the program?
15. Have you evaluated your community outreach program(s)?
16. What was your evaluation result?
17. Please check all the specific demographic characteristics that are considered in the design of your community outreach program.

Rail Infrastructure Modifications

18. Have any recent rail infrastructural modifications occurred at your agency within the past 10 years in an attempt to reduce trespassers or suicides?
19. Please describe the infrastructural modifications.
20. Did a specific incident trigger this modification?
21. When did your agency introduce these modifications?
22. Did you collect baseline data prior to the infrastructure modification?
23. What is the estimated cost/expenditure for those infrastructural modifications?
24. Have you evaluated your infrastructural modifications?
25. What was your evaluation result?

Procedural Modifications

26. Has your agency implemented any procedural modifications to reduce trespassers and suicides?
27. What are those procedural modifications?
28. Did a specific incident trigger this modification?
29. When did your agency introduce these modifications?
30. Did you collect baseline data prior to implementation?
31. What is the estimated cost/expenditure for those procedural modifications?
32. Have your procedural modifications included working with local or transit law enforcement to increase police presence or other enforcement tactics?
33. Have you evaluated your procedural modifications?
34. What was your evaluation result?

Rail Operator Training

35. Does your operator training include any modules that focus on trespassing or suicide intervention or prevention?
36. Please describe the content of the rail operator training modules focusing on trespassing/suicide incident prevention.
37. Is this content covered in new rail operator training?
38. Is this content covered in refresher training for rail operators?
39. Did a specific incident trigger this training?
40. When did your agency introduce those rail operator training courses?
41. Do you have baseline data from prior to the introduction of the rail operator training modules on trespasser or suicide intervention or prevention?
42. What is the estimated cost/expenditure for the training?
43. Have you evaluated your driver training courses?
44. What was your evaluation result?

Signage

45. Has your agency installed any new signage to prevent trespassers or suicides?
46. Please describe the new signage that has been installed to prevent trespassers.
47. How many have been installed?
48. Where were those signs installed? (check all that apply)
49. Did a specific incident trigger this new signage installation?
50. When did your agency install the new signage?
51. Do you have baseline data from before the signage was installed?
52. What is the estimated cost/expenditure for the new signage installation?
53. Have you evaluated your newly installed signage?
54. What was your evaluation result?

### Social Services and Crisis Intervention Programs

55. Has your agency coordinated with social services and crisis intervention programs to decrease suicides your area?
56. What are those social services/crisis intervention programs?
57. Did a specific incident trigger this social services/crisis intervention?
58. When did your agency initiate this social services/crisis intervention?
59. Do you have baseline data prior to the coordination of those programs?
60. What is your agency's frequency of interaction with the social services and crisis intervention programs?
61. What is the estimated cost/expenditure for social services/crisis intervention?
62. Have you evaluated your social services/crisis intervention?
63. What was your evaluation result?

New Technologies

64. Have you introduced or deployed any new technologies in your agency in an attempt to reduce trespassers or suicides?
65. What technologies has your agency deployed?
66. Did a specific incident trigger this this deployment of the new technologies?
67. When did your agency deploy these new technologies?
68. Do you have baseline data prior to the implementation of the new technologies?
69. What is the estimated cost/expenditure for the deployment of those new technologies?
70. Have you evaluated your new technologies?
71. What was your evaluation result?

72. Can you identify if any of the trespasser or suicide prevention mitigation measures have led to any improvement in safety at your agency?
73. Can you attribute any improved safety success to any of the mitigation measures? (check all that apply)
74. What trends have occurred? Please send supporting data to abc@xxx.yyy
75. Please provide us with your successful experiences/stories and lessons learned.
76. Please provide us with any recommendations for a rail agency to effectively prevent or reduce trespassers and suicides.

Appendix E

AI Framework for Railroad Trespass Detection
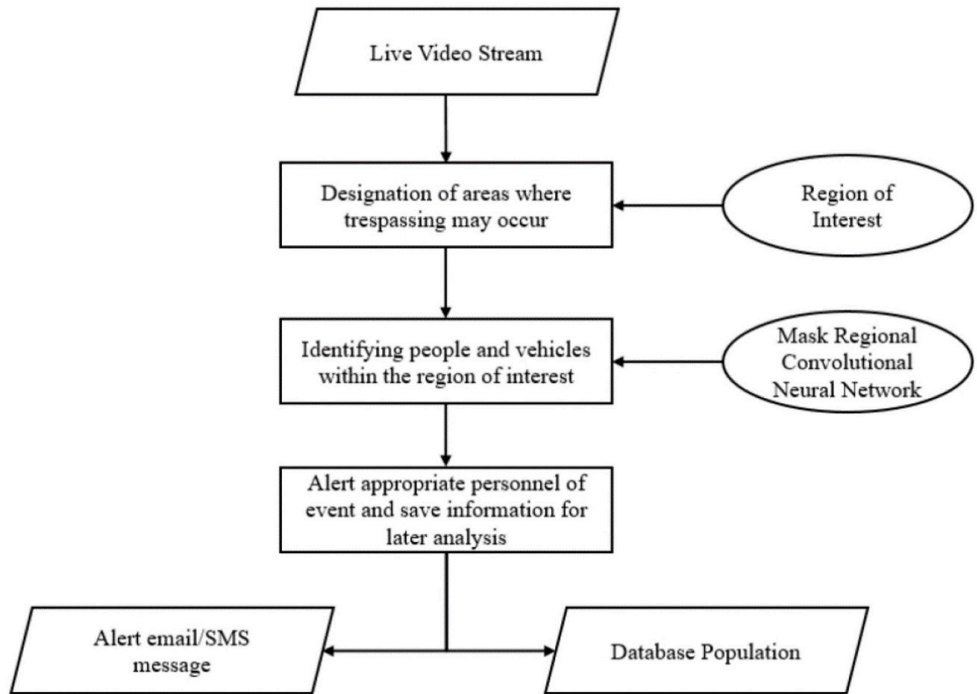
Source: Adopted from Zaman et al., 2019

Figure E-1 *General AI framework for detecting trespassing at railroads*

Acronyms and Abbreviations

AI	Artificial Intelligence
ATV	All-Terrain Vehicles
BART	Bay Area Rapid Transit
CAV	Connected and Automated Vehicles
CDC	Centers for Disease Control and Prevention
CFR	Code of Federal Regulations
CUTR	Center for Urban Transportation Research
CV	Connected Vehicle
DOT	Department of Transportation
EU	European Union
FAA	Federal Aviation Administration
FAST Act	Fixing America's Surface Transportation Act
FDOT	Florida Department of Transportation
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
IED	Improvised Explosive Devices
MAP–21	Moving Ahead for Progress in the 21st Century
MARTA	Metropolitan Atlanta Rapid Transit Authority
MBTA	Massachusetts Bay Transportation Authority
NTD	National Transit Database
NTSB	National Transportation Safety Board
PTC	Positive Train Control
ROW	Right-of-Way
RTA	Rail transit agencies
SDP	Standards Development Program
SEPTA	Southeastern Pennsylvania Transportation Authority
SMS	Safety Management Systems
SSO	State Safety Oversight
SSRR	Safety Standards Research Report
UAS	Unmanned Aircraft System
USDOT	United States Department of Transportation
USF	University of South Florida
WMATA	Washington Metropolitan Area Transit Authority

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