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# FTA Standards Development Program: Needs Assessment for Transit Rail Transmission-Based Train Control (TBTC)

**Nate Stoehr**
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**Transportation Technology Center, Inc.**
**A subsidiary of the Association of American Railroads**

U.S. Department of Transportation
Federal Transit Administration

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| 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)** | | |
| **°F** | Fahrenheit | 5 (F-32)/9 or (F-32)/1.8 | Celsius | °C |

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14. ABSTRACT
Based on NTSB safety recommendations issued to FTA regarding the implementation of transmission-based train control (TBTC), a rail transit industry needs assessment and research were performed to identify standards, systems and products that have the potential to provide risk reduction benefits from the industry. Through the research, which included National Transit Database (NTD) data analysis, a rail transit agency survey, and literature review, it was determined that TBTC can reduce risks for rail transit agencies and that the technology merits further investigation and research to determine the most appropriate application to mitigate specific hazards within operational environments.

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# Abstract

Based on NTSB safety recommendations issued to FTA regarding the implementation of transmission-based train control (TBTC), a rail transit industry needs assessment and research were performed to identify standards, systems and products that have the potential to provide risk reduction benefits from the industry. Through the research, which included National Transit Database (NTD) data analysis, a rail transit agency survey, and literature review, it was determined that TBTC can reduce risks for rail transit agencies and that the technology merits further investigation and research to determine the most appropriate application to mitigate specific hazards within operational environments.

This report was prepared for the Center for Urban Transportation Research (CUTR) by Transportation Technology Center, Inc. (TTCI), a subsidiary of the Association of American Railroads, Pueblo, Colorado. The report is based on investigations and tests conducted by TTCI with the direct participation of CUTR to criteria approved by them. The contents of this report imply no endorsements whatsoever by TTCI of products, services, or procedures, nor are they intended to suggest the applicability of the test results under circumstances other than those described in this report. TTCI is not a source of information with respect to these tests, nor is it a source of copies of this report. TTCI makes no representations or warranties, either expressed or implied, with respect to this report or its contents. TTCI assumes no liability to anyone for special, collateral, exemplary, indirect, incidental, consequential, or any other kind of damages resulting from the use or application of this report or its contents.

# Executive Summary

The Federal Transit Administration (FTA) entered into a cooperative agreement with the University of South Florida and its Center for Urban Transportation Research (CUTR) to develop a Safety Standards Research Report. The purpose of the report was to identify areas of transit safety risk within the industry, inventory existing transit safety standards (or those from other transportation industries that could be modified to address transit safety-related risks) and establish focus areas for further research to support FTA's Standards Development Program (SDP).

In support of these initiatives and in response to National Transportation Safety Board (NTSB) safety recommendations issued to FTA regarding the implementation of Transmission-Based Train Control (TBTC), CUTR and Transportation Technology Center, Inc. (TTCI) partnered to conduct a rail transit industry TBTC needs assessment. This report focuses on TTCI's research portion of the assessment.

In rail transit, TBTC is often referred to as Communications Based Train Control (CBTC); for commuter rail applications, it is referred to as Positive Train Control (PTC). TBTC consists of a series of wayside transceivers that continuously communicate via secure, radio- to-railcar TBTC equipment. Train and wayside control information is consolidated by wayside control equipment, fed through servers, and displayed at central control locations. Train speed and positional information is consolidated and compared against track equipment states, providing a safe zone of moving blocks surrounding each train. The system automatically brakes trains where necessary, ensuring proper train separation and collision avoidance. Legacy train control systems include various tiers of fixed-block, Automatic Train Control (ATC) and Automatic Block Signaling (ABS) systems, each possessing different levels of train control.

Researchers conducted an analysis of National Transit Database (NTD) reportable events to identify events in which operator error was a contributing factor. During the review, root causes of safety events were determined, to the extent possible, and events were assigned an operational risk class. Operational risk classes are defined based on similarities among events within each risk class. This analysis revealed that approximately 4% of transit rail reported events typically mitigated by TPTC were the result of operator (train or controller) errors.

NTD data analysis by TTCI indicated that approximately 400 FTA reportable events occurred during a nine-year period, from January 1, 2008, to May 31, 2017, that may have been mitigated with TBTC. The RTA survey results indicated that approximately 9,000 hazardous conditions (i.e., conditions that had the potential to result in a reportable event but did not necessarily result in an event) across the industry during a five-year period may have been mitigated using TBTC. To better understand the most appropriate risk reduction approach, a cost-benefit analysis may provide much-needed insight into the financial and operational impact of adopting TBTC across the industry.

NTD data are not entirely adequate to fully quantify the types and levels of risk in the rail transit industry. Root cause information is lacking for each event. Inclusion of such information would provide the rail transit industry with the ability to more easily determine incident and safety trends allowing the industry to identify potential risk areas for prompt mitigation.

A rail transit agency (RTA) survey was conducted to gather information regarding train control-related incidents that occurred at agencies but may not have been reported to the NTD due to NTD reporting thresholds. The survey was submitted by FTA through State Safety Oversite Agencies (SSOAs) to all FTA-regulated RTAs. In part, the survey requested that RTAs provide a count of train control-related incidents from the previous five years that were the direct result of operator error risk classes mitigatable by TBTC or similar technologies. Survey results were received from all 53 regulated transit agencies; upper-level survey results are shown in the Findings below.

The survey revealed information about existing train control methods and standards used by U.S. transit agencies. The research revealed industry standards (e.g., IEEE, AREMA, AAR) used in the development and implementation of transit agency train control signal systems. The various standards were then compared for similarities across the industry and evaluated to understand the practicality of standardizing train control technology. Research determined relevant international train control standards that may be applicable to the transit TBTC environment. The research also identified domestic and international advanced train control system products.

All the identified standards, systems, and products have the potential to provide risk reduction benefits to the rail transit industry. TBTC's potential as a risk reduction technology merits further investigation and research into the most appropriate use in the rail transit industry. Identification of solutions should consider specific mitigatable hazards and operational risk classes to scope the requirements for the various modes and RTA specific operating environments.

## Findings

- For non-exclusive right-of-way such as a shared lane with vehicular traffic, TBTC will not be able to stop a rail vehicle before it collides with a non-rail vehicle stopped in a shared lane.
- An analysis of NTD data suggests that 4% or fewer rail-related incidents reported to NTD were directly related to TBTC mitigatable risk classes.

- A survey of RTAs revealed that 9,348 (83%) of train control-related hazardous conditions that have occurred across the industry have the potential to be mitigated by TBTC.
- RTA survey results revealed that 73% of transit lines use ATC or ABS, approximately 8% use CTC, and approximately 19% of lines do not use any train control signal system.
- RTA survey results revealed that the most widely used train-control relevant standard is 49 CFR 236.1005 Requirements for Positive Train Control systems with 20 individual transit lines reported using this standard for development and implementation.
- Due to the limitations of the NTD noted, the data analysis highlights a need for more descriptive information to be captured as part of NTD incident reporting, such as the "Primary Cause Code" and "Secondary Cause Code" fields, with pre-defined and selectable values similar to those used for FRA Accident/Incident Reporting.
- There are numerous TBTC systems available on the domestic and international markets, the majority of which are designed to mitigate train-on-train collisions and overspeed operation of a train and to enforce stop train stops as appropriate.
- An in-depth cost-benefit analysis may be required to fully understand the financial and operational impact of TBTC on the rail transit industry. This analysis should include the potential positive impact of reducing overall operational risk (i.e., incidents avoided) as well as the potential financial and operational impact that the development, installation, and implementation of TBTC may have on each RTA.

# Section 1 Introduction

The Federal Transit Administration (FTA) entered into a cooperative agreement with the University of South Florida and its Center for Urban Transportation Research (CUTR) to develop a Safety Standards Research Report. The report identifies areas of transit safety risk within the industry, inventory existing transit safety standards (or those from other transportation industries that could be modified to address transit safety-related risks), and establish focus areas for further research to support FTA's Standards Development Program (SDP). Through the SDP, research and background studies are being performed on safety critical emphasis areas to support the identification, modification, or development of voluntary standards or recommended practices for the public transit industry. In addition, the program supports the CUTR research team to coordinate with the American Public Transportation Association (APTA), the transit industry's standard development organization, and provide the research and background information necessary to support APTA's standards process.

Since the early 1980s, concepts for Advanced Train Control Systems (ATCS), including various types of Communications Based Train Control (CBTC), which is the same as train-based train control (TBTC), have been researched, developed, and implemented in a variety of operational environments. CBTC concepts started to be realized in the transit industry in the early 2000s starting at NYCT. CBTC makes use of radio communications between train and wayside transceivers to ensure safe train separation. In addition, over the years, there have been numerous incidents in freight, passenger, commuter, and transit rail transportation that resulted from the failure of a train operator to properly adhere to operating rules, including movement authority and speed limits. In 2008, the U.S. Congress passed the Rail Safety Improvement Act of 2008 (RSIA 08), which mandated the implementation of PTC—a type of CBTC—on the majority of FRA-regulated freight, passenger, and commuter rail lines in the country. The National Transportation Safety Board (NTSB) has investigated numerous rail transit accidents in which failure of a train operator to adhere to speed or movement authority limits was a contributor to the accident.

Events such as the collision of a Chicago Transit Authority (CTA) train into the bumping post at the end of the track at O'Hare Station on March 24, 2018, led the NTSB to issue a safety recommendation to FTA regarding the implementation of TBTC, a term synonymous with CBTC. NTSB's recommendation to FTA (R-15-022, Supersedes Safety Recommendation R-09-008):

> Require[s] rail transit agencies to implement transmission-based train control systems that prevent train collisions.

To effectively respond to NTSB's recommendation, FTA asked the CUTR and TTCI research teams to assist in developing recommendations for the transit industry by starting development of standards and/or recommended practices relating to the implementation of TBTC.

TBTC is a railway train control signal system that uses data communication between a train, wayside devices, and the railway back office to manage train movement. CBTC is able to continually monitor a train's location on the rail network with a higher degree of accuracy than more traditional signaling systems such as Automatic Block Singling (ABS). Additionally, movement authority information (commonly referred to as Mandatory Directives) is transmitted to the train. If a situation occurs in which the train is being operated in a manner that threatens to exceed one of these mandatory directives (i.e., train traveling at excessive speed or predicted to pass a point on a track that it is not authorized to proceed beyond), the train is automatically brought to a stop.

Systems such as TBTC are complex and require significant financial and operational investment to implement on existing rail lines, combined with the future maintenance expenses. For example, implementation of PTC is expected to cost the traditional freight railroad industry in excess of $10 billion. Further, conversion away from fixed block systems toward CBTC are starting to occur at agencies such as Bay Area Rapid Transit (BART)[1] with a projected cost estimate of $798 million.

Before pursuing standardization and implementation of such a system, it is prudent to assess the needs of the technology and to find an optimal balance between safety enhancement and cost-effectiveness. The initial phase of this project focused on a needs assessment and a review of existing advanced train control systems and standards to develop recommendations for a path forward.

[1] https://www.bart.gov/about/projects/corecapacity.

Section 2

# Incident Data Analysis – National Transit Database

TTCI was tasked with reviewing incidents reported in the National Transit Database (NTD) to identify incidents in which operator error was a contributing factor and to organize those incidents into Operational Risk Classes. However, NTD data are not entirely adequate to fully quantify the types, and levels of risk in the rail transit industry. Root cause information for each incident is lacking.

For this analysis, operator error is defined as the failure of a rail transit employee to perform an assigned task in a manner that is consistent with applicable operating and safety rules that results in a negative, unintended consequence.

It is important to note that "operator error" may not be the direct result of an error on the part of the rail vehicle operator; rather, the term may indicate an error on the part of other transit agency employees such as dispatchers, brakemen, conductors, yard utility workers, or track maintenance personnel.

Operational risk classes were defined based on similarities between incidents within each risk class.

TTCI reviewed the incident descriptions contained in the data from the NTD to define the Operational Risk Classes to be used in the analysis. A complete list of all Operational Risk Classes is provided in Appendix A.

Table 2-1 lists the operational risk classes determined to be potentially mitigated by TBTC technology.

TTCI reviewed approximately nine years of NTD data provided by FTA through CUTR for incidents occurring from January 1, 2008, through May 31, 2017. The data set contains 58,884 individual entries for "Major Events" across all modes of operation within the transit industry. TTCI's analysis began with applying a simple filter to return only rail-related incidents. This filter returned a total of 11,196 rail-related incidents, which includes all NTD reported mass transit and commuter rail events.

The most useful field for determining the apparent root cause of an incident is "Incident Description." This field is free-form text, which allows the user to enter a long form narrative of the incident.

