September 28, 2023 Railroad Investigation Report RIR-23-12

# Beyond Full Implementation: Next Steps in Positive Train Control

**Abstract**: In this report, the National Transportation Safety Board (NTSB) examines current positive train control (PTC) and PTC-related technologies and regulations. The report includes work already performed across existing NTSB accident investigations, additional information from interviews, and public sources to provide a clear, accurate representation of the current state of PTC. The report considers PTC's capabilities, limitations, safety goals, and safety performance. The report provides analysis of safety issues impacting four areas: restricted speed operations, end-of-track collisions, switching mode, and work zone protection on active tracks. The report notes promising but not yet mature technologies that may improve PTC's safety performance and considers the role regulations may play in expanding and realizing PTC's potential to further advance rail safety. As a result of this investigation, the NTSB has made safety recommendations to the Federal Railroad Administration.

# Contents

# Figures

# Acronyms and Abbreviations

| | |
|---|---|
| **ACSES** | Advanced Civil Speed Enforcement System |
| **Amtrak** | National Railroad Passenger Corporation |
| **BNSF** | BNSF Railway |
| **CBTC** | Communications-Based Train Control |
| ***CFR*** | *Code of Federal Regulations* |
| **CSX** | CSX Transportation |
| **EIC** | employee-in-charge |
| **ETD** | end-of-train device |
| **FRA** | Federal Railroad Administration |
| **I-ETMS** | Interoperable Electronic Train Management System |
| **LIRR** | Long Island Rail Road |
| **Metro-North** | Metro-North Railroad |
| **MOW** | maintenance-of-way |
| **NJT** | New Jersey Transit |
| **NTSB** | National Transportation Safety Board |
| **PTC** | positive train control |
| **RSIA 2008** | Rail Safety Improvement Act of 2008 |
| **RTC** | rail traffic controller |
| **RWIC** | roadway worker in charge |

# Executive Summary

In December 2020, the Federal Railroad Administration (FRA) announced that positive train control (PTC) was fully implemented as required by the Rail Safety Improvement Act of 2008. The widespread implementation of PTC followed decades of National Transportation Safety Board (NTSB) recommendations based on PTC-preventable accidents.

This report examines current FRA regulations related to PTC and technological developments that have occurred since full deployment in 2020. We then discuss and re-evaluate seven previous accidents in light of these developments. This report and its accompanying docket represent the NTSB's first engagement with PTC since the FRA and affected railroads achieved compliance with the statutory requirements of the Rail Safety Improvement Act of 2008.

The report begins with an overview of PTC systems, including recent history, underlying technologies, and limitations. After this overview, the report is organized into safety issues affecting four areas: restricted speed operations, end-of-track collisions, switching operations, and roadway worker protection. The report makes recommendations to the FRA.

## What We Found

At present, PTC is successful at signal enforcement, but limitations in PTC systems' access to train location information impede detection of and response to train-to-train collision threats during restricted speed operations. We found that research can support the development and implementation of PTC technologies that, by reliably identifying and locating the end of a train and communicating that information to other trains, can prevent train-to-train collisions during restricted speed operations.

We also found that advancements in PTC and PTC-related technologies can prevent or mitigate the severity of end-of-track collisions in terminals; once these technologies are deployed, exceptions to PTC installation for terminals would no longer be needed. Further, we found that PTC software components for switching, or restricted, mode that require human intervention to return to active PTC protection on main tracks can result in PTC signal enforcement being unnecessarily disabled within 5 miles of the switching operation.

Finally, we found that other technologies, such as tablet computers used by roadway workers in charge, can be deployed in PTC to improve communication and enforcement of working limits.

## What We Recommended

As a result of this investigation, we recommended that the FRA complete and publish research on PTC technologies to prevent train-to-train collisions during restricted speed operations and develop a plan to implement research results. We also recommended that the FRA work with railroads to eliminate exceptions to PTC installation for terminals.

We made a recommendation to the FRA to require railroads to adopt engineering controls that automatically return PTC to active mode following switching operations. This recommendation supersedes safety recommendation R-20-18 regarding engineering controls limiting the use of PTC in restricted mode on main tracks. We further recommended that the FRA require railroads to implement technologies that eliminate the risk of miscommunication about established working limits and PTC protection.

# 1 Introduction

The Rail Safety Improvement Act (RSIA) of 2008 requires Class I railroads and each "entity providing regularly scheduled intercity or commuter rail passenger transportation" to develop, submit, and carry out a plan for implementing positive train control (PTC) (RSIA 2008).[1] RSIA 2008 defines a PTC system as "a system designed to prevent train-to-train collisions, over-speed derailments, incursions into established work zone limits, and the movement of a train through a switch left in the wrong position" (RSIA 2008). PTC installation is required on tracks with regularly scheduled intercity or commuter passenger rail service and Class I railroad main lines carrying poison- or toxic-by-inhalation hazardous materials.[2] RSIA 2008 also gives the U.S. Secretary of Transportation regulatory authority to designate tracks as main lines, which may require PTC installation.

The Federal Railroad Administration (FRA) regulates PTC under Title 49 *Code of Federal Regulations* (*CFR*) Part 236, Subpart I, which provides track- and operation-specific requirements and exceptions for PTC deployment and use. PTC deployment was subject to a series of statutory deadlines, and the FRA adopted a regulatory approach intended to help railroads meet these deadlines with compliant and interoperable PTC systems.[3] According to the FRA, at the time of this report's publication, 42 railroads are subject to the PTC mandate, including 7 Class I railroads, Amtrak (also known as the National Railroad Passenger Corporation), and various commuter and regional or short line railroads. The FRA also reports that PTC systems were deployed on 57,536 miles of track as of December 2020, a status the FRA

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[1] Visit ntsb.gov to find additional information in the public docket for this NTSB investigation (case number DCA21SR003). Use the CAROL Query to search safety recommendations and investigations.

[2] (a) The statute defines a *main line* as a segment of track that carries more than 5 million gross tons of railroad traffic. Main line is distinct from main track, the term commonly used by industry and the FRA to describe track used to move cargo and passengers. *Main track* is used in this report except when discussing the requirements of RSIA 2008 or regulations that specifically mention main lines. (b) RSIA 2008 does not require PTC installation on track segments carrying poison- or toxic-by-inhalation hazardous materials, provided that the segment is not a main line. These products may also be carried over non-PTC-equipped track owned by a Class II or Class III railroad, provided that this track is not used for passenger service or, if used for passenger service, is granted a main line track exception. (c) Class I railroads are railroads with annual revenues of more than about $500 million, Class II railroads have annual revenues of more than about $40 million, and Class III railroads have revenues below the Class II threshold. These values are regularly adjusted for inflation.

[3] RSIA 2008 originally set December 31, 2015, as the deadline to implement PTC. In late 2015, Congress passed the Positive Train Control Enforcement and Implementation Act, extending the compliance deadline 3 years to December 31, 2018. That bill required the FRA to grant further extensions to December 31, 2020, for railroads meeting statutory criteria.

characterized as "full implementation" of PTC under statutory and regulatory requirements (FRA 2020).