TTCI data analysts performed a "word cloud" search using various keywords running against the "Incident Description" field. Initial results appeared promising, as the search narrowed the total number of incidents significantly to

334. The team then manually reviewed the "Incident Description" for each of the returned incidents and found that only 28 were related to the risk classes listed in Table 2-1.

**Table 2-1** *Operational Risk Classes Potentially Mitigated by TBTC Technology*

| Operational Risk Class | Definition |
|---|---|
| Control System Failure | A failure of the train control system to properly maintain safe operations of trains. Examples include, but are not limited to:<br>• Computer-aided Dispatch (CAD) system failure<br>• Crossing protection controller failure<br>• Onboard train control failure |
| Derailment – At Switch | Mainline derailment of rail transit vehicle at or in the immediate vicinity of a switch, frog, diamond, or crossover |
| Derailment – Overspeed | Mainline derailment caused by train traveling at speed in excess of posted civil speed or temporary speed restriction |
| Movement Authority Violation | Failure on the part of a rail transit vehicle operator to properly adhere to movement authority limits. This may include failure to stop prior to exceeding movement authority limits. Examples include, but are not limited to:<br>• Unauthorized entry into established work limits providing on-track protection for track workers<br>• Moving past authorized movement authority limits without dispatcher permission or prior to receiving new movement authority limits |
| Operator – Failure to Control Vehicle | Failure on the part of the rail transit vehicle operator to properly control their vehicle. This includes incidents that appear to be caused by a lack of situational awareness on the part of the operator. Examples include, but are not limited to:<br>Failure to apply brakes soon enough to come to safe stop<br>• Failure to yield right-of-way to pedestrians and/or highway motor vehicles<br>• Failure to stop and inspect switch points before traveling through switch<br>• "Powering" through a switch |
| Stop Signal Violation | Failure on the part of a rail transit vehicle operator to bring vehicle to a safe stop before passing a stop signal; this may also include failing to stop at posted "Stop Signs" in operational modes that require adherence to motor vehicle street signs |
| Switch Alignment/Defect | Incident occurring as the direct result of a switch either being misaligned (i.e., not thrown to the proper position) or a defective switch; this includes incidents of "split switch" |

"Event Type Desc" was determined to be a secondary field of value in the filtering process. In an effort to further limit the total number of incidents requiring manual review, TTCI removed "Event Type Desc" entries such as Aggravated Assault, Arson, Bomb Threat, Robbery, Suicide, and Tornado. "Event Type Desc" entries such as "Derailment," "Mainline Derailment," "Other," and "Rail Collision" remained, returning a total of 5,728 incidents potentially mitigated by TBTC. At this point in the filtering process, the location of the incident was not a consideration (i.e., mainline and/or revenue service vs. yard/terminal/shop facility and/or non-revenue service).

A preliminary review of incident descriptions of the output data quickly revealed that many of the incidents were the result of human error on the part of the general public (e.g., passengers, pedestrians, trespassers, private motor vehicle operators) and not directly the result of any rail transit vehicle operator error. Of the 5,728 incidents, 20 resulted in a train-on-train collision, 17 potentially were the direct result of operator error on the part of one or both of the transit vehicle operators involved in the train-on-train collision, and 6 occurred in a yard or non-revenue service as noted in the incident description.

A second round of data filtering was conducted and focused on filtering various fields within the data set to more accurately return incidents potentially mitigatable by TBTC. A simple example was to filter on the following: 3 Mode = Rail, Event Type Desc = Rail Collision. This filter returned a total of 4,549 incidents.

A preliminary review of the incident descriptions once again revealed that many (4,307, nearly 95%) of the incidents labeled "rail collision" were the fault of the general public; potential rail transit vehicle operator error accounted for only 242 (approximately 5%) of the reported incidents.

Considerable effort was put into assigning an Operational Risk Class to all rail-related incidents. To do this, TTCI first filtered the data into logical groupings using additional fields. First level filtering began with using "Event Type Desc" as the primary field for grouping. Examples include the following:

- Filter to determine suicide events:
  - 3 Mode = Rail
  - Event Type Desc = Suicide
  - Total Incidents = 1,032
  - Operational Risk Class Assigned = Pedestrian/Trespasser
- Filter to determine passenger-on-passenger violence events:
  - 3 Mode = Rail
  - Event Type Desc = Aggravated Assault, Assault, Burglary, Homicide, Larceny/Theft, Rape, Robbery
  - Total Incidents = 3,950
  - Operational Risk Class Assigned = Assault/Robbery

Although this filtering/logical grouping proved beneficial, it was minimally effective using only the additional "Event Type Desc" field. The "Collision with" field was used as a secondary filter, which proved to be helpful but not entirely effective in filtering incidents that could be assigned the same operational risk class. For example:

- Filter to determine collisions resulting from highway motor vehicle operator fault:
  - 3 Mode = Rail
  - Event Type Desc = “Derailment,” “Main Line Derailment,” “Rail Collision”
  - Collision With = “Motor Vehicle,” “Motor Vehicle, Motor Vehicle,” “Non-Transit Motor Vehicle (POV)”
  - Total Incidents = 2,359
  - Operational Risk Class Assigned = Employee Struck by Train, Highway Vehicle (POV) at Fault, Operator – Failure to Control Vehicle, Obstruction in/on Track, Stop Signal Violation, Unknown

As can be seen in the results above, a review of the incident descriptions revealed that not all were a result of error on the part of a highway vehicle operator. Many of the incident descriptions either explicitly stated a root cause or contained enough detail to infer the most likely root cause. In these cases, the incident was assigned the most appropriate Operational Risk Class as defined in Appendix A. Incident descriptions that lacked enough detail for a determination to be made were assigned an operational risk class of “Unknown.” Table 2-2 shows the total number of occurrences and percentage of the total data sample for each operational risk class. The number of incidents in each Operational Risk Class that may be directly related to operator errors that TBTC or similar technology are typically designed to mitigate are shown in Table 2-3.

**Table 2-2** *Operational Risk Class Totals*

| Operational Risk Class | Number of Occurrences | Percentage of Total (%) |
|---|---|---|
| Assault/Robbery | 3,967 | 35.43 |
| Collision in Yard | 17 | 0.15 |
| Control System Failure | 4 | 0.04 |
| Derailment – At Switch | 49 | 0.44 |
| Derailment – On Track Equipment | 55 | 0.49 |
| Derailment – Overspeed | 3 | 0.03 |
| Derailment – Unknown | 85 | 0.76 |
| Derailment – Yard | 134 | 1.20 |
| Employee Struck by Train | 22 | 0.20 |
| Employee Trip/Fall | 2 | 0.02 |
| Fire | 181 | 1.62 |
| Highway Vehicle (POV) at Fault | 2,163 | 19.32 |
| Movement Authority Violation | 6 | 0.05 |
| N/A – TBTC | 684 | 6.11 |
| Obstruction in/on Track | 88 | 0.79 |

**Table 2-2 (cont.)** *Operational Risk Class Totals*

| Operational Risk Class | Number of Occurrences | Percentage of Total (%) |
|---|---|---|
| Operator – Failure to Control Vehicle | 210 | 1.88 |
| Operator – Failure to Control Vehicle – On-Track Equipment | 3 | 0.03 |
| Passenger at Station/Platform | 408 | 3.64 |
| Passenger on Train | 20 | 0.18 |
| Pedestrian/Trespasser | 2,472 | 22.08 |
| Standing Vehicle Improperly Secured | 12 | 0.11 |
| Stop Signal Violation | 27 | 0.2 |
| Switch Alignment/Defect | 127 | 1.13 |
| Track or Structure Failure | 52 | 0.46 |
| Transit Vehicle – Standing in the Foul | 6 | 0.05 |
| Transit Vehicle Mech/Elec Failure | 117 | 1.05 |
| Unknown | 237 | 2.12 |
| Weather/Natural Disaster | 45 | 0.40 |
| TOTAL | 11,196 | 100.00 |

**Table 2-3** *Operational Risk Classes – Potentially Mitigated by TBTC*

| Operational Risk Class | Number of Occurrences |
|---|---|
| Control System Failure | 4 |
| Derailment – At Switch | 49 |
| Derailment – Overspeed | 3 |
| Employee Struck by Train | 22 |
| Movement Authority Violation | 6 |
| Operator – Failure to Control Vehicle | 210 |
| Stop Signal Violation | 27 |
| Switch Alignment/Defect | 127 |
| TOTAL | 448 |

Of the 11,196 rail incidents reported to the NTD, only 448 (approximately 4%) were potentially mitigatable through the use of TBTC technology. This total represents a "best-case scenario," as it assumes that all incidents have the potential to be mitigated with TBTC. Additionally, Table 2-3 represents a count of all rail incidents across the transit industry regardless of the location or type of service (revenue or non-revenue) in which the incident occurred.

It is important to note that of the Operational Risk Classes identified as having the potential to be mitigated by TBTC, not all are likely to be eliminated. To better understand the overall impact that TBTC may have across the transit industry, the Operational Risk Classes were broken down further into two separate groups: classes typically designed to be eliminated by TBTC systems and classes potentially reduced by a TBTC system.

## Operational Risk Classes Typically Designed to be Mitigated by TBTC

TBTC, in all its forms, has limitations; however, there are certain types of incidents that are currently commercially available TBTC systems and specifically designed to address during normal line-of-road operations. Those Operational Risk Classes, as defined during the NTD data review, include:

- Derailment – Overspeed
- Movement Authority Violation
- Stop Signal Violation

Together, these risk classes account for 36 incidents occurring across the rail transit industry. More importantly, this set of risk classes addresses the operator errors most likely to contribute to the occurrence of a train-on-train collision:

- Movement Authority Violation
- Stop Signal Violation

NTD data revealed that 20 train-on-train collisions occurred between January 1, 2008, and May 31, 2017. Of those, 9 occurred in non-revenue service (i.e., in a yard, shop, or service facility). Of the 11 remaining incidents, 8 were the direct result of the rail transit vehicle operator failing to properly maintain control of their vehicle; the 3 remaining incidents were related to switch alignment and/or defects.

## Additional Operational Risk Classes Potentially Reduced by TBTC

Of the risk classes that have the potential to be mitigated by TBTC, a review of the NTD data showed that, due to the nature of the incidents, the following Operational Risk Classes have the potential to be reduced with the implementation of TBTC:

- Derailment – At Switch
- Employee Struck by Train
- Operator – Failure to Control Vehicle
- Switch Alignment/Defect

To better understand why these risk classes may be reduced, it is important to first understand how these risk classes are defined and assigned.

“Derailment – At Switch” is defined as a mainline derailment of rail transit vehicle at or in the immediate vicinity of a switch, frog, diamond, or crossover. During the review of NTD incidents, TTCI determined that 49 incidents occurred in which a derailment took place at or near a switch. In all 49 cases, the incident descriptions lacked the detail required to determine a specific root cause. Examples include:

- “Front wheels derailed after proceeding through switch 17.”
- “Streetcar lead truck, second axle derailed during diverging move thru switch.”
- “Operator stated that the front wheels went through the switch but that the rear wheels went off the tracks for unknown reasons.”

Due to the lack of sufficient detail regarding the root cause of the incidents, it is difficult to determine the degree to which TBTC may mitigate derailments occurring at or near a switch. It can be assumed that some portion of the incidents may be mitigated by TBTC as a result of switch position monitoring inherent in many systems that could be referred to as TBTC.

“Employee Struck by Train” is defined as an incident involving a rail transit employee coming into contact with an operating train during the performance of their duties. During the review of NTD incidents, TTCI determined that 22 incidents occurred when rail transit employees were struck by a train while performing their duties. Incident descriptions varied in their detail; therefore, it was not entirely clear in every incident if the employee was struck because of rail vehicle operator error or an error on the part of the struck employee. For incidents when an employee was struck by a train because of a rail transit vehicle operator failing to stop their vehicle prior to entering a work zone, TBTC may likely mitigate such incidents; however, for incidents when employees were outside of work limits or had positioned themselves in the foul of live/unprotected track, TBTC would not have been able to mitigate the risk.

“Operator – Failure to Control Vehicle” is defined as the failure on the part of the rail transit vehicle operator to properly control their vehicle. This includes incidents that appear to be caused by a lack of situational awareness on the part of the operator. During the review of NTD incidents, TTCI determined that 210 occurred as a direct result of a rail vehicle operator failing to properly control their vehicle.