Any PTC system deployed by a railroad must be interoperable—that is, the controlling locomotive must be able to communicate with and respond to the systems used by other railroads.[4] Under 49 *CFR* 236.1011, railroads must receive FRA approval of a PTC implementation plan to ensure compliance and interoperability between host and tenant railroads.[5] FRA regulations require interoperability of PTC systems so that they can function when locomotives owned by one railroad operate over tracks owned by a different railroad, including during movements across property boundaries. Many railroads operate over one another's track, and many of these railroads have adopted similar PTC systems to ensure interoperability and to enable them to file jointly for FRA approval of modifications.[6]

The practical demands of interoperability and the statutory and regulatory requirements for PTC approvals made the FRA a critical partner in shaping the current implementation of PTC. The Rail Safety Advisory Committee (RSAC, an advisory committee established by the FRA in 1996 and responsible for developing consensus-based regulatory standards) worked closely with the industry to develop regulations conducive to the timely implementation of safe PTC systems.[7] Although these PTC systems, which primarily involve signal enforcement, represent a marked improvement in safety as envisioned by RSIA 2008, technical limitations and the need for stakeholder consensus in the rulemaking process resulted in the deployed PTC systems not fully achieving the performance goals of collision avoidance envisioned by the National Transportation Safety Board (NTSB).[8]

The NTSB conducted a review of FRA regulations, currently deployed PTC systems, recent developments in PTC technology, and our past recommendations

[4] Title 49 *CFR* 236.1003.

[5] A *host railroad* is a railroad with effective operating control over a segment of track. A *tenant railroad* is a non-host railroad operating on track where PTC is required.

[6] Material modifications of existing PTC systems are subject to FRA approval under 49 *CFR* 236.1021.

[7] For more information about RSAC, see https://rsac.fra.dot.gov/about.

[8] In its response to the FRA's July 21, 2009, notice of proposed rulemaking on PTC systems, the NTSB stated that it "urges the FRA and the railroads to work on developing technology that will improve the prevention of rear-end collisions at restricted speeds and to incorporate that technology into existing PTC systems as it becomes available." NTSB to U.S. Department of Transportation, Attention: Docket No. FRA-2008-0132, Notice No. 1, August 18, 2009.

relevant to the issues presented in this report. We also re-evaluated seven previous accidents and identified situations in which hazards were not fully mitigated by current PTC systems and how these hazards could be mitigated by recent technological developments.[9]

The NTSB identified the following safety issues:

- Insufficient information about train location during restricted speed operations
- Obsolete exceptions to PTC use in terminal environments
- Overreliance on administrative controls to prevent unsafe use of switching mode on main tracks
- Unsafe train incursions into established working limits

This report first will describe PTC. Each issue area will then be addressed, focusing on current requirements, technological developments since PTC implementation, case studies associated with the issue area, and a discussion of how current and future technological developments could improve safety.

[9] For a list of all NTSB recommendations that address PTC, see Appendix C: Previously Issued Safety Recommendations

# 2 Positive Train Control Systems

## 2.1 Overview

PTC uses a communications system and combinations of locomotive-mounted, wayside, and back-office equipment to enforce signals and permanent and temporary speed restrictions. Each PTC system uses an in-cab display to communicate information to the engineer and a speed control unit to automatically apply brakes ("penalty braking") if the engineer fails to comply with speed restrictions. PTC calculates a safe braking profile as the train approaches a signal requiring deceleration and will apply the train's brakes if the engineer does not slow the train within the parameters of the calculated profile. Current PTC systems were overlaid on existing signal infrastructure, and their exact methods of operation, train detection, and communication vary based on this underlying infrastructure and design choices. Figure 1 provides an illustration of how one type of PTC system can operate.

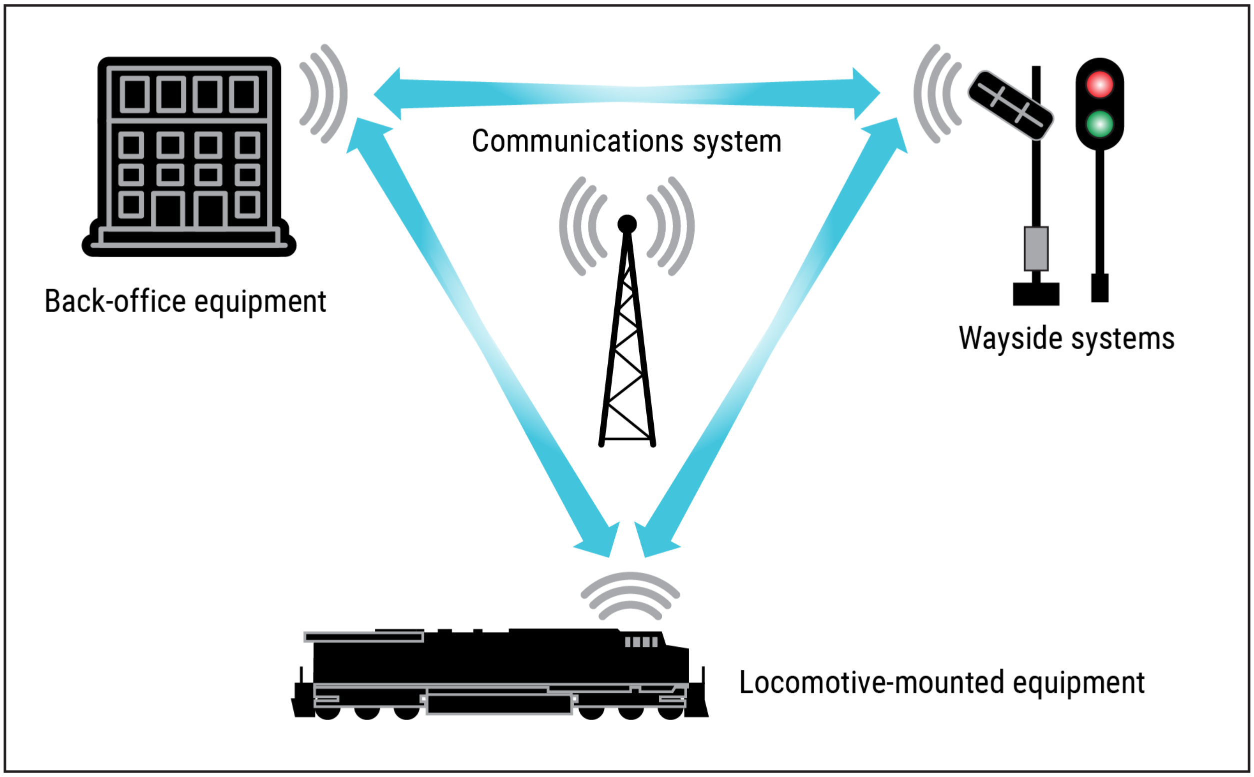


**Figure 1.** Illustration of key PTC components of one type of system. (Based on an illustration from the Association of American Railroads.)

As noted above, several interoperable PTC systems are in current use. The most common by number of users and route miles is the Interoperable Electronic Train Management System (I-ETMS), which is used by several Class I railroads, numerous commuter railroads, and Amtrak (when operating as a tenant railroad). In Amtrak's Northeast Corridor, Amtrak uses the Advanced Civil Speed Enforcement System II (ACSES II); CSX Transportation (CSX) uses ACSES II when operating as a tenant on Amtrak track. Other commuter railroads use their own systems, such as the Communications-Based Train Control (CBTC) system operated only by the Port Authority Trans-Hudson. Most of the examples in this report reference I-ETMS, but the findings and recommendations are broadly applicable because PTC systems share the basic features described above: locomotive-mounted, wayside, and back-office systems that share information to enforce signals and other speed restrictions.

## 2.2 Train Location and Communication

PTC systems use GPS units mounted on locomotives, track-mounted transponders, track circuits, or combinations of these technologies to establish train locations.[10] Most systems track only the head of the train, either through GPS or a sensor that detects unique track-mounted transponders and resets a wheel-tachometer–based positioning system at these fixed points. As such, most PTC systems do not directly monitor an entire train's location; they detect a locomotive's speed and location relative to signals.[11] I-ETMS, for example, uses GPS to identify the distance between a train's head end and a target such as a signal.[12] In addition, I-ETMS uses track circuit occupancy to determine which track the train is on and, therefore, which signal it must obey, and uses on-board equipment to measure and control the train's speed. Because the precise length of the train is unknown, the rear end's location is unknown to the PTC system, and I-ETMS cannot monitor the rear end's location. It detects the head end position relative to signals.

Information such as signal indications, speed restrictions, and track integrity status is communicated to locomotive-mounted equipment through modulation of track circuit current, dedicated wayside radios, or internet-connected devices. Radios or hard lines are used to communicate information from the field to back-office systems and vice versa; the exact role of back-office systems varies between PTC

[10] This report uses *location* to describe information about where a train is relative to signals and on-rail equipment. It uses *position* for all other spatial information, such as when describing the mounting site for an on-train device or resolution of a positioning system.

[11] This is true of the most widely deployed systems. CBTC, a less common type of PTC system, can provide more complete information about a train's footprint when paired with certain underlying infrastructure. In the United States, only the Port Authority Trans-Hudson uses CBTC under the RSIA 2008 mandate. For a full explanation of CBTC and moving block architecture, see the Port Authority Trans-Hudson's PTC Implementation Plan, Revision 7.0, dated December 15, 2015, and accessible here: https://www.regulations.gov/document/FRA-2010-0034-0034.

[12] A *target* is point or feature of the rail system visible to the PTC system.

implementations. Because trains from one railroad (a tenant railroad) may operate over another railroad's track (a host railroad), tenants and hosts must maintain interoperable systems that allow communication between their respective trains, wayside equipment, and back offices.

## 2.3 Positive Train Control System Limitations

### 2.3.1 Signal Enforcement

Currently deployed PTC systems enforce signals, and their efficacy depends on signals being set correctly. For example, if a dispatcher prematurely removes signal protection from established working limits, PTC will no longer prevent a train from transiting the work zone.[13] When two trains occupy the same signaling block (a condition permitted by some signals), each train's speed control will enforce the speed limit set for the block; PTC will not detect or respond to a close approach or collision between the trains.

### 2.3.2 Fidelity and Accuracy

PTC systems that use GPS can be degraded by loss of GPS reception or accuracy, as can occur in tunnels, underground, in sheds, or in urban canyons. If GPS cannot fix a train's location before the train departs its initial terminal, the PTC system will not initialize, and the train may proceed only if it complies with requirements set by 49 *CFR* 236.1029(b), which provide for additional speed limitations, signal protection, and other safety measures.[14]

There are limits to GPS accuracy even with strong reception, which can complicate performance. For example, conventional GPS offers an average position accuracy of 15 meters (about 50 feet), and differential GPS can improve this to 3–5 meters (10–17 feet). This is insufficient to resolve track occupancy in multi-track environments, however, where track centers may be 13 feet apart; in these situations, track circuits are often used to determine occupancy.[15] This level of GPS accuracy also

[13] *Working limits* are defined by 49 *CFR* 214.7 as a segment of track with definite boundaries upon which trains and engines may move only as authorized by the roadway worker having control over that defined segment of track. See section 6 for more on working limits.

[14] See 49 *CFR* 236.1029(g) for temporary exceptions that allowed a train to proceed under some additional circumstances if its PTC system failed to initialize before departure from its initial terminal. These exceptions ended on December 31, 2022.

[15] For a detailed discussion of current GPS technology in rail applications and emerging technologies, see FRA, "High Accuracy Global Positioning System Tests: Phase I" (Washington, D.C.: FRA, 2021).

limits PTC's ability to accommodate some common train movements; commuter trains regularly must stop within a few feet of end-of-track bumper posts (posts used to prevent trains from going past the end of the section of track).

### 2.3.3 Main Track and Switching Operations

PTC systems provide protection on main tracks; they are not intended to protect trains or personnel in yards. Practical considerations limit PTC protection during switching operations that involve main track operations. For example, one movement that trains commonly perform during switching operations—reversing onto a main track through a red signal—is not permitted by PTC systems, and engineers must manually activate a "switching mode" that disables signal enforcement during switching operations that involve a train reversing onto signaled track.[16]

[16] *Switching mode* is more commonly referred to as *restricted mode*. This report uses *switching mode* to avoid confusion with *restricted speed*, an unrelated operating condition.

# 3 Restricted Speed Operations

## 3.1 Introduction

Restricted speed operations occur when a train operates below 20 mph (or at a lower limit set by operation rules) and at a speed that will allow it to stop within one-half the range of vision of the operator.[17] Restricted speed is not a fixed value; what qualifies as restricted speed varies with the stopping distance of the train, sight distances, conditions affecting visibility, and any speed limits set by the railroad. The effectiveness of restricted speed at preventing collisions depends on human performance, such as the crew's vigilance and awareness of these variables, which can be unreliable.

RSIA 2008 describes a PTC system as one capable of preventing train-to-train collisions. Under FRA regulations, a PTC system is configured to prevent train-to-train collisions if trains are required to operate at restricted speed and if the onboard PTC equipment enforces the upper limit of the railroad's restricted speed rule.[18] Case studies presented in section 3.3 reveal the limits of PTC systems as currently configured in preventing rear-end train-to-train collisions; technology improvements, however, offer a path forward.

## 3.2 Technology Improvements

PTC systems enforce signals, but under a *permissive block system*, trains may proceed past a signal indicating that the track ahead is occupied provided the trains operate at restricted speed as dictated by signals and operating rules. For example, while a red absolute signal means stop and stay stopped, a red permissive signal means proceed at restricted speed and be prepared to stop. Under these conditions, PTC's signal enforcement alone does not ensure train separation because most currently deployed PTC systems cannot recognize trains as targets. Once past a signal and within the already-occupied block, PTC will not enforce a stop as long as the train does not exceed the maximum speed limit set by railroad policy, and the

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[17] *Restricted speed* is defined by FRA regulations in 49 *CFR* 236.812.