TBTC systems are designed to avoid potential collision incidents by first alerting the operator of a stop target or speed restriction ahead. If the operator fails to take the appropriate action to the alert, the rail vehicle onboard TBTC system orders a penalty brake rate to stop prior to the final stop location. In exclusive right-of-way operations, TBTC has great potential to reduce the occurrences of incidents as a result of a rail vehicle operator failing to obey posted speed, restrictions, light signals, or other external indications.

In the case of non-exclusive right-of-way, rail vehicles share operating space with other non-rail vehicular traffic such as a shared lane of traffic on a public roadway. In these situations, TBTC is not likely to mitigate potential collisions with personally operated vehicles or other obstructions because existing TBCS systems generally are not capable of determining the existence of outside obstacles. Proper handling of the rail vehicle by the operator is still required to avoid a collision.

"Switch Alignment/Defect" is defined as an incident occurring as the direct result of a switch either being misaligned (i.e., not thrown to the proper position) or a defective switch. This includes incidents of "split switch." This incident class is similar in many ways to "Derailment – At Switch;" however, these incidents include additional detail that suggest that incidents were caused by either the switch being misaligned or because of switch malfunction. This includes incidents of "split switch" as noted in the definition. Although it is a fairly broad statement, TTCI assumes that a switch that is properly maintained, properly aligned, and locked for movement will allow for the safe travel of a rail vehicle through that switch—even if that rail vehicle has a wheel profile approaching wear limits for flange height and flange width (often considered a cause for "split switch" incidents).

All incidents in this class were a result of either an identified split switch malfunction (switch thrown while vehicle wheel sets were on either side of the switch) or the result of the switch not being aligned properly for the intended route of the rail transit vehicle. These incidents do not include occurrences where a rail transit vehicle operator failed to stop and inspect switch alignment in accordance with operating rules of dispatcher/control operator instructions (such incidents fall under the operational risk class of "Operator – Failure to Control Vehicle."

Assuming that reportable incidents are fully eliminated to the maximum extent by TBTC, transit agencies can expect a maximum of a 4% reduction in the occurrence of reportable incidents as a result of the use of TBTC systems.

Section 3

# Incident Data Analysis – Transit Agency Surveys

TTCI, in cooperation with FTA, conducted a survey of U.S. transit agencies to determine the total number of train control-related incidents that have occurred during the previous five years. The survey was submitted by FTA to all State Safety Oversite Agencies (SSOAs) requesting that information be gathered from each Rail Transit Agency (RTA) under their jurisdiction. Researchers received responses from 53 agencies.

The intent of this survey was to capture, to the maximum extent possible, a count of train control-related incidents that may not have been otherwise reported to the NTD due to not meeting reporting thresholds set by FTA. For reference, NTD reporting thresholds for rail modes can be found in Table 3 1.

**Table 3-1** *2018 NTD Rail Modes Reporting Thresholds*[2]

| Category | Reporting Threshold |
|---|---|
| Fatalities | Fatalities:<br>• Confirmed within 30 days<br>• Including suicides |
| Injuries (non- serious) | Require immediate transport away from the scene for medical attention (1 or more persons) |
| Serious Injuries | Whether or not the person is transported away from the scene for medical attention (1 or more persons), but that:<br>• Require hospitalization for more than 48 hours, commencing within 7 days from the date of the event<br>• Result in a fracture of any bone (except simple fractures of fingers, toes, or nose)<br>• Cause severe hemorrhages, nerve, muscle, or tendon damage<br>• Involve an internal organ<br>• Involve second- or third-degree burns, or any burns affecting more than five percent of the body surface |
| Substantial Damage | Damage to any involved vehicles, facilities, equipment, rolling stock, or infrastructure that disrupts the operations of the rail transit agency and adversely affects the structural strength, performance, or operating characteristics of the vehicle, facility, equipment, rolling stock, or infrastructure, requiring towing, rescue, on-site maintenance, or immediate removal prior to safe operation |
| Collisions | Collisions that:<br>• Meet an injury, fatality, substantial damage, or evacuation threshold<br>• Include suicides or attempted suicides that involve contact with a transit vehicle<br>• Occur at a rail grade crossing<br>• Involve an individual in the right-of-way<br>• Involve a rail transit vehicle and a second rail transit vehicle |

[2] National Transit Database (2018), Safety & Security Reporting Manual, https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/ntd/69096/2018-safety-and-security-policy-manual.pdf

**Table 3-1 (cont.)** *2018 NTD Rail Modes Reporting Thresholds*

| Category | Reporting Threshold |
|---|---|
| Evacuations | Evacuations include:<br>• Evacuation of a transit facility or vehicle for life-safety reasons<br>• Evacuations to controlled rail right-of-way (excludes evacuation to a platform, except for life safety)<br>• Both transit-directed evacuations and self-evacuations that meet either of the above two criteria |
| Derailments | Both mainline and yard derailments and non-revenue vehicle derailments |
| Runaway Train | Events involving a runaway train with or without the operator on board, including movement of a rail transit vehicle on the mainline, yard, or shop that is uncommanded, uncontrolled, or unmanned due to an incapacitated, sleeping, or absent operator, or the failure of a rail transit vehicle's electrical, mechanical, or software system or subsystem |

However, the survey did not specifically request a count of train control-related incidents that were not reported to the NTD, nor did the survey specifically request only those train control-related incidents that occurred in revenue service. The questions were asked in such a way as to identify the type of train control-related incident (e.g., train-on-train collision, near-miss) and total train incidents as a function of a "root-cause" or Operational Risk Class potentially mitigatable by TBTC. Appendix C includes a copy of the survey Form 3 submitted to the RTAs.

Upon receipt of the completed surveys, data analysists compiled all Form 3 survey results into a single spreadsheet, which allowed for easier data analysis. Table 3-2 shows the reported counts of train control-related incidents sorted by root cause.

**Table 3-2** *Summary – RTA Incident Survey Results*

| Root Cause | Train-on-Train Collisions | Near-Miss Train Control-Related Incidents | Total Train Control-Related Incidents |
|---|---|---|---|
| Movement authority/stop violation | 8 | 29 | 7,249 |
| Overspeed | 1 | 114 | 1,101 |
| Control operator/dispatcher error | 15 | 5 | 892 |
| Switch misalignment/failure | 1 | 0 | 106 |
| Other | 8 | 1 | 1,955 |
| Total | 33 | 149 | 11,303 |

The above root causes directly related to one or more of the defined operational risk classes shown in Appendix A. For example:

**Table 3-3** *RTA Survey Root Causes and Operation Risk Class Correlation*

| Survey Root Cause | Operational Risk Class |
|---|---|
| Movement authority/stop violation | • Movement Authority Violation<br>• Stop Signal Violation |
| Overspeed | • Derailment – Overspeed<br>• Operator – Failure to Control Vehicle |
| Control operator/dispatcher error* | • Operator – Failure to Control Vehicle |
| Switch misalignment/failure | • Switch Alignment/Defect |
| Other | • Unknown |

*Note: "Control Operator/Dispatcher Error" was originally intended to identify those incidents that were the direct result of an error on the part of dispatch personnel; it was not intended to identify incidents that were the direct result of error on the part the rail vehicle operator. After the survey results were returned, researchers realized that the use of the term "Operator" may have been interpreted to mean rail vehicle operator. Although not the intent, the resulting information is still relevant and both types of human error (i.e., vehicle operator or dispatcher) are potentially mitigated by TBTC.

## RTA Survey Results: Train-on-Train Collisions

A total of 33 train-on-train collisions were reported across the RTAs during a five-year period. Of the reported train-on-train collision incidents, approximately 72% (24) were the direct result of human error potentially mitigatable by the use of TBTC. The other incidents fall into Operational Risk Classes that may be mitigatable by the use of TBTC depending on the specifics of the incident. Table 3-4 and Figure 3-1 show a breakdown of the train-on-train incident counts by root cause/operational risk class.

**Table 3-4** *RTA Survey Results: Train-on-Train Collisions*

| Operational Risk Class | Sum of Train-on-Train Collisions | Percentage of Train-on-Train Collisions (%) |
|---|---|---|
| Control Operator/Dispatcher Error | 15 | 46 |
| Movement Authority/Stop Violation | 8 | 24 |
| Other | 8 | 24 |
| Overspeed | 1 | 3 |
| Switch Misalignment/Failure | 1 | 3 |
| Total | 33 | 100 |

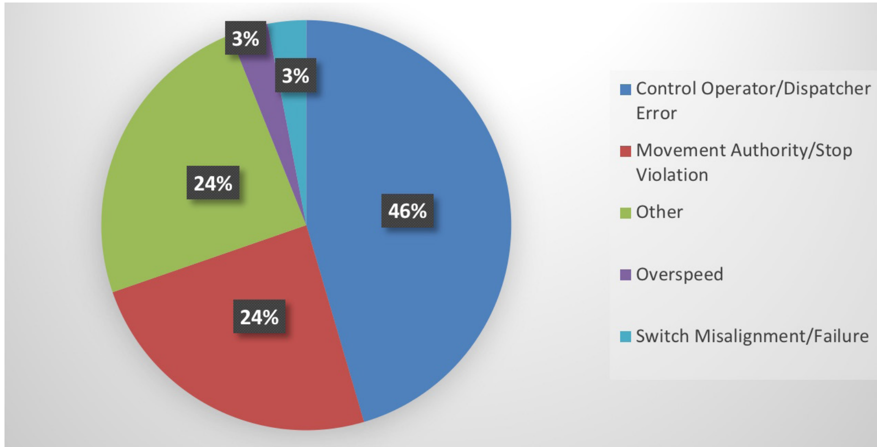


**Figure 3-1** *RTA survey results: Train-on-train collisions*

## RTA Survey Results: Near-Miss Train-on-Train Incidents

For the RTA survey, a "near-miss train control-related Incident" is defined as "a narrowly avoided collision." Although a collision was avoided, the train control-related incident still represents an otherwise unfavorable outcome as a result of some form of human error. These train control-related incidents are important for two reasons:

- Although a collision was avoided, the level of risk to both the RTA and the general public (i.e., passengers) was high. However, the train control-related incident may not meet the FTA threshold for reporting and therefore is not represented in the NTD data.
- Many "near-miss" situations are the result of human error. Depending upon the type of human error, the near-miss situation may be mitigated through the implementation of TBTC, thus reducing the overall risk to the RTA.

A total of 149 near-miss train control-related incidents were reported across the RTAs during a five-year period. Of the reported near-miss train-on-train incidents, approximately 77% (114) were the direct result of an overspeed violation on the part of the rail transit vehicle operator. Further, nearly all near-miss train-on-train incidents (148 of 149) were the result of Operational Risk Classes that TBTC is specifically designed to mitigate during line-of-road operations (the only exception being one classified as "Other," which may also be mitigatable by the use of TBTC depending on the details). Table 3-5 and Figure 3-2 show a breakdown of the near-miss train-on-train incident counts by root-cause/operational risk class.

**Table 3-5** *RTA Survey Results: Near-Miss Train-on-Train Incidents*

| Operational Risk Class | Sum of Near-Miss Train Control-Related Incidents | Percentage of Near-Miss Train Control-Related Incidents (%) |
|---|---|---|
| Control Operator/Dispatcher Error | 5 | 3 |
| Movement Authority/Stop Violation | 29 | 19 |
| Other | 1 | 1 |
| Overspeed | 114 | 77 |
| Switch Misalignment/Failure | 0 | 0 |
| Grand Total | 149 | 100 |

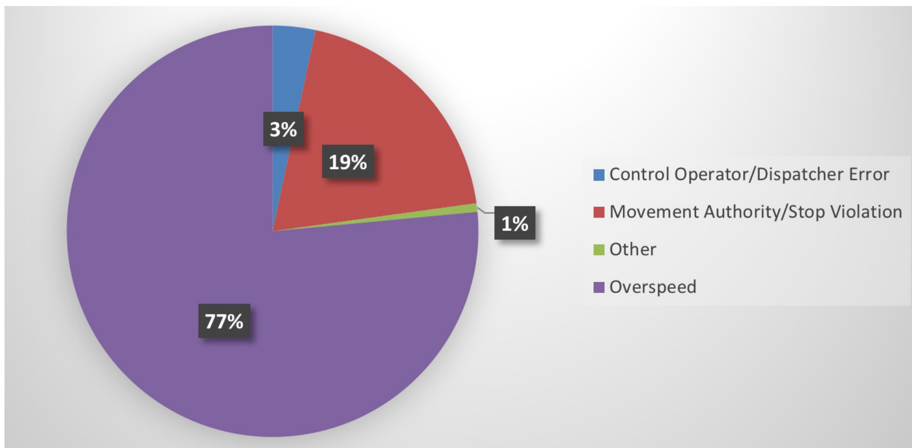


**Figure 3-2** *RTA survey results: Near-miss train control-related incidents*

## RTA Survey Results: Train Control-Related Incidents

For the RTA survey, a "Train Control-Related Incident" is defined as "an event that indicates an operating rule or safe vehicle handling practice is inadequate. It may also be the failure of an individual to adhere to established operating rules and safe vehicle handling practices." The intent of this question was to quantify the occurrences of train control-related incidents that a transit agency tracks internally irrespective of the need for reporting of that incident to the NTD. It is assumed that each transit agency tracks "unusual occurrences" that in some way affect operations and that these occurrences, or train control-related incidents, inform rulemaking and changes to operating practices.