[18] Title 49 *CFR* 236.1005 states: "A PTC system shall be considered to be configured to prevent train to train collisions … if trains are required to be operated at restricted speed and if the onboard PTC equipment enforces the upper limits of the railroad's restricted speed rule (15 or 20 miles per hour). This applies to: (1) Operating conditions under which trains are required by signal indication or operating rule to: (i) Stop before continuing; or (ii) Reduce speed to restricted speed and continue at restricted speed until encountering a more favorable indication or as provided by operating rule." The requirement in 49 *CFR* 236.1005 (f) further applies to "operation of trains within the limits of a joint mandatory directive."

crew alone must observe and respond appropriately to the presence of other trains or equipment. Avoiding a rear-end collision depends on the combination of PTC-enforced low speeds and the crew's successful adherence to restricted speed requirements.

The NTSB has identified three families of technologies that could enable PTC to prevent rear-end train-to-train collisions rather than signal enforcement: object detection, GPS tracking, and virtual block systems. These technologies are described below.

### 3.2.1 Object Detection

Object detection systems typically use data from cameras, radar, or other technologies to construct a model of the surrounding environment. The NTSB has documented the limitations of object detection in other modes, both in correspondence with US Department of Transportation modal administrations and in highway accident investigations (NTSB 2017, 2019, 2020).[19] According to the FRA's Chief of Train Control and Communication (within the FRA's Office of Research, Development and Technology), the FRA is working to develop performance requirements for object detection systems.[20]

The FRA is also testing object detection systems' ability to classify objects. Emergency braking can risk derailment, so a system able to automatically initiate an emergency application of the train's air brakes needs to discriminate between objects and react appropriately. An object that poses no or low risk of derailment—such as a windblown bag of trash or tree branch—requires a different response than a car fouling the tracks at a railroad–highway grade crossing, a person, or the rear of another train.[21]

### 3.2.2 GPS Tracking

The FRA is currently testing technologies able to determine and communicate the precise location of a train's rear end using GPS-equipped end-of-train devices

[19] Earlier this year, the NTSB responded to notices for proposed rulemaking on automatic emergency braking performance standards for light vehicles (up to 10,000 pounds) and heavy vehicles (more than 10,000 pounds).

[20] The transcript of this and other interviews conducted for this report is available in the public docket.

[21] An object is *fouling* a track when positioned such that it would be struck by a train on that track.

(ETDs).[22] FRA research determined that the mounting position of ETDs has a significant effect on GPS performance; depending on this position, the body of the last railcar may block enough of the sky to preclude a consistent, reliable GPS signal. Because ETDs serve other functions—notably, relaying braking information to the engineer and, in some cases, performing two-way braking—the position of the device is not arbitrary.[23]

Wabtec, which manufactures I-ETMS, is developing a similar GPS-based system for tracking the rear ends of trains. Wabtec's system uses a GPS-equipped ETD to pinpoint the rear end of the train and radio this information to the locomotive. Further development could support communicating the rear end's location to wayside equipment to enforce train separation.

The system being tested by the FRA and the one under development by Wabtec depend on GPS-equipped ETDs. These are becoming more common in the rail industry, though the GPS is currently used for inventory tracking rather than train location.

### 3.2.3 Virtual Block Systems

On April 29, 2018, BNSF Railway (BNSF) filed for a patent on a system to locate a train's ends using existing track circuits (BNSF 2021).[24] This technology monitors the change in electrical characteristics of the track circuit as a train traverses a signal block, creating a "virtual block" within the physical block. For a westbound train, the signal house west of the train detects when the head end enters a new virtual block and communicates this information to wayside or on-board equipment, while the signal house east of the train detects and communicates when the rear end leaves a virtual block. The resolution of the system depends on how many virtual blocks comprise the physical signal block. For a 2-mile block, four virtual blocks would

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[22] (a) The ETD is the only powered railcar-mounted unit accommodated by current railcar design and therefore a logical base for a GPS module. ETDs are usually mounted on or near the last rear coupler in a consist and are powered by a small turbine-powered electrical generator that runs on airflow from the brake line. (b) Currently, the FRA's research is exploratory and not yet directed to approval of any specific technology.

[23] When a train applies its air brakes, each railcar's brakes activate when the pressure in the brake line falls. This drop in pressure propagates from the locomotive at the speed of sound, meaning that railcars further from the locomotives apply their brakes later, resulting in elevated in-train forces. In *two-way braking*, the air brake application propagates from both the head and rear ends of a train, reducing in-train forces.

[24] For the full patent, see https://patentimages.storage.googleapis.com/db/10/be/7d94888e9360b9/US10894550.pdf.

locate the head and rear ends of a train to within half a mile. Based on this information, the system would maintain a buffer zone behind the train, adjusting speed restrictions for approaching trains to maintain separation.

On August 2, 2021, BNSF requested FRA approval to field test this new technology (FRA 2021). An FRA response dated April 5, 2022, indicated that the FRA was still reviewing and deliberating on the merits of the request.[25]

## 3.3 Case Studies

### 3.3.1 Kingman, Arizona, June 5, 2018

On June 5, 2018, a westbound BNSF intermodal train, S MEMSCO1 02L, was operating on multiple main track in centralized traffic control territory when it collided with the rear of a slow-moving eastbound work train, WNEESGM1 05.1 (NTSB 2021). The work train was making an eastbound reverse move to drop off an employee before traveling west to exit one of the two main tracks. Upon rounding a curve and sighting the work train, the intermodal train's crew did not initially realize that the work train was on their track. The intermodal train's engineer initiated an emergency application of the train's air brakes too late to prevent the collision, which resulted in a fatality and serious injuries.

PTC was in use in the area of the accident, and both trains were equipped with Wabtec's I-ETMS, which establishes signals as targets, and operating below 15 mph. For I-ETMS, a restricting signal is a target that requires restricted speed, which is 20 mph on BNSF tracks. At the time of the accident, the system was designed to give visual and audible alarms upon exceeding the 20-mph restriction by 3 mph, but the intermodal train was traveling at 15 mph. Further, if a target were detected and the engineer did not take action to reduce speed within a time interval calculated based on train speed and a braking algorithm, I-ETMS would automatically apply brakes and bring the train to a stop. However, the rear of a train was not an I-ETMS target, thus the system did not trigger the approaching train to penalty brake. Because of the low speed in this collision (below 15 mph) and lack of targets requiring a stop, neither train's I-ETMS initiated braking.

The NTSB found in the Kingman investigation that the crewmembers of intermodal train S MEMSCO1 02L operated at a speed that did not allow their train to

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[25] The status of this and related requests on the FRA nonrulemaking docket for BNSF PTC plans (FRA 2010-0056) can be found at https://www.regulations.gov/docket/FRA-2010-0056.

stop within half the range of vision as specified in Title 49 *Code of Federal Regulations* 236.812 for restricted speed operations.