A total of 11,303 train control-related incidents were reported across the RTAs during a five-year period. Of the reported train control-related incidents, approximately 64% (7,249) were the direct result of movement authority/stop violations on the part of the rail transit vehicle operator. Further, approximately 83% (9,348) were the result of Operational Risk Classes that TBTC is conceived to mitigate during line-of-road operations. Table 3-6 and Figure 3-3 show a breakdown of the train control-related incident counts by root cause/ operational risk class.

**Table 3-6** *RTA Survey Results: Train Control-Related Incidents*

| Row Labels | Sum of Train Control-Related Incidents | Percent of Train Control-Related Incidents (%) |
|---|---|---|
| Control Operator/Dispatcher Error | 892 | 8 |
| Movement Authority/Stop Violation | 7,249 | 64 |
| Other | 1,955 | 17 |
| Overspeed | 1,101 | 10 |
| Switch Misalignment/Failure | 106 | 1 |
| Total | 11,303 | 100 |

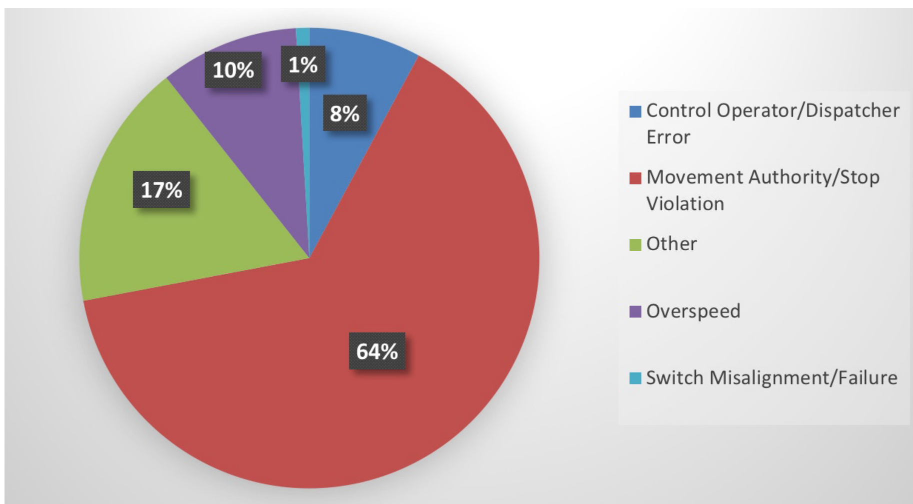


**Figure 3-3** *RTA survey results: All train control-related incidents*

Although NTD data include all reportable incidents that have occurred during a nine-year period, the majority fall into Operational Risk Classes that are not mitigatable by TBTC; the RTA survey data focused on train control-related hazardous conditions. As such, it is not appropriate to reach a conclusion as to what extent TBTC will reduce total hazardous conditions, but it is possible to estimate the extent to which TBTC may potentially mitigate train control-related hazardous conditions. The survey data indicate that there have been approximately 10,000 train control-related hazardous events over the past five years that were potentially mitigatable by TBTC.

# Section 4 Current Transit Train Control Methods

TTCI conducted a survey to determine the train control methods currently in use by transit agencies in the U.S. With input from several transit agency safety officers, researchers developed a draft survey requesting such information as:

- Agency name
- Rail modes of operation
- Current train control methods in use per rail mode of operation
- Specifications/standards used in the design and implementation of each train control system
- Information on whether an agency requires interoperable train control with another transit agency or freight railroad

The draft survey was reviewed by FTA, and it was determined that the questions and content requested by TTCI were in line with a questionnaire FTA was developing for submission to the RTAs. FTA requested that TTCI develop a joint survey that would suit the needs of the research being conducted by both organizations. As a result, TTCI and FTA worked together to develop an FTA/TTCI survey to gather the information required regarding train control signal systems and train control related incidents (see Appendix D). Appendix B shows a copy of survey Form 2 submitted to the RTAs. Questions 3 through 5 were specifically added at TTCI's request to gather information regarding train control methods and systems currently used across the various agencies.

RTAs were asked to submit a separate Form 2 for each type of train control signal system utilized by the RTA. TTCI received responses from 53 individual transit agencies that provided 85 Form 2 submissions, accounting for approximately 202 individual lines. Table 4-1 shows a breakdown of the train control signal systems in use on a per line basis as reported by the RTAs. Table 4-2 shows train control signal systems in use, on a per line basis, as a function of Rail Mode.

**Table 4-1** *Count of Rail Transit Lines per Train Control Signal System*

| Train Control Signal System | Total Lines |
|---|---|
| Automatic Block Signaling (ABS) | 68 |
| Automatic Train Control (ATC) | 79 |
| Centralized Traffic Control (CTC) | 16 |
| None | 39 |
| Total | 202 |

**Table 4-2** *Transit Train Control Signal Systems*

| Rail Mode | Automatic Block Signaling (ABS) | Automatic Train Control (ATC) | Centralized Traffic Control (CTC) | None |
|---|---|---|---|---|
| Heavy rail | 25 | 38 | 5 | 0 |
| Light rail | 43 | 37 | 10 | 18 |
| Monorail/people mover | 0 | 4 | 0 | 0 |
| Other | 0 | 0 | 1 | 3 |
| Streetcar/trolley | 0 | 0 | 0 | 18 |
| Total | 68 | 79 | 16 | 39 |

Tables 4-1 and 4-2 clearly show that ATC is the primary train control signal system in use by U.S. transit agencies, especially in heavy and light rail modes. It is important to note that there are various ATC system providers and several tiers of performance capabilities within the ATC category. Additionally, ABS is the second most widely used train control system and, according to survey results, is used exclusively in heavy and light rail operations.

For cases in which ATC was identified as the train control signal system for a line (or group of lines), the RTA was asked to indicate the type of ATC operation. Table 4-3 shows a breakdown of the ATC operation types across the transit industry as reported by the RTAs.

**Table 4-3** *RTA ATC Operation Types*

| | CBTC | Full Automatic Train Operations | Manual Operations | Partial Automatic Train Operations |
|---|---|---|---|---|
| Automatic Train Control (ATC) | 8 | 27 | 28 | 16 |

It is difficult to determine similarities across transit agencies with respect to train control signal systems, as is it common for transit agencies to use multiple forms of train control across their networks. This means that a single agency may have very different control methods from one rail line to the next. It may be more appropriate for the rail transit industry to develop multiple standards for train control systems or to adopt existing standards such as those established for freight and passenger rail operations.

To that end, the survey also requested that RTAs provide information regarding relevant train control standards (e.g., IEEE 1474, AAR MSRP Sec. K) used in the development and implementation of the train control signal system(s) across their agency. Responses to this question were limited but illustrate some apparent commonalities.

As noted, RTAs responded with an individual Survey Form 2 for each line or group of lines that share a common train control signal system. The survey requested that the RTA select all applicable standards used for the development and implementation of the signal control system used on the lines represented on the form; as such, some RTAs made multiple selections. Table 4-4 shows that RTAs are currently adhering to established FRA standards in the development of their train control signal systems.

**Table 4-4** *Train Control Standards Utilized by RTAs*

| Train Control Signal System | IEEE 1473 | IEEE 1474.1 | IEEE 1474.2 | AAR MSRP Sec. K | 49 CFR. 236.1005 | EN 50126 | EN 50128 | EN 50129 | IEC 61508 | Other |
|---|---|---|---|---|---|---|---|---|---|---|
| Automatic Block Signaling (ABS) | 1 | 1 | 1 | 2 | 9 | | | | | 11 |
| Automatic Train Control (ATC) | 2 | 3 | 2 | 3 | 7 | 3 | 3 | 3 | 3 | 8 |
| Centralized Traffic Control (CTC) | 1 | | | | 2 | | | | | 3 |
| No Selection Made | | | | | | | | | | |
| None | | | | | 1 | | | | | 1 |
| Other | | | | | 1 | | | | | 1 |
| Total: | 4 | 4 | 3 | 5 | 20 | 3 | 3 | 3 | 3 | 24 |

A selection of “Other” prompted the RTAs to include a description of what standards were used, assuming that it was not already listed for selection. Additional standards that were noted include:

- IEEE 730m, IEEE Standard for Software Quality Assurance Processes
- IEEE 828, IEEE Standard for Configuration Management in Systems and Software Engineering
- IEEE 1474.4, IEEE Recommended Practice for Functional Testing of Communications-Based Train Control (CBTS) System
- MIL-STD-882E, Department of Defense Standard Practice System Safety
- AREMA *Communications and Signals Manual*

Many of the additional identified standards are related to the systems engineering process undertaken in the development of the various aspects of the train control signal system. These standards should be investigated further as part of the systems engineering process to determine those that most closely align with the needs of the transit industry and adopted as appropriate.

# Section 5 Applicable Train Control Standards and Products/Systems

Standards from several sources were identified as potentially applicable to TBTC. Upon further review, TTCI narrowed the search to the list of standards shown in Table 5-1. These standards come from a variety of sources, some of which are railroad-specific, and many explicitly address the various components of TBTC. Those that do not are more general standards that address system aspects such as system reliability, availability, maintainability, and safety. The intent is not to provide a comprehensive list of all standards that may be applicable to TBTC but to provide an indication of some of the more prevalent standards and an indication of the types of standards that could be adopted when considering TBTC technology.

**Table 5-1** *Applicable Train Control Standards*

| Source | Standard/Reference | Standard Description |
|---|---|---|
| Institute of Electrical and Electronics Engineers | IEEE 1473-2010 | IEEE standard for communications protocol aboard passenger trains |
| | IEEE 1474.1-2004 | IEEE standard for Communications-Based Train Control (CBTC) performance and functional requirements |
| | IEEE 1474.2-2003 | IEEE standard for user interface requirements in Communications-Based Train Control (CBTC) systems |
| | IEEE 1474.3-2008 | IEEE recommended practice for Communications-Based Train Control (CBTC) system design and functional allocations |
| | IEEE 1474.4-2011 | IEEE recommended practice for functional testing of a Communications-Based Train Control (CBTC) system |
| | IEEE 1475-2012 | IEEE standard for the functioning of interfaces among propulsion, friction brake, and train-borne master control on rail rapid transit vehicles |
| | IEEE 1483-2000 | IEEE standard for verification of vital functions in processor-based systems used in rail transit control |
| | IEEE 1698-2009 | IEEE guide for the calculation of braking distances for rail transit vehicles |
| | IEEE 16-2004 | IEEE standard for electrical and electronic control apparatus on rail vehicles |
| Code of Federal Regulations | 49 CFR Subpart I | Requirements for Positive Train Control systems |
| Association of American Railroads Safety and Operations Manual of Standards and Recommended Practices | Section K-I | Railway electronics systems architecture and concepts of operation |
| | Section K-II | Locomotive electronics and train consist systems architecture |
| | Section K-III | Wayside electronics and mobile worker communications architecture |
| | Section K-IV | Office architecture and railroad electronics messaging |
| | Section K-V | Electronics environmental requirements and system management |
| | Section K-VI | Railway data management and communications |

**Table 5-1 (cont.)** *Applicable Train Control Standards*

| Source | Standard/Reference | Standard Description |
|---|---|---|
| Defense Standardization Program | MIL-STD-882C | System safety |
| | MIL-STD-882E | System safety |
| | MIL-HDBK-217 | Reliability prediction of electronic equipment |
| Federal Highway Administration Manual of Uniform Traffic Control Devices | MUTCD Part 8 (2009) | Traffic control for railroad and light rail transit grade crossings |
| International Union of Railways | 2006/679/EC | Technical specification for interoperability relating to the control-command and signaling subsystem of the trans-European conventional rail system |
| European Committee for Electrotechnical Standardization | EN 50126-1:2017 | Railway applications – The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS) - Part 1: Generic RAMS Process |
| | EN 50126-2:2017 | Railway Applications – The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS) - Part 2: Systems Approach to Safety |
| | CLC/TR 50126-3:2008 | Railway Applications – The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS) - Part 3: Guide to the Application of EN 50126-1 for Rolling Stock RAM |
| | EN 50128:2011 | Railway applications – Communication, signaling and processing systems – Software for railway control and protection systems |
| | EN 50129:2018 | Railway applications – Communication, signaling and processing systems – Safety related electronic systems for signaling |
| International Electrotechnical Commission | IEC 61508:2010 | Functional safety of electrical/electronic/programmable electronic safety-related systems |

Several train control systems that could be considered for TBTC were also identified across the railroad industry, many of which are currently in use by both freight and passenger railroads.

Table 5-2 provides a list of the systems identified. As with the applicable train control standards, the intent is not to provide a comprehensive list of all systems that could be considered for use as TBTC systems but to provide a sample that can provide an indication of the different implementations when considering this technology. The systems in this list were identified from publicly available information, including technical reports and conference presentations, supplier marketing information, and supplier website information.

**Table 5-2** *Applicable Train Control Systems*

| System | Developer/Supplier | Railroads/Agencies |
|---|---|---|
| Advanced Train Administration and Communications System (ATACS) | East Japan Railway Company (JR East) | East Japan Railway Company |
| Advanced Train Management System (ATMS) | Lockheed Martin and the Australian Rail Track Corporation (ARTC) | Australian Rail Track Corporation Ltd. (ARTC) |
| Advanced Civil Speed Enforcement System (ACSES) | Alstom, Hitachi, Siemens & Bombardier | Metro North, Long Island, SEPTA, Amtrak, NJT |
| Caltrain Communications Based Overlay Signal System Positive Train Control (CBOSS PTC) | Caltrain | Caltrain |
| Enhanced Automatic Train Control (E-ATC) | Alstom | TriMet |
| Interoperable-Electronic Train Management System (I-ETMS™) | Wabtec | Class I's, Metrolink, San Diego North County, and Maryland Area Regional Commuter (MARC) |
| Incremental Train Control System (ITCS) | Alstom | Amtrak, Fortescue Railway, FENOCO Railway, Qinghai- Tibet Railway |
| Trainguard® PTC | Siemens | Unknown |
| Trainguard® Sentinel | Siemens | Panama Canal Railway Company, TasRail, and Nacala-Moatize |
| MRS Logistica's SIACO | Wabtec | MRS Logistica SA |
| Cambridge Sentinel System | Cambridge Communications and Signaling Systems | Lycoming Valley |
| Protran Collision Avoidance System (CAS) | Protran | Unknown |
| Railway Collision Avoidance System | Intelligence on Wheels | Unknown |

All systems listed above are capable of benefitting transit agencies in terms of reducing risk in some or all Operational Risk Classes, as outlined above in Table 5-2.

Table 5-3 provides a high-level capability overview of each system listed in Table 5-3. Each capability is applicable to the mitigation of one or more operational risk class. Systems designed to stop a train do so if a violation occurs such as an overspeed, stop signal, or movement authority violation. Fail safe systems will stop a train if the onboard equipment enters into a failed state—e.g., a control system failure. Preventing movement through improper switch alignment should mitigate switch derailments and switch alignment/defects. Preventing overspeed derailments directly mitigates an operational risk class. Preventing unauthorized incursions into work zones mitigates some instances of employees being struck by a train. Preventing train-on-train collisions requires the enforcement of movement authority and stop signals. The added capability of doing so while in restricted speed (20 mph or less) when the train is following another train in the same block signal is also noted.

The capabilities of each system shown in Table 5-3 were identified from publicly available information including technical reports and conference presentations, supplier marketing information, and supplier website information.

**Table 5-3** *High Level System Capabilities*

| System | Designed to Enforce or Stop a Train | Prevents Movement of Train through Improper Switch Alignment | Prevents Overspeed Derailments | Prevents Unauthorized Incursions into Work Zones | Prevents Train-to-Train Collisions |
|---|---|---|---|---|---|
| ATACS | X | X | X | X | X |
| ATMS | X | X | X | X | X |
| ACSES | X | | X | X | X |
| ACSES II | X | X | X | X | X |
| CBOSS PTC | X | X | X | X | X |
| E-ATC | X | X | X | X | X |
| I-ETMS | X | X | X | X | X |
| ITCS | X | X | X | X | X |
| Trainguard PTC | X | X | X | X | X |
| Trainguard Sentinel | X | X | X | X | X |
| MRS Logistica's SIACO | X | X | X | X | X |
| Cambridge Sentinel System | | X | X | X | X |
| Protran Collision Avoidance System | | X | | | X |
| Railway Collision Avoidance System | | | | X | X |

## Section 6 Potential Risk Reduction Approaches

TBTC offers the potential to reduce operational risk across the rail transit industry. However, it is not capable of reducing all risks in all situations. As a result, any risk reduction approach must consider the operational environment in which it is being used.

All potential TBTC solutions noted in have the potential to reduce RTA operational risks in Exclusive Right-of-Way operations. Generally, these systems are designed to avoid potential collision incidents by first alerting the operator of a stop target or speed restriction ahead. If the operator fails to take the appropriate action to ensure that the rail vehicle is either stopped prior to the stop target or slowed to the posted restricted speed, the onboard system initiates a penalty brake application bringing the rail vehicle to a stop.

It is not uncommon for RTAs to share operating space with the general public. This Non-Exclusive Right-of-Way can take many forms such as a shared lane with vehicular traffic (often used as a left-turn lane for vehicular traffic). The systems that could be considered for TBTC rely on train location information (GPS, GNSS, in-track transponders, axle counting systems, etc.) to determine the train's location, speed, and heading with respect to a stop target or a speed restriction ahead. These systems do not scan the external environment ahead of the train for potential obstructions or collision risks. In these situations, whereas TBTC may be able to enforce a stop if required by the signal system, it may not be able to stop a rail vehicle before it collides with a non-rail vehicle stopped in a shared lane. Rail vehicle operator situational awareness and safe operating practices will continue to be required to ensure rail vehicle and general public safety. In operational cases such as this, it may be more appropriate to have a TBTC system that simply ensures operator situational awareness through the issuance of in-cab alerts or prompts.

Finally, external environmental scanning also may be used to assist in the mitigation of collision incidents; an investigation of these systems is beyond the scope of this project. Other FTA research efforts are exploring the availability, feasibility, and deployment potential for onboard collision avoidance systems.

# Section 7 Summary

Operational risk exists within the rail transit industry and takes many forms, from attempted "suicide by train," or motor vehicle operators making illegal left turns in front of trains, to rail vehicle operators failing to properly maintain control of their vehicle. TBTC offers the potential to reduce the overall risk encountered by RTAs.

It is difficult to determine the risk reduction potential of TBTC across the U.S. rail transit industry. Analysis of NTD incident data suggests that the general public—motor vehicle operators or pedestrians/trespassers—pose the greatest risk to transit rail operations, making up more than 41% of all the major incidents reported. Incidents such as these are not likely to be affected by the implementation and use of TBTC. An analysis of the same data suggests, at most, only 4% of the incidents reported to NTD were directly related to TBTC mitigatable risk classes.

The RTA survey specifically requested a total count train control-related incidents including those with TBTC mitigatable root causes encountered over the past five years. The results revealed that approximately 10,000 train control-related hazardous conditions (whether NTD reportable or not) occurred at Federally-regulated RTAs that had the potential to be mitigated by TBTC. Although most events potentially could be mitigated by TBTC, the NTD incident data indicate that most did not result in a NTD reportable incident.

Whereas TBTC can help mitigate many train control-related hazards present in transit operations, the number of incidents attributable to these hazards is relatively low, considering all reportable incidents.

Section 8

# Opportunities for Further Research

Train control signal systems vary across agencies and potentially from line-to-line within a given agency. An in-depth cost-benefit analysis may be required to fully understand the financial and operational impact of TBTC. This analysis should include the potential positive impact of reducing overall operational risk (i.e., incidents avoided) as well as the potential financial and operational impact that the development, installation, and implementation of TBTC may have on each RTA. This will likely be different for each agency as the level of investment will vary.

The rail transit industry experiences a vast array of risks and, per NTD incident data, most of that risk is not mitigable with TBTC. Additional analysis may be required to determine all Operational Risk Classes that should be mitigated by TBTC. Identification of these risk classes can then be used to inform the development of TBTC functional and performance requirements specific to transit rail and its various modes.

The data analysis highlighted a need for more descriptive information to be captured as part of NTD incident reporting. Generally, root-cause information is lacking from incident reports. Incident reports that do contain root-cause information have that information embedded in a free-form text field, which makes sorting and filtering of the data into meaningful categories difficult. The creation of "Primary Cause Code" and "Secondary Cause Code" fields, with pre-defined and selectable values such as those used for FRA Accident/Incident Reporting, may prove useful for future analyses.

The following are the major findings from this research:

- For Non-Exclusive Right-of-Way such as a shared lane with vehicular traffic, TBTC will not be able to stop a rail vehicle before it collides with a non-rail vehicle stopped in a shared lane.
- An analysis of NTD data suggests that 4% or fewer rail related incidents reported to NTD were directly related to TBTC mitigatable risk classes.
- A survey of RTAs revealed that 9,348 (83%) of train control-related hazardous conditions that have occurred across the industry have the potential to be mitigated by TBTC.
- RTA survey results revealed that 73% of transit lines use ATC or ABS, approximately 8% use CTC, and approximately 19% of lines do not use any train control signal system.
- RTA survey results revealed that the most widely used train-control relevant standard is 49 CFR 236.1005 Requirements for Positive Train Control systems, with 20 individual transit lines reported as using this standard for development and implementation.

- Due to the limitations of the NTD noted, the data analysis conducted highlights a need for more descriptive information to be captured as part of NTD incident reporting, such as “Primary Cause Code” and “Secondary Cause Code” field, with pre-defined and selectable values similar to those used for FRA Accident/Incident Reporting.
- There are numerous TBTC systems available on the domestic and international markets, the majority of which are designed to mitigate the train-on-train collisions and overspeed operation of the train and to enforce stop train stops as appropriate.
- An in-depth cost-benefit analysis may be required to fully understand the financial and operational impact of TBTC on the rail transit industry. This analysis should include the potential positive impact of reducing overall operational risk (i.e., incidents avoided) as well as the potential financial and operational impact that the development, installation, and implementation of TBTC may have on each RTA.

# Appendices

# Appendix A: Identified Operational Risk Classes

| Operational Risk Class | Definition |
|---|---|
| Assault/Robbery | Any incident of involving a physical attack on a person, or the taking of property unlawfully from a person or place by force or threat of force. Examples include, but are not limited to:<br>• Pushing victim down stairway.<br>• Pushing victim into path of moving train.<br>• Cutting victim with a knife.<br>• Spitting in face of victim.<br>• Victim struck with intent to harm by assailant. |
| Collision in Yard | Collision between a rail transit vehicle and other vehicles, not in revenue service, occurring in terminal, yards, and shop tracks. This may include collisions with vehicles stored or standing in adjacent tracks (i.e., side swipe), but in which the incident description is not sufficiently clear to determine location or condition of standing vehicle. |
| Control System Failure | A failure of the train control system to properly maintain safe operations of trains. Examples include, but are not limited to:<br>• Computer Aided Dispatch (CAD) system failure.<br>• Crossing protection controller failure.<br>• Onboard train control failure. |
| Derailment – At Switch | Mainline derailment of rail transit vehicle at or in the immediate vicinity of a switch, frog, diamond, or crossover. |
| Derailment – On Track Equipment | Derailment of on track equipment (e.g., Hi-rail vehicle, tamper). Derailment may happen on mainline or yard tracks. |
| Derailment – Overspeed | Mainline derailment caused by train traveling at speed in excess of posted civil speed or temporary speed restriction. |
| Derailment – Unknown | Mainline derailment with no identified cause. |
| Derailment – Yard | Derailment in a yard or other non-revenue location. Derailment on other than mainline track. This includes derailments as a result of yard switch alignment/defects or moving over yard track derails. |
| Employee Struck by Train | Incident involving a rail transit employee coming into contact with an operating train during the performance of duties. |
| Employee Trip/Fall | Employee trip or fall while performing duties. |
| Fire | An occurrence of a fire. Fire may be present onboard rail vehicle or within the track/ROW. Fires on rail vehicles identified as being the direct result of mechanical or electrical failures are not included in this risk class. |
| Highway Vehicle (POV) at Fault | Incident directly caused by motor vehicles and otherwise unavoidable by the rail vehicle operator. Examples include, but are not limited to:<br>• Illegal left-hand turn into the path of train.<br>• Failure to stop at red light.<br>• Failure to obey posted traffic signs.<br>• Running around active crossing protection devices (i.e., crossing gates).<br>• Failure to yield right-of-way to rail transit vehicle.<br>• Colliding with rear-end of standing rail transit vehicle.<br>• Stopped on (fouling) grade crossing or tracks. |