### 3.3.2 Red Oak, Iowa, April 17, 2011

On April 17, 2011, an eastbound BNSF coal train C-BTMCNM0-26, BNSF 9159 East, traveling about 23 mph, collided with the rear end of a standing BNSF maintenance-of-way (MOW) equipment train U-BRGCRI-15, BNSF 9470 East, near Red Oak, Iowa (NTSB 2012). The collision resulted in the derailment of 2 locomotives and 12 cars. The lead locomotive's modular crew cab was detached, partially crushed, and involved in a subsequent diesel fuel fire. Both crewmembers on the striking train were fatally injured.

At the time of this accident, PTC was not installed at the accident site nor on the locomotives. BNSF later implemented I-ETMS, which would have enforced a speed limit past the restricting signal but provided no rear-end detection or collision avoidance capabilities.

The NTSB issued two findings related to PTC:

- Had the positive train control/Electronic Train Management System currently in development been installed on the Creston Subdivision, it most likely would not have prevented this accident because it does not identify the rear end of a standing train as a target and because it allows following movements at up to 23 mph.

- The positive train control designs that are being deployed and the Federal Railroad Administration's final rule on the application of positive train control are unlikely to prevent future restricted speed rear-end collisions similar to the 58 rear-end collisions reported to the Federal Railroad Administration over the last 10 years or the collision at Red Oak because train speeds at the upper limit of restricted speed are allowed.

## 3.4 Safety Analysis

Both the Kingman and Red Oak rear-end collisions occurred during restricted speed operations, meaning that safety depended on crew compliance with restricted speed requirements. The Kingman collision occurred despite the presence of an FRA-compliant PTC system, which did not prevent the crew from striking the rear of the train ahead of theirs. Currently deployed PTC systems would not have prevented the Red Oak collision because they allow train speeds at a fixed upper limit; once both trains occupied the same signal block, they were wholly reliant on human performance for safe operation.

Kingman and Red Oak illustrate the gap in PTC protections left by dependence on signal enforcement when a permissive block system is used—that is, PTC enforces speeds based on signal indications but cannot adapt to other factors like visibility or the presence of other equipment. As discussed earlier, PTC governs train movements relative to signals but not relative to one another; trains are not system targets, and complete, accurate, and precise information about train location is not available to most currently deployed PTC systems. As such, PTC enforces signals but does not detect collision threats. The rear end of a train is not visible to the system even though it can become a collision threat once trains are permitted to share signal blocks, and this results in a single point of failure: the performance of the crew, who may misjudge another train's location and distance (as in Kingman) or may be fatigued (as in Red Oak) or otherwise distracted.

FRA regulations consider a PTC system enforcing a railroad's upper limit on restricted speed during restricted speed operations as meeting the requirements of RSIA 2008. However, this method means that PTC systems cannot prevent all restricted speed rear-end collisions because the systems do not collect enough information about train location to set a train as a target. PTC systems detect only where and how head ends are moving within the existing signal blocks. The outcome is that collision avoidance during restricted speed movements depends on the crew correctly judging range of vision, often over distances of a mile or more, and then adjusting the train's speed appropriately and responding in time to collision threats. Therefore, the NTSB concludes that although currently deployed PTC systems can enforce a fixed speed limit, insufficient information about train location precludes PTC from effectively detecting and responding to train-to-train collision threats during restricted speed operations.

Technologies under research and development can render the rear of a train visible to PTC, either through object detection, monitoring by a GPS-equipped ETD, or a virtual block system. These emerging technologies could provide PTC with more precise information about train locations. Two of these technologies—GPS and virtual block systems—provide information about distances between trains, even around blind corners or when multi-track environments make judging a train's location difficult, thus addressing the restricted speed failure in the Kingman collision. Setting the rear ends of trains as targets would allow PTC to identify a collision threat encountered during restricted speed operations and respond by braking. Although PTC can reduce the severity of collisions by enforcing speed limits, it cannot prevent all of the types of collisions that occur due to human errors, and can still result in injuries and fatalities.

Currently deployed PTC systems generally do not have the ability to detect the presence of other trains and respond to a potential train-to-train collision. This gap in ability leaves the crew solely responsible to observe and respond appropriately to the presence of other trains or equipment, even in situations when such a response is complicated by visibility conditions, crew performance, or other factors. The crew of the striking train in the Kingman, Arizona, collision misjudged another train's location and failed to brake in time, resulting in a rear-end collision; a PTC system with independent access to the location of other trains and ability to impose a penalty brake could have prevented this collision. In the case of Red Oak, Iowa, the striking train was traveling at a speed a deployed PTC system would have permitted, but the crew was incapacitated by fatigue and did not maintain the vigilance needed to detect the standing MOW equipment, resulting in a rear-end collision. The use of a more advanced PTC system that brakes in response to collision threats could have prevented the collision. In both cases, a PTC system with collision-avoidance capabilities for restricted speed operations would not have had to rely on human performance and observations, particularly as they apply to the requirement that an operator assess stopping distance as a function of their range of vision and current speed. By detecting and responding to the presence of other trains, such a system would address the difficulty of judging distances in restricted speed environments.

The NTSB recognizes that the FRA and private entities have research and development efforts underway related to performance requirements for object detection sensors and to test improved GPS technologies. The NTSB is encouraged by efforts to support improvements to PTC-related technologies that could be used to prevent train-to-train collisions during restricted speed operations. Further, although the NTSB believes that eventually amending FRA regulations to expand PTC requirements beyond enforcement of railroad's maximum restricted speed limits would further support the implementation of improved PTC technology, the NTSB acknowledges that the technologies discussed are still under development. Therefore, the NTSB concludes that, for PTC to ensure safe train separation when trains are operating under restricted speed in a permissive block, technologies must be deployed that will reliably identify and locate the end of a train and communicate that information to other trains in the area. Therefore, the NTSB recommends that the FRA complete and publish the results of current research into PTC technologies to prevent train-to-train collisions during restricted speed operations. The NTSB further recommends that the FRA, once the results of this research are available, develop a plan to implement any promising PTC technologies for train-to-train collision avoidance.

# 4 End-of-Track Collisions

## 4.1 Introduction

About 21 railroads have requested and received exceptions to PTC installation for passenger terminals as of January 2023. Under 49 *CFR* 236.1019, the FRA considers exceptions on main line track that meet certain criteria, such as speeds of less than 20 mph and no or limited freight operations.[26] These exceptions do not prevent accidents in the terminal environment (see section 4.3), but precision improvements in PTC technologies may render such exceptions obsolete.

## 4.2 Technology Improvements

The terminal exceptions in 49 *CFR* 236.1019 were incorporated to allow for previously recognized technical challenges that could prevent PTC systems from working or degrade their effectiveness. These challenges included GPS reception (terminals are often underground, where reception is poor), GPS accuracy (trains routinely need to stop close to bumper posts), and the complexity of the terminal interlocking (the proximity of switches and the many route combinations complicate the operation of track circuits).