| | |
|---|---|
| | • Positioned within foul of track/too close to track/within dynamic envelope.<br>• LRV hit by personally operated vehicle (POV).<br>• Reverse move of POV into path of train/backing out of parking spaces.<br>• Incident descriptions that state that rail vehicle was struck by a highway vehicle assumes that the highway motor vehicle is at fault. This is because the rail vehicle is not able to take evasive action, aside from emergency braking, to avoid a collision with a highway motor vehicle. |
| Movement Authority Violation | Failure on the part of a rail transit vehicle operator to properly adhere to movement authority limits. This may include failure to stop prior to exceeding movement authority limits. Examples include, but are not limited to:<br>• Unauthorized entry into established work limits providing on-track protection for track workers.<br>• Moving past authorized movement authority limits without dispatcher permission or prior to receiving new movement authority limits. |
| N/A – TBTC | Not applicable to TBTC control system or on-rail train operations. Examples include, but are not limited to:<br>• Evacuation of facilities due to high levels of carbon monoxide.<br>• Passengers stranded in station elevator.<br>• Unattended bag/suspicious packages.<br>• Bomb threat.<br>• Train/station/platform evacuation due to smoke. |
| Obstruction In/On Track | Foreign objects blocking the safe passage of a train over the track. This may include abandoned or stopped motor vehicles at grade crossings. This does not include motor vehicles that illegally attempt to go around active grade crossing protection devices (i.e., crossing gates). Examples include, but are not limited to:<br>• Overhead wires down in path of train or across track.<br>• Downed trees.<br>• Abandoned motor vehicle/POV fouling track.<br>• Collapsed retaining wall(s).<br>• Contractor work equipment (i.e., crane boom, bucket truck boom) fouling tracks.<br>• Debris fouling tracks and/or switches. |
| Operator – Failure to Control Vehicle | Failure on the part of the rail transit vehicle operator to properly control their vehicle. This includes incidents that appear to be caused by a lack of situational awareness on the part of the operator. Examples include, but are not limited to:<br>• Failure to apply brakes soon enough to come to safe stop.<br>• Failure to yield right-of-way to pedestrians and/or highway motor vehicles.<br>• Failure to stop and inspect switch points before traveling through switch.<br>• “Powering” through a switch. |
| Passenger at Station/Platform | Incident occurring as a direct result of a passenger at a station, or on a platform, performing an unsafe or illegal act. Examples include, but are not limited to:<br>• Running into the side of an arriving/departing train.<br>• Being stuck by arriving/departing train while standing to close to platform edge.<br>• Sitting on edge of platform.<br>• Slipping and falling from edge of platform onto roadbed.<br>• Slips, trips, and falls resulting in contact with arriving/departing train.<br>• Intoxicated passengers falling into arriving/departing train. |

| | |
|---|---|
| | • Intoxicated passengers falling onto roadbed.<br>• Medical conditions (e.g., fainting, heart attack, seizure) resulting in passenger falling into arriving/departing train.<br>These incidents do not include individuals that purposefully place themselves with in the roadbed/gage such as trespassers walking in the gage, walking along right-of-way in the foul, or individuals attempting to commit suicide. |
| Passenger on Train | Incident occurring as a direct result of a passenger on a train performing an unsafe or illegal act. Examples include, but are not limited to:<br>• Riding on top of train ("train surfing").<br>• Riding on or about couplers.<br>• Passing between cars without authorization.<br>These incidents do not include individuals that are injured as a result of another external root-cause (i.e., not the direct result of the passenger's actions). |
| Pedestrian/Trespasser | Incidents occurring as a direct result of person(s) fouling the track when otherwise not authorized to do so. Examples include, but are not limited to:<br>• Walking within the gage of the rail.<br>• Walking along right-of-way in the foul of the track.<br>• Suicide/attempted suicide.<br>• Pedestrians/bicycle riders walking/riding around active crossing protection devices (crossing gates, crosswalk signals).<br>• Pedestrian/bicycle riders walking/riding in front of train due to a lack of attention, situational awareness, or distraction<br>These incidents also include individuals that are found to be in the roadbed, either alive or deceased, but it is unclear as to how the individual arrived there. |
| Standing Vehicle Improperly Secured | Standing (i.e., not moving) attended or unattended vehicle that has not been properly secured against unintended movement. |
| Stop Signal Violation | Failure on the part of a rail transit vehicle operator to bring vehicle to a safe stop before passing a stop signal. This may also include failing to stop at posted "Stop" signs in operational modes that require adherence to motor vehicle street signs. |
| Switch Alignment/Defect | Incident occurring as the direct result of a switch either being misaligned (i.e., not thrown to the proper position) or a defective switch. This includes incidents of "split switch." |
| Track or Structure Failure | Failure of the track structure (e.g., rail damage, tie damage, ballast damage) or of support structure along the right-of-way (e.g., bridges, retaining walls, tunnel walls) causing a condition that poses a threat to the safe passage of a train at maximum authorized track speed. |
| Transit Vehicle – Standing in the Foul | Rail transit vehicle that has been positioned in a track such that it poses a collision risk to other on-track equipment moving on or about adjacent tracks. |
| Transit Vehicle – Mech/Elect Failure | Incident occurring as the direct result of a mechanical or electrical failure of a rail vehicle. Examples include, but are not limited to:<br>• Inoperative/malfunctioning train air brake system.<br>• Broken wheel.<br>• Broken axle.<br>• Overheated journal bearing.<br>• "Blown traction motor."<br>• Dynamic brake failure. |

| | |
|---|---|
| Unknown | Unable to determine root-cause of incident due to incident description lacking detail. Examples include, but are not limited to:<br>• "Accident with injury: Intersection accident with an auto."<br>• "Collision with vehicle."<br>• "Hit by trolley."<br>• "LRV collision with privately owned vehicle."<br>• "Car collision."<br>• "Side-swipe collision."<br>It is not assumed that an incident description that notes a rail transit vehicle colliding with a vehicle or person is the fault of the rail vehicle operator. In the absence of additional information specifically identifying the at fault party, no determination can be made. |
| Weather/Natural Disaster | Primary cause of incident was as a result of inclement weather or other natural disasters. This also includes man-made conditions that adversely affect the operating environment. Examples include, but are not limited to:<br>• Ice/snow build up in switches/frogs.<br>• Standing water on tracks/track submerged.<br>• Ballast washout due to heavy rains/running water.<br>• Tornado.<br>• Hurricane.<br>• Power outage due to severe weather.<br>• Flooding of track/station due to water main break. |

# Appendix B:
# Survey Form 2 Submitted to RTAs

U.S. Department of Transportation
Federal Transit Administration

**State Safety Oversight Agency Information Request**

Office of Transit Safety and Oversight
Washington, DC

## Form #2 – Train Control Signal System Information

Please reference the accompanying guide for assistance.

Please email one completed Form #1 and its associated Form(s) #2 by **May 7, 2019** (90 days from the date of the accompanying letter) to FTASystemSafety@dot.gov.

Please submit one form for every type of train control signal system an RTA uses.

| **1. RTA name:** |
|---|
| |

| **2. State RTA line(s) with a common signal system technology:** |
|---|
| |

| **3. Select the RTA mode(s) for the line(s) stated in question 2 above:** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Heavy Rail | | Light Rail | | Streetcar/ Trolley | | Monorail/ People Mover | Other: | |

| **4. State the train control signal system type: (Select only one.)** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Automatic Block Signaling (ABS) | | Automatic Train Control (ATC) | | Centralized Traffic Control (CTC) | | None | | Other: | |

| **5. If ATC, specify the type of operations: Select only one – lowest automated level)** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Full Automatic Train Operations | | Partial Automatic Train Operations | | Manual Operations | | CBTC | | Other: | |

| | **6. Has the RTA added redundancy to the train control signal system to identify "loss of train detection" in real-time and subsequently stop trains automatically? (Select only one.)** |
|---|---|
| | No |
| | Yes – Please describe: |

| | **7. Specify activities the RTA conducted since November 2012 (when the Transit Train Control Assessment was completed) to reduce the risk of "loss of train detection" or "train signal failures" from occurring. (Select all activities that apply.)** |
|---|---|
| | Regularly updates relevant SOPs, forms, and test procedures/reports for train signal system inspection and maintenance programs |
| | Regularly performs internal reviews/audits of the train signal inspection and maintenance procedures |

| | |
|---|---|
| | Regularly conducts inspections of train control signal system |
| | Developed and implemented a signal maintenance training program |
| | Regularly conducts hazard analysis of the train signal system |
| | Upgraded the train control system or equipment resulting in improved identification of “loss of train detection” |
| | Developed or developing plans for future upgrades to train control system design and equipment |
| | For train control systems sharing lines, evaluated if there is an incompatibility safety risk or other safety risk associated with this practice and implemented measures to mitigate such risk. |
| | Other - Please describe: |
| | None |

**8. Specify oversight activities the SSOA conducted to reduce the risk of “loss of train detection” or “train signal failure” from occurring since November 2012.**

| Select all activities that apply: | | Verification Method/Date |
|---|---|---|
| | 1. Met with RTA to understand process for inspection and testing train signal performance | |
| | 2. Reviewed relevant SOPs, forms, and test procedures/reports for train signal system inspection and maintenance | |
| | 3. Audited RTA’s train signal inspection and maintenance procedures and defect tickets | |
| | 4. Conducted inspections independently or jointly with RTA of train signal system | |
| | 5. Audited signal maintenance training program | |
| | 6. Conducted or reviewed hazard analysis of the train control signal system | |
| | 7. Developed a corrective action plan to address potential train signal system non-failsafe failures. | |
| | 8. Began oversight of project to upgrade the train signal system to include a safety certification process | |
| | 9. Other - Please describe: | |
| | 10. None | |

**9. If the RTA line(s) have audio frequency track circuits, has the RTA implemented the American Public Transportation Association (APTA) RT-SC-S-009-03 Standard recommendations? (Please verify below.)**

| Select all activities that apply: | | Description |
|---|---|---|
| | 1. Conducts updates to maintenance and inspection procedures, as needed | |
| | 2. Conducts shunt sensitivity verification tests every 12 months or similar OEM recommended frequency | |
| | 3. Unshunted and unintended signals tests every 12 months or similar OEM recommended frequency | |
| | 4. Unintended or spurious signals test | |
| | 5. Cab signal level measurement every 12 months or similar OEM recommended frequency | |
| | 6. Implementation of signal maintenance training program | |
| | 7. APTA or OEM recommended test equipment | |
| | 8. No recommendations implemented | |

| **10. What specifications/standards were used in the design and implementation of this train control system? (Select all that apply.)** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | IEEE 1473 | | IEEE 1474.1 | | IEEE 1474.2 | | AAR MSRP Sec. K | | 49 C.F.R. 236.1005 |
| | EN 50126 | | EN 50128 | | EN 50129 | | IEC 61508 | | Other - Please describe: |

# Appendix C:
# Survey Form 3 Submitted to RTAs

U.S. Department of Transportation
Federal Transit Administration

**State Safety Oversight Agency Information Request**

Office of Transit Safety and Oversight
Washington, DC

## Form #3 – Train Control Related Incidents

Please email one completed Form #3 for each RTA by **May 7, 2019** (90 days from the date of the accompanying letter) to FTASystemSafety@dot.gov.

| | |
|---|---|
| **1. RTA name:** | |
| | |
| **2. How many train-on-train collisions did the RTA experience in the past 5 years? (Please enter the number for each root cause below.)** | |
| | Movement authority/stop violation |
| | Overspeed (permanent or temporary) |
| | Control operator/dispatcher error |
| | Switch misalignment/failure |
| | Other train control system related train-on-train collisions – Please describe: |
| | Total |
| **3. How many near-miss train-on-train incidents has the RTA experienced in the past 5 years? A "near-miss incident" is a narrowly avoided collision. (Please enter the number for each root cause below.)** | |
| | Movement authority/stop violation |
| | Overspeed (permanent or temporary) |
| | Control operator/dispatcher error |
| | Switch misalignment/failure |
| | Other train control system related near miss incident – Please describe: |
| | Total |
| **4. How many train incidents has the RTA experienced in the past 5 years?** An "incident" is an event that indicates an operating rule or safe vehicle handling practice is inadequate. It may also be the failure of an individual to adhere to established operating rules and safe vehicle handling practices. (Please enter the number for each root cause below.) | |
| | Movement authority/stop violation |
| | Overspeed (permanent or temporary) |
| | Control operator/dispatcher error |
| | Switch misalignment/failure |
| | Other train control system related incidents – Please describe. |
| | Total |

# Appendix D:
# FTA/TTCI Survey

U.S. Department of Transportation
Federal Transit Administration

Headquarters
1200 New Jersey Avenue, SE
Washington, D.C. 20590

**February 6, 2019**

**Subject: Information Request – Train Control Systems (NTSB R-09-07) and (NTSB R-15-22)**

Dear State Safety Oversight Agency Representative:

To address the National Transportation Safety Board (NTSB) Recommendations R-09-07 and R-15-22, we are sending the attached information request forms to collect information on your Rail Transit Agencies' (RTAs') train signal system technology and related incidents. These forms are due within 90 days from the date of this letter.