Technology has improved since full implementation of PTC systems. For example, the Regional Transit District, a commuter railroad in Colorado, uses I-ETMS in terminals and sets bumper posts as "zero speed targets," enforcing automatic stops before the train reaches the end of the track and the bumper post. Other methods for overcoming GPS- and interlocking-related problems use non-GPS sensors and data to determine train locations. Wabtec and the PTC Interoperable Train Control Working Committee identified PTC-related technologies that do not require continuous GPS coverage in their interviews with the NTSB, as described below.[27]

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[26] According to 49 *CFR* 236.1019, track in passenger terminals may be granted an exception if: "(1) The maximum authorized speed for all movements is not greater than 20 miles per hour, and that maximum is enforced by any available onboard PTC equipment within the confines of the yard or terminal; (2) Interlocking rules are in effect prohibiting reverse movements other than on signal indications without dispatcher permission; and (3) Either of the following conditions exists: (i) No freight operations are permitted; or (ii) Freight operations are permitted but no passengers will be aboard passenger trains within the defined limits."

[27] The PTC Interoperable Train Control Working Committee comprises representatives from several Class I railroads using the same PTC system and other stakeholders.

Dead reckoning, or using wheel tachometer data to monitor a train's location, is already a feature of some PTC systems deployed on main lines and offers an option for overcoming poor GPS reception in passenger terminals. The ACSES II system (whose users include Amtrak and CSX in Amtrak's Northeast Corridor) relies on track-mounted transponders rather than GPS to locate trains; a sensor on the locomotive detects the transponder and resets the tachometer count at this known coordinate, reducing tachometer error to zero. ACSES II monitors the locomotive's location relative to signals using tachometer data until the train reaches the next transponder, which again resets the tachometer.

In an interview with the NTSB, Wabtec reported that its I-ETMS system uses wheel tachometer data if it loses GPS coverage. The system accumulates uncertainty over time and distance; this uncertainty is factored into its calculations until it reaches a threshold at which operation becomes unreliable.[28] I-ETMS can operate in this mode for miles, provided that the track is accurately mapped.[29] This dead reckoning sees daily use in environments where GPS reception is intermittent (such as Glenwood Canyon in western Colorado) or non-existent (such as the 6.2-mile Moffatt Tunnel in northern Colorado).

For its commuter lines in the Chicago metropolitan area, Union Pacific prevents high-speed end-of-track collisions in its Chicago terminal by imposing a series of progressively lower speed restrictions at points identified using tachometer and track data. This implementation brings a train within 3 to 6 feet of a bumper post at less than 3 mph. The system tracks train locations precisely enough to allow trains to transit the terminal interlocking without undue delay. Amtrak uses similar solutions at Union Station in Los Angeles to mitigate end-of-track collisions.

## 4.3 Case Studies

### 4.3.1 Hoboken, New Jersey, September 29, 2016

On September 29, 2016, New Jersey Transit (NJT) train 1614 failed to stop, overrode a bumper post at the end of track 5, and struck a wall of the Hoboken

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[28] Different railroads impose different responses once the system has accumulated enough error to become unreliable. Trains are allowed to proceed to the final location for which they have movement authority. Then, depending on the railroad, they may be required to stop or permitted to proceed under more restrictive rules.

[29] The NTSB's interviews resulted in varying estimates of how long I-ETMS can operate on dead reckoning. The minimum estimate was a "single-digit number of miles"; the maximum estimate was "over 10 miles."

Terminal (NTSB 2018).[30] Train 1614 consisted of one controlling passenger car (cab car), three passenger cars, and one locomotive at the rear of the train. The train was traveling about 21 mph at the time of the accident. One person on the passenger platform was struck by falling debris and died; 110 passengers and crewmembers were injured.

NJT's PTC deployment was incomplete at the time of the accident, but the planned PTC system designated the terminal interlocking at Hoboken as "other-than-main line track." At the terminal interlocking, the system would limit train speeds, but no technology would intervene to prevent trains from colliding with the end of the track. As such, the planned PTC may not have prevented the collision.

### 4.3.2 Brooklyn, New York, January 4, 2017

On January 4, 2017, Long Island Rail Road (LIRR) passenger train 2817 collided with the platform at the end of track 6 in the Atlantic Terminal in Brooklyn, New York (NTSB 2018a).[31] The train's engineer fell asleep and did not stop before the end of the track. The lead end of the lead car struck the bumper post while traveling about 13 mph and continued through a wall, eventually coming to rest on top of the concrete platform at the end of the track. A total of 108 people were injured.

PTC was not installed on the track or train at the time of the accident; LIRR was still in the process of deploying its PTC system. However, LIRR had requested, and the FRA had approved, an other-than-main-line exception for PTC at the Atlantic Terminal station. In accordance with this exception, LIRR operating rules would limit the authorized track speeds to 5 mph, but no technology would automatically enforce this limit or intervene to prevent the train from colliding with the end of the track. The train control system would instead enforce a 15-mph speed limit set by a restricting signal in compliance with 49 *CFR* 236.1019 (b).

In a special investigation report addressing both the Hoboken and Brooklyn end-of-track collisions, the NTSB issued two findings relevant to PTC:

- As evidenced by these two accidents, relying solely on an engineer's ability to stop his or her train before reaching the end of these tracks does not provide the level of safety necessary to protect the public.

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[30] The bumper post in this accident was a rigid structure level with the train's coupler at the end of the track.

[31] The bumper post in this accident consisted of four legs supporting a steel block level with the train's coupler.

- The use of operating rules and procedures to mitigate end-of-track collisions was an inadequate method for preventing these accidents because it failed to eliminate the possibility of a single point failure. (NTSB 2018b)

## 4.4 Safety Analysis

The FRA's regulatory requirements allowing the approval of main line track exceptions for passenger terminals for about 21 railroads as of January 2023, including the exceptions provided to the terminals in the Hoboken and Brooklyn collisions, were promulgated before the presence of the functioning family of PTC systems now in place. Modern PTC systems now can overcome problems with GPS tracking and efficiently move trains through complex interlocking while maintaining signal enforcement. Several passenger terminals today are equipped with systems that would have prevented or mitigated the Hoboken and Brooklyn collisions by monitoring train locations and slowing or stopping the trains as they neared the end of the track, eliminating the single point of failure shared by both collisions: complete reliance on the engineer to slow and stop the train. These technology enhancements could render the need for exceptions unnecessary in many cases. Therefore, the NTSB concludes that precision improvements in PTC and PTC-related technologies can prevent or mitigate the severity of end-of-track collisions in terminals, removing the need for most terminal exceptions once the technologies are deployed. As such, the NTSB recommends that the FRA work with railroads to remove terminal exceptions currently granted under 49 *CFR* 236.1019 using available improved PTC-related technologies.

# 5 Switching Mode

## 5.1 Introduction

Switching operations that occur near a main track may require reverse movement through restricting signals. To perform this movement, an engineer must manually turn off a PTC system's signal enforcement functions. In this state—referred to in this report as "switching mode"—a PTC system remains compliant with FRA regulations as long as switching is performed at restricted speed and the PTC system enforces the upper limit of the railroad's restricted speed policy (49 *CFR* 236.1005). In their current iteration, some systems still require human intervention to activate PTC protection after a switching operation.