The FTA may issue Information Requests to the State Safety Oversight Agencies (SSOAs), consistent with the estimates supplied to the Office of Management and Budget (OMB), as detailed in OMB Control No. 2132-0558.

**NTSB Recommendation R-09-07**

The attached Information Request directs SSOAs to collect and verify information to address NTSB Recommendation R-09-07. After the fatal Washington Metropolitan Area Transit Authority Metrorail train collision near Fort Totten station on June 22, 2009, the NTSB issued R-09-07 stating:

> "Advise all rail transit operators that have train control systems capable of monitoring train movements to determine whether their systems have adequate safety redundancy if losses in train detection occur.
>
> If a system is susceptible to single point failures, urge and verify that corrective action is taken to add redundancy by evaluating track occupancy data on a real-time basis to automatically generate alerts and speed restrictions to prevent train collisions."

The FTA took rapid initial action to address R-09-07, releasing its July 13, 2009, "Dear Colleague" letter to the industry on the same day that the NTSB issued R-09-07. FTA also worked with the Transportation Research Board (TRB) and the Transit Cooperative Research Program (TCRP) developing the "quick study" used to survey Transit Train Control Systems nationwide for single-point failures and to recommend practices for detecting and preventing such failures.

The TCRP research project showed that reliable and safe operation of track circuitry is critical to the signal system. Few RTAs can evaluate track occupancy data on a real-time basis to automatically generate alerts and speed restrictions to prevent train collisions in response to single point failures, as recommended by the NTSB. However, FTA, in its work with TCRP and the American Public Transportation Association (APTA), determined that the development and implementation of test procedures to check track circuit performance at periodic intervals can mitigate risks associated with a signal system failure.

From the results of the TCRP project, issued in a final report in November 2012, APTA developed *Standard for Audio Frequency Track Circuit Inspection and Maintenance* (APTA RT-SC-S-009-03 Rev 1), issued on December 31, 2014. This standard establishes test procedures to detect a potential "loss of shunt condition," identify failure modes based on manufacturer analysis, define best practice for documenting test programs, define outdated and/or superseded test requirements, and determine appropriate intervals for testing in the rail transit industry.

- **Additional Action Required**

On February 23, 2017, FTA submitted a letter to the NTSB requesting closure of Safety Recommendation R-09-07, based on the July 13, 2009, "Dear Colleague" letter; the TCRP "quick study" survey; Project J-6 Task 77: APTA/FTA Transit Train Control Assessment; and the development of the APTA industry standard for audio frequency track circuit inspection and maintenance.

On April 6, 2017, the NTSB informed the FTA that it could not close Safety Recommendation R-09-07 because, while the TCRP project and APTA rail transit safety standard address the Safety Recommendation's urgent concerns, FTA has not supplied evidence that either FTA or the SSOAs have verified rail transit operators implemented corrective action.

Therefore, FTA is issuing this information request, directing each SSOA to supply information on the train control technology used, by line, for each RTA in its jurisdiction and on how the SSOA has verified actions taken by the RTA to address R-09-07.

- **NTSB Recommendation R-15-22**

The attached Information Request directs SSOAs to collect train control related incident information to support the development of FTA's response to NTSB Recommendation R-15-22. After the March 24, 2014 accident in which a Chicago Transit Authority train collided with a bumping post, rode over the bumping post and went up an escalator at the end of the track at O'Hare Station, NTSB issued R-15-22 stating:

> "Require rail transit agencies to implement transmission-based train control (TBTC) systems that prevent train collisions."

The FTA responded to the NTSB on August 7, 2015 that it would thoroughly evaluate existing research of TBTC technology before determining whether to require its implementation by all rail transit agencies that receive Federal financial assistance under 49 U.S.C. Chapter 53.

In addition to evaluating TBTC technology, FTA is collecting information from the National Transit Database (NTD) and NTSB accident investigation reports to review train control-related events.

- **Additional Action Required**

In its effort to better understand and quantify train control related risks, hazards, and incidents in the rail transit industry, FTA requires additional research. Therefore, FTA is issuing this information request, directing each SSOA to supply information on train control train control related incidents, train-on-train collisions, and train-on-train near misses RTAs have experienced in the past five years. This information will be used to support the development of a response to NTSB Recommendation R-15-22.

- **Information Request Forms**

FTA requests that SSOAs complete the attached forms:

- *Form 1 - SSOA and RTA Information*. This form requests administrative data such as contact information for the SSOA personnel working on this response and also asks the State to identify the RTAs in its jurisdictions if there are any changes from the FY18 formula apportionment, the modes of service provided, and the number of different signal and train control systems used by each RTA, by line, in its program.
- *Form 2 - Train Signal System Information*. This form requests information citing RTA actions implemented in response to the NTSB recommendation and SSOA activities to verify RTA activities were conducted. Form 2 should be completed for each train control signal system used by each RTA in the SSOA's jurisdiction. There is an attached Guide to Completing Form 2 that provides detailed explanations and/or examples for each question in Form 2.
- *Form 3 – Train Control Related Incidents Information.* This form requests information on the number of train control related incidents, train-on-train collisions, and train-on-train near misses, the RTA has experienced in the past five years.

Please email completed Information Request forms **no later than May 7, 2019**, which is 90 calendar days after the date of this letter, to:

- FTA System Safety email inbox at FTASystemSafety@dot.gov

If you have any questions, or if we can be of assistance, please direct your questions to FTASystemSafety@dot.gov or to Ms. Kara Waldrup at kara.waldrup@dot.gov. We thank you for your attention to this matter.

Sincerely,

Candace Key
Acting Director, Office of System Safety

U.S. Department of Transportation
Federal Transit Administration

**State Safety Oversight Agency Information Request**

Office of Transit Safety and Oversight
Washington, DC

# Form #1 – State Safety Oversight Agency (SSOA)

Please email one completed form #1 and its associated forms #2 by **May 7, 2019** (90 days from the date of the accompanying letter) to: FTASystemSafety@dot.gov

| | | | |
|---|---|---|---|
| **1. Name of SSOA:** | | | |
| | | | |
| **2. SSOA Point-of-Contact for this information request:** | | | |
| Name: | | | |
| Email: | | Phone: | |
| **3. If there are any changes of which RTAs are in the SSOA's jurisdiction from the 2018 Formula Apportionment Table, please state them below:** | | | |
| | | | |
| **4. State the names of all RTA lines in the SSOA's jurisdiction:** | | | |
| | | | |
| 5. **How many Forms #2 are you submitting? Submit one Form #2 for each type of train control signal system an RTA uses.** | | | |
| | | | |

**IMPORTANT – General Notes**

Complete a separate Form #2 for each RTA line that has different train signal control technology.

- ***Example 1***: Los Angeles Metro operates two Heavy Rail Transit (HRT) lines, named the Red and Purple lines. As the Red and Purple lines operate the same signal system technology, only one form is needed for the Red and Purple lines combined.
- ***Example 2***: Los Angeles Metro also operates four Light Rail Transit (LRT) lines, named the Green, Gold, Blue, and Expo lines. The Green Line's signal system technology differs from the other LRT lines; therefore, two (2) forms are required:
  - 1 form for the Green line
  - 1 form for the combination of Gold, Blue, and Expo lines
  - In Questions 3–10, please mark "X" to the left of the response, except when marking "other" to the right of the response.
  - Questions in the shaded parts of the forms should not be altered.

| Question 1. Rail Transit Agency (RTA) name: |
|---|
| Name of the Rail Transit Agency (RTA).<br>• Please submit separate forms for each RTA within the State Safety Oversight Agency's (SSOA) jurisdiction if there is a change from the FY18 formula apportionment.[1]<br>– If an RTA is in engineering or construction, please complete a form for that system.<br>– The RTA must meet the 49 C.F.R. Part 674 definition (not subject to Federal Railroad Administration). |
| **Question 2. State RTA line(s) with a common signal system technology:** |
| List the line(s) as referred to on the RTA rail map, etc.<br>• Please submit separate forms for each RTA line that has a different train signal control technology. If the lines operate the same technology, then you may include multiple rail lines in this field. (Example: You can list Gold Line, Blue Line, and Expo Line.) |
| **Question 3. Select the RTA mode(s) for the line(s) stated in question 2, above:** |
| Specify the mode(s) for the RTA line(s) stated in question 2. Only one selection should be made for the subject RTA line(s).<br>**Please submit separate forms for each RTA mode (or line, when necessary).**<br>Heavy Rail Transit (HRT) – A transit mode that is an electric railway with the capacity for a heavy volume of traffic. It is characterized by:<br>– High speed and rapid acceleration passenger rail cars operating singly or in multi-car trains on fixed rails<br>– Separate rights-of-way (ROW) from which all other vehicular and foot traffic are excluded<br>– Sophisticated signaling, and<br>– High platform loading.<br>Light Rail Transit (LRT) – A transit mode that typically is an electric railway with a light volume traffic capacity compared to heavy rail (HR). It is characterized by:<br>– Passenger rail cars operating singly (or in short, usually two cars, trains) on fixed rails in shared or exclusive right-of-way (ROW).<br>– Low or high platform loading; and<br>– Vehicle power drawn from an overhead electric line via a trolley or a pantograph.<br>Streetcar Trolley – This mode is for rail transit systems operating entire routes predominantly on streets in mixed-traffic. This service typically operates with single-car trains powered by overhead catenaries and with frequent stops. The Streetcar Trolley may be a historic or modern vehicle.<br>Monorail/People Mover – Monorail/Automated Guideway (MG). An electrically-powered mode of transit operating in an exclusive guideway or over relatively short distances. The service is characterized by either monorail systems with human-operated vehicles straddling a single guideway or by people-mover systems with automated operation. |
| **Question 4. Train control signal system type(s): (Select all that apply.)** |
| Select the mainline train signal system(s).<br>• Multiple signal system selections can be made for mainline operations of the subject RTA line(s). Do not include the signal system for yard, shop, and other non-mainline locations<br>– Example: If the Blue Line LRT system operates with Automatic Train Control (ATC) for a portion and is also street running without signal system protection for a portion, the section would be "ATC" and "None."<br>– Traffic signals used for streetcars, etc., are marked as "None."<br>• ABS – Automatic Block Signaling – The line is divided into series of sections or blocks with automatic signals that control train operations and signal display. |

| |
|---|
| • ATC – Automatic Train Control – ATC can control the train speed and, if necessary, stop trains near appropriate signals, usually by the cab-signaling system.<br>• CTC – Centralized Traffic Control – CTC consolidates train routing information to a control center or dispatch capable of controlling interlocking and switches. |
| **Question 5. If ATC, specify the type of operations: (Select only one – lowest automated level.)** |
| Select the ATC train signal system that is used during normal operations.<br>• Select only one, the lowest automated signal system level, signal system type forthe RTA line(s). Do not include the signal system for yard, shop, and other non-mainline locations.<br>  – Example: If the Blue Line LRT system operates with “Partial Automatic Train Operations” for a portion and is also street running “Manual Operations,” select “Manual Operations.”<br>• Full Automatic Train Operations – The system controls all train activity including train movement and door operation. An example would be a Monorail.<br>• Partial Automatic Train Operations – The onboard operator initiates train movement by pushing a start button or opens doors.<br>• Manual Operations – The operator manually controls and stops train movement and other functions. (Note that this is for ATC manual train operation, and the signal system is capable of controlling train speed.)<br>• Communications-based Train Control – CBTC – Capable of ATC, Automatic Train Protection (ATP), Automatic Train Operation (ATO), and Automatic Train Supervision (ATS). The car- borne and wayside processors can implement vital functions. (Most RTAs do not have CBTC.) |
| **Question 6. Has the RTA added redundancy to the train control system to identify “loss of train detection” in real-time and subsequently stop trains automatically? (Select only one.)** |
| If the train control signal system has adequate redundancy for detecting train control signal failures such as loss of train detection, track occupancy validation, and circuit anomalies and can automatically alert and slow other trains, select “yes” and describe.<br>• Note that most signal systems are not capable of providing real-time alerts and automatically restricting speed due to signal system failures or abnormalities, without a supporting overlay system.<br>  – <u>Example</u>: The Blue Line LRT signal system and supervisory control and data acquisition (SCADA) system allow for monitoring trains at the control center. However, if a shunt error occurs, and train signal occupancy is momentarily lost (the train does not register in the block), the signal system does not recognize the shunt error and does not alert or stop nearby trains. The answer would be “No” to question 6.<br>• Note that most signal systems are not capable of automatically responding tonon-failsafe signal system failure. |
| **Question 7. Specify activities the RTA conducted since November 2012 (when the Transit Train Control Assessment was completed) to reduce the risk of “loss of train detection” or “train signal failures” from occurring: (Select all activities that apply.)** |
| Select activities the RTA has implemented for the line(s) since NTSB’s recommendation.<br>• You can select multiple activities.<br>  – Example: If the Blue Line LRT has both “Updated relevant SOPs…” and “Future upgrades planned to train control system design and equipment,” select both activities. |