## 5.2 Technology Improvements

Initially, as part of their PTC deployment, CSX used an I-ETMS that required the train's engineer to manually toggle between switching mode and active mode (in which PTC provides signal enforcement). An I-ETMS software update later added a safeguard intended to limit the use of switching mode on main tracks by prompting the engineer to confirm whether they want to remain in switching mode after the train has been in switching mode for 5 miles.[32] If the engineer does not respond to the prompt within 30 seconds, the PTC applies the brakes and brings the train to a stop before allowing the engineer to resume control.

## 5.3 Case Study

On August 12, 2019, about 5:09 a.m., local time, westbound CSX freight train H70211 collided with the side of eastbound CSX freight train W31411 at a switch near Carey, Ohio (NTSB 2020a). The collision occurred after the westbound train completed switching operations and departed on the main track without toggling the PTC system back to active mode. Because the PTC was not providing signal enforcement, the system did not apply the train's brakes as the train approached and passed a wayside signal indicating a required stop short of the switch. About 3 miles from where the crew had completed switching operations, the westbound train struck the side of the eastbound train, causing both trains to derail multiple cars.

The NTSB identified several findings relevant to PTC during the investigation:

[32] The threshold for limiting the use of switching mode on main tracks is 5 miles because of the longer switching distances used by some Class I railroads in the western United States.

- This collision could have been prevented had the positive train control system on the westbound train been in active mode as the train approached the stop signal at Control Point Springs.

- The administrative controls specified in Title 49 *Code of Federal Regulations* 236.1005 (f) in territories with positive train control systems that use the restricted mode feature are inadequate for preventing train-to-train collisions.

- Based on information gathered during the course of this investigation, CSX Transportation's positive train control training program did not include particular emphasis on the use of restricted mode specific to its limitations of enforcement of restrictive signal aspects, encroachment into an established work zone, and movement through an improperly lined switch.

On September 15, 2020, as a result of this investigation, the NTSB issued the following recommendation to the FRA:

> Review the software changes being developed by the Interoperable Train Control Application Committee regarding positive train control restricted mode and amend Title 49 *Code of Federal Regulations* Part 236 to require railroads to revise their positive train control systems to implement engineering controls that will automatically limit the use of restricted mode on main tracks. (R-20-18)

This recommendation is related to the software components of I-ETMS, a system used by CSX and many other freight railroads. The NTSB's intent was to eliminate the hazard illustrated by the Carey, Ohio, collision: violation of a signal because the engineer failed to configure the PTC system to provide signal enforcement.

On April 29, 2021, the FRA approved a request for amendment to the I-ETMS Mixed System Positive Train Control Safety Plan concerning the new I-ETMS Onboard Software Version 6.3.20.0.[33] The amendments include the addition of a set of warning prompts when the train is in restricted mode. If the warning prompts are not acknowledged, I-ETMS initiates enforcement braking, as described above in section 5.2. Based on this action, the NTSB classified the recommendation Open—Acceptable Response.

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[33] The railroads that use I-ETMS submit requests for amendments collectively to ensure interoperability and to streamline the approval process.

## 5.4 Safety Analysis

The Carey, Ohio, collision occurred after the engineer left the PTC system in switching mode after finishing switching operations. The FRA-approved I-ETMS software update, which was intended to help railroads address PTC's role as a contributing cause in this accident, allows PTC to remain in switching mode for 5 miles before prompting the engineer of this fact. Therefore, the update does "limit the use of restricted mode on main tracks," which is what the NTSB recommended the FRA require.

However, the limit imposed by the current version of I-ETMS is a prompt after a 5-mile threshold, meaning that the update's limit on use of switching mode would not have prevented the Carey collision, which occurred about 3 miles after the end of switching operations. Within the 5-mile threshold, PTC will provide signal enforcement only if the engineer independently remembers to toggle back to active mode; main track traffic thus remains exposed to the risk of operator error. Therefore, the NTSB concludes that the switching (restricted) mode software components of I-ETMS require human intervention to return to active PTC protection on main tracks, resulting in the potential for the engineer to leave PTC signal enforcement unnecessarily disabled within 5 miles of the switching operation initiation.

Thus, the simple mileage-based software components for use of switching mode invites questions about acceptable levels of risk exposure. Assuming a typical block length of 2 miles, the current software solution could allow a train to pass two or three signals without PTC protection before prompting the engineer to activate PTC. However, a stricter mileage limit that requires an engineer's attention so frequently during ongoing switching operations may become a dangerous distraction. There may be an optimal balance between these risks, or there may be viable but unexplored alternative control thresholds that can mitigate risks during and after switching operations. Because the current 5-mile I-ETMS threshold would not have prevented a known switching mode–related accident, the NTSB recommends that the FRA require that railroads adopt engineering controls that automatically return PTC to the active mode following switching operations. Because we do not believe that the current solution of automatically stopping the train after 5 miles following switching operations is an adequate solution, Safety Recommendation R-20-18 is classified Closed—Superseded by Recommendation R-23-10.

# 6 Work Zone Protection on Active Tracks

## 6.1 Introduction

Working limits are defined segments of track upon which trains may move only as authorized by a roadway worker with control over that segment. RSIA 2008 requires that PTC prevent train incursions into working limits, which in FRA regulations are established through exclusive track occupancy, inaccessible track, foul time, or train coordination (49 *CFR* 214.7).[34] FRA regulations require each PTC system to prevent incursions into established working limits without authorization and verification from the dispatcher or roadway worker in charge (49 *CFR* 236.1005). The FRA interprets the RSIA 2008 mandate to mean that PTC systems must communicate with train dispatchers and roadway workers in charge (RWICs) to establish and remove working limits.[35]

## 6.2 Technology Improvements

FRA's Office of Railroad Development stated in interviews with the NTSB that it has funded the development of an employee-in-charge (EIC) tablet computer that allows the EIC to control the entry of trains into a work zone and restrict their speeds (FRA 2010, p. 2613).[36] If the EIC does not grant authority for a train to enter the work zone, the PTC system automatically stops the train short of the working limits. If the EIC authorizes the train to enter the work zone, the EIC may establish a maximum

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[34] (a) *Exclusive track occupancy* is a method of establishing working limits on controlled track in which movement authority of trains and other equipment is withheld by the train dispatcher or control operator or restricted by flagmen. (b) *Inaccessible track* is created by physically preventing entry and movement of trains and equipment. (c) *Foul time* is a method of establishing working limits on controlled track in which a roadway worker is notified by the train dispatcher or control operator that no trains will operate within a specific segment of controlled track until the roadway worker reports clear of the track. (d) *Train coordination* is a method of establishing working limits on track where a train holds exclusive authority to move and the crew of that train yields that authority to a roadway worker. (See 49 *CFR* 214.7.)

[35] According to the FRA, "Working limits are obtained by contacting the train dispatcher, who will confirm an authority only after it has been transmitted to the PTC system's server … once a work zone limit has been established, the PTC system must be notified. The PTC system must continue to obey that limit until it is notified by the dispatcher or roadway worker in charge, with verification from the other, either that the limit has been released and the train is authorized to enter or the roadway worker in charge has authorized movement of the train through the work zone" (FRA 2010).