| Activity (To reduce risk of loss of train detection/signal failure) |
|---|
| 1. Regularly updates relevant SOPs, forms, and test procedures/reports for train signal system inspection and maintenance program<br>2. Regularly performs internal reviews/audits of the RTA's train signal inspection and maintenance procedures.<br>3. Regularly conduct inspections with of its train control signal system and it includes activities to mitigate the risk of loss of train detection occurring.<br>4. Developed and implemented a signal maintenance training program.<br>5. Conducted hazard analysis of the train signal system.<br>6. Upgraded the train control system or equipment.<br>7. Developed or developing plans for future upgrades to train control system design and equipment.<br>8. For train control systems sharing lines, evaluated if there is an incompatibility safety risk or other safety risk associated with this practice and implemented measures to mitigate such risk.<br>a. Example: If light rail diesel multiple unit shares a line with freight, the RTA evaluated whether there is incompatibility between the technologies used and, if so, the incompatibility issue was mitigated by some additional measure.<br>9. Other, please describe.<br>10. None |
| **Question 8. Specify oversight activities the SSOA conducted to reduce the risk of "loss of train detection" or "train signal failure" from occurring since November 2012.** |
| Select activities the SSOA has verified for the line(s) since November 2012.<br>• You can select multiple activities.<br>– Example: If the SSOA has "Met with RTA" and "Audited RTA's train signal inspection and maintenance procedures," select both activities<br>• In the "Verification" column, include details of supporting activities, the date of meeting, the date of three-year review, etc. |

| ***Activity (To reduce risk of loss of train detection/ signal failure)*** | ***Example of references to include in "Verification" Column*** |
|---|---|
| 1. Met with RTA to understand process for inspection and testing train signal performance. | List processes discussed and meeting date(s). |
| 2. Reviewed relevant SOPs, forms, and test procedures/reports for train signal system inspection and maintenance. | Specify review date(s), the SOP number, form information, test procedure information, test report date, etc. Note, may be part of three-year audit, participation in internal review, etc. |
| 3. Audited RTA's train signal inspection and maintenance procedures. | Include SSOA audit activity and date(s). May include independent inspections or participation in RTA's inspections, etc. |

| Question 8. Specify oversight activities the SSOA conducted to reduce the risk of "loss of train detection" or "train signal failure" from occurring since November 2012. | |
|---|---|
| 4. Conducted inspections independently or jointly with RTA of train signal system. | Include inspection activity, dates, and follow-up inspection(s), if applicable. |
| 5. Audited signal maintenance training program. | Include audit type and date(s). Note, may be part of three-year audit, participation in internal review, participation in signal course, etc. |
| 6. Conducted or reviewed hazard analysis of the train control signal system. | Include type of signal system-specific hazard analysis reviewed or conducted and the date; list hazard mitigations, resolutions, and closures. |
| 7. Developed a corrective action plan to address potential train signal system non- failsafe failures. | Describe any corrective action plan, and include date assigned, status, and date closed (if applicable). |
| 8. Began oversight of project to upgrade the train signal system. | Describe signal upgrades and include estimated completion date. |
| 9. Other, please describe. | If not already addressed, please explain any activities your State has conducted with the RTA to address NTSB's recommendation for real-time track occupancy alerts and speed restrictions to prevent train collisions<br>• Describe other activities not mentioned above, with specifics such as dates. |
| 10. None | |

**Question 9. If the RTA line(s) have audio frequency track circuits, has the RTA implemented the American Public Transportation Association (APTA) RT-SC-S-009-03 Standard recommendations? (Please verify below.)**

This question only applies to signal systems with audio frequency track circuits, such as Washington Metro. Select the APTA recommendations the RTA line(s) has implemented since the APTA RT-SC-S-009-03 was revised in 2014.

- You may select multiple activities.
  - Example: If the RTA has addressed APTA recommendations for "updates to maintenance and inspection procedures" and "Implementation of signal maintenance training program," then select both activities.

- In the "Description" column, include details supporting activities, such as specific SOP numbers, bulletin numbers, frequency of inspection, etc.
- Refer to APTA standard for additional details:
- APTA Standard for Audio Frequency Track Circuit Inspection and Maintenance:
  - https://www.apta.com/resources/standards/Documents/APTA-RT-SC-S-009-03%20Rev%201%20Audio%20Frequency%20Track%20Circuit%20Inspection%20%20Maintenance.pdf

| 10. What specifications/standards were used in the design and implementation of this train control system? (Select all that apply.) |
| --- |
| Please select the standard, regulation, or specification that were used in the design and implementation of this train control system. {Institute of Electrical and Electronics Engineers (IEEE), Association of American Railroads (AAR), European Standard (EN), International Electrotechnical Commission (IEC), Code of Federal Regulations (C.F.R.)}<br>• IEEE 1473<br>• IEEE 1474.1<br>• IEEE 1474.2<br>• AAR MSRP Sec. K<br>• 49 C.F.R. 236.1005<br>• EN 50126<br>• EN 50128<br>• EN 50129<br>• IEC 61508<br>• Other - Please describe: |

U.S. Department of Transportation
Federal Transit Administration

**State Safety Oversight Agency Information Request**

Office of Transit Safety and Oversight
Washington, DC

# Form #2 – Train Control Signal System Information

Please reference the accompanying guide for assistance.

Please email one completed form #1 and its associated Form(s) #2 by **May 7, 2019** (90 days from the date of the accompanying letter) to FTASystemSafety@dot.gov.

Please submit one form for every type of train control signal system an RTA uses.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **1. RTA name:** | | | | | | | | | |
| | | | | | | | | | |
| **2. State RTA line(s) with a common signal system technology:** | | | | | | | | | |
| | | | | | | | | | |
| **3. Select the RTA mode(s) for the line(s) stated in question 2 above:** | | | | | | | | | |
| | Heavy Rail | | Light Rail | | Streetcar/ Trolley | | Monorail/ People Mover | Other: | |
| **4. State the train control signal system type: (Select only one.)** | | | | | | | | | |
| | Automatic Block Signaling (ABS) | | Automatic Train Control (ATC) | | Centralized Traffic Control (CTC) | | None | Other: | |
| **5. If ATC, specify the type of operations:** (Select only one – lowest automated level) | | | | | | | | | |
| | Full Automatic Train Operations | | Partial Automatic Train Operations | | Manual Operations | | CBTC | Other: | |
| **6. Has the RTA added redundancy to the train control signal system to identify "loss of train detection" in real-time and subsequently stop trains automatically? (Select only one.)** | | | | | | | | | |
| | No | | | | | | | | |
| | Yes – Please describe: | | | | | | | | |
| **7. Specify activities the RTA conducted since November 2012 (when the Transit Train Control Assessment was completed) to reduce the risk of "loss of train detection" or "train signal failures" from occurring: (Select all activities that apply.)** | | | | | | | | | |
| | 1. Regularly updates relevant SOPs, forms, and test procedures/reports for train signal system inspection and maintenance programs | | | | | | | | |
| | 2. Regularly performs internal reviews/audits of the train signal inspection and maintenance procedures | | | | | | | | |
| | 3. Regularly conducts inspections of train control signal system | | | | | | | | |
| | 4. Developed and implemented a signal maintenance training program | | | | | | | | |
| | 5. Regularly conducts hazard analysis of the train signal system | | | | | | | | |
| | 6. Upgraded the train control system or equipment resulting in improved identification of "loss of train detection" | | | | | | | | |

| | |
|---|---|
| | 7. Developed or developing plans for future upgrades to train control system design and equipment |
| | 8. For train control systems sharing lines, evaluated if there is an incompatibility safety risk or other safety risk associated with this practice and implemented measures to mitigate such risk. |
| | 9. Other - Please describe: |
| | 10.None |

| | | |
|---|---|---|
| **8. Specify oversight activities the SSOA conducted to reduce the risk of "loss of train detection" or "train signal failure" from occurring since November 2012.** | | |
| Select all activities that apply: | | Verification Method / Date |
| | 1. Met with RTA to understand process for inspection and testing train signal performance | |
| | 2. Reviewed relevant SOPs, forms, and test procedures/reports for train signal system inspection and maintenance | |
| | 3. Audited RTA's train signal inspection and maintenance procedures and defect tickets | |
| | 4. Conducted inspections independently or jointly with RTA of train signal system | |
| | 5. Audited signal maintenance training program | |
| | 6. Conducted or reviewed hazard analysis of the train control signal system | |
| | 7. Developed a corrective action plan to address potential train signal system non-failsafe failures. | |
| | 8. Began oversight of project to upgrade the train signal system to include a safety certification process | |
| | 9. Other – Please describe: | |
| | 10.None | |
| **9. If the RTA line(s) have audio frequency track circuits, has the RTA implemented the American Public Transportation Association (APTA) RT-SC-S-009-03 Standard recommendations? (Please verify below.)** | | |
| Select all activities that apply: | | Description |
| | 1. Conducts updates to maintenance and inspection procedures, as needed | |
| | 2. Conducts shunt sensitivity verification tests every 12 months or similar OEM recommended frequency | |
| | 3. Unshunted and unintended signals tests every 12 months or similar OEM recommended frequency | |
| | 4. Unintended or spurious signals test | |
| | 5. Cab signal level measurement every 12 months or similar OEM recommended frequency | |
| | 6. Implementation of signal maintenance training program | |
| | 7. APTA or OEM recommended test equipment | |
| | 8. No recommendations implemented | |

| 10. What specifications/standards were used in the design and implementation of this train control system? (Select all that apply.) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | IEEE 1473 | | IEEE 1474.1 | | IEEE 1474.2 | | AAR MSRP Sec. K | | 49 C.F.R. 236.1005 |
| | EN 50126 | | EN 50128 | | EN 50129 | | IEC 61508 | | Other - Please describe |

U.S. Department of Transportation
Federal Transit Administration

**State Safety Oversight Agency Information Request**

Office of Transit Safety and Oversight
Washington, DC

# Form #3 – Train Control Related Incidents

Please email one completed Form #3 for each RTA by **May 7, 2019** (90 days from the date of the accompanying letter) to FTASystemSafety@dot.gov.

| | |
|---|---|
| **1. RTA name:** | |
| | |
| **2. How many train-on-train collisions did the RTA experience in the past 5 years? (Please enter the number for each root cause below.)** | |
| | Movement authority/stop violation |
| | Overspeed (permanent or temporary) |
| | Control operator/dispatcher error |
| | Switch misalignment/failure |
| | Other train control system related train-on-train collisions – Please describe: |
| | Total |
| **3. How many near-miss train-on-train incidents has the RTA experienced in the past 5 years?** A "near-miss incident" is a narrowly avoided collision. **(Please enter the number for each root cause below.)** | |
| | Movement authority/stop violation |
| | Overspeed (permanent or temporary) |
| | Control operator/dispatcher error |
| | Switch misalignment/failure |
| | Other train control system related near miss incident - Please describe: |
| | Total |
| **4. How many train incidents has the RTA experienced in the past 5 years?** An "incident" is an event that indicates an operating rule or safe vehicle handling practice is inadequate. It may also be the failure of an individual to adhere to established operating rules and safe vehicle handling practices. **(Please enter the number for each root cause below.)** | |
| | Movement authority/stop violation |
| | Overspeed (permanent or temporary) |
| | Control operator/dispatcher error |
| | Switch misalignment/failure |
| | Other train control system related incidents – Please describe. |
| | Total |

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East Building
1200 New Jersey Avenue, SE
Washington, DC 20590
*https://www.transit.dot.gov/about/research-innovation*