[36] *Employee-in-charge* is synonymous with *roadway worker in charge*.

operating speed for the train consistent with the safety of the roadway workers, which would be enforced by PTC.

## 6.3 Case Studies

### 6.3.1 Chester, Pennsylvania, April 3, 2016

On April 3, 2016, southbound Amtrak train 89 struck a backhoe with a worker inside near Chester, Pennsylvania (NTSB 2017a). This accident occurred within working limits originally established by a roadway worker in charge through exclusive track occupancy. The RWIC requested foul time from the dispatcher to establish working limits. When the foreman in charge of an MOW group changed, Amtrak used a sequential procedure in which one foreman would report the track clear, or release his foul time, with the dispatcher. The other foreman would then request foul time from the dispatcher. On the morning of the accident, a series of fouling activities were released but not re-established when the night foreman transferred authority to the day foreman. This allowed train 89 to enter the working limits and strike the backhoe.

As a result of this investigation, the NTSB identified several findings related to human error, miscommunication, and the absence of secondary shunting devices, which would have preserved PTC protection even when the dispatcher released the working limits.[37] Among these findings were the following:

- Had the two foremen communicated with the train dispatcher jointly about the transfer of fouls from one foreman to the other, it is likely that on-track safety and protection would not have lapsed and the accident would not have happened.
- The inadequate and inconsistent use of supplemental shunting devices by Amtrak engineering personnel effectively defeated the roadway worker protection component of Amtrak's ACSES and thereby placed maintenance-of-way employees, equipment, and the traveling public at greater risk of harm.
- Disengagement by a supervisor from a critical and regulated safety communication process reduces safety layering and at a minimum encourages other lax safety habits.

[37] A *secondary shunting device*, or supplemental shunting device, occupies a track circuit and will cause a signal to indicate that the track ahead is occupied. PTC will enforce this signal indication regardless of the movement authority granted by the dispatcher. Amtrak required the use of secondary shunting devices, but the rule was not followed in this accident.

In a safety recommendation report based on this accident and others, the NTSB observed that:

> … procedural-based protections for MOW employees are fallible to human error. … these procedural safeguards can be supplemented with PTC protections by requiring the establishment of working limits whenever the track must be fouled in controlled track territories. (NTSB 2018c)

### 6.3.2 West Haven, Connecticut, May 28, 2013

On May 28, 2013, Metro-North Railroad (Metro-North) passenger train 1559, which was traveling westbound at 70 mph on the New Haven Line main track 1, struck and killed a track foreman in West Haven, Connecticut (NTSB 2014, NTSB 2014a). Before the accident, the track foreman contacted a Metro-North rail traffic controller (RTC) at the Operations Control Center to request that main track 1 near the work site be removed from service. To fulfill this request, the RTC placed blocking devices to prevent trains from entering the area.[38] The track foreman then requested, and was granted, authority from the RTC to move the crane that was within the work site. Once on industrial track 5, the foreman reported to the RTC that he was in the clear of the interlocking on track 5.

The RTC, who was still completing his training, interpreted this statement to mean the foreman was in the clear on industrial track 5 (that is, the crane was on industrial track 5 and clear of main track 1). In fact, the foreman's activities were still fouling main track 1. The RTC removed the blocking device on main track 1 and routed train 1559 into the area on main track 1, where the train struck and killed the foreman.

The NTSB determined that the West Haven accident was caused by the removal of signal protection and the failure of Metro-North to use any redundant feature to prevent the single-point failure.[39]

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[38] *Blocking devices* are electronic locks applied in the Operations Control Center to prevent the routing of trains onto tracks. In the system used by Metro-North, applying and removing a blocking device involved clicking on a drop-down menu on a computer screen. When a blocking device was applied, an indication showed on the RTC's screen at the point of application.

[39] The NTSB later issued a special investigation report that addressed the West Haven fatality and four other accidents involving Metro-North. The report included findings and recommendations related to organizational factors and human performance. For more information, see *Organizational Factors in Metro-North Railroad Accidents*. NTSB/SIR-14/04. Washington, DC: NTSB.

## 6.4 Safety Analysis

Under FRA regulations, PTC work zone protection is a subset of signal enforcement: when a signal does not allow movement into established working limits, PTC will prevent the train from passing the signal. Setting the signal to prevent movement into the work zone is incumbent upon adequate and sufficient communication between the dispatcher and the RWIC. However, communication failures in each of the accidents described in section 6.3 resulted in working limits being released, leaving the roadway workers without PTC protection. In Chester, the RWIC beginning his shift did not realize that he needed to re-establish fouls released by the departing RWIC, and no system automatically notified him that the work zone was unprotected. In West Haven, a dispatcher misunderstood a statement by a foreman. The foreman never realized the work zone no longer had protection, because no feedback was available. Therefore, the NTSB concludes that miscommunications between dispatchers and RWICs can result in PTC working limits being mistakenly removed, creating an unprotected work zone for personnel within established working limits.

The EIC tablet computers being developed by an FRA research project that allows the EIC to control the entry of trains into the work zone and restrict their speed is one potential solution to prevent miscommunications between dispatchers and RWICs. The research project uses the tablet computer to provide an RWIC with real-time information about whether they hold movement authority and the extent of the working limits. Integrated into both the dispatch and PTC systems, such a device could supplement verbal communication with an engineering control. Releasing protection would require an action by the RWIC, such as an electronic signature, rather than a dispatcher's inference of approval.

More broadly, the computerized communication networks underlying existing PTC systems open opportunities for innovative solutions about how to confirm movement authority and working limits and how safety-critical information between RWICs, dispatchers, and train crews is conveyed to prevent train incursions into work zones. Although an EIC tablet computer is a promising approach already supported by current technologies, it does have limitations that must be addressed, such as cellular service availability. Therefore, the NTSB believes that other technologies and approaches currently in development should also be considered. The NTSB concludes that technology that supplements verbal communication along with engineering controls can be used to improve enforcement of work zone protection to eliminate the risk of miscommunication resulting in unauthorized or otherwise unsafe train incursions into established working limits. Therefore, the NTSB recommends that the FRA require railroads to implement technologies that eliminate the risk of miscommunication between dispatchers and RWICs regarding established working limits and PTC protection.

# 7 Conclusions

## Findings

1. Although currently deployed positive train control (PTC) systems can enforce a fixed speed limit, insufficient information about train location precludes PTC from effectively detecting and responding to train-to-train collision threats during restricted speed operations.

2. For positive train control to ensure safe train separation when trains are operating under restricted speed in a permissive block, technologies must be deployed that will reliably identify and locate the end of a train and communicate that information to other trains in the area.

3. Precision improvements in positive train control (PTC) and PTC-related technologies can prevent or mitigate the severity of end-of-track collisions in terminals, removing the need for most terminal exceptions once the technologies are deployed.

4. The switching (restricted) mode software components of the Interoperable Electronic Train Management System require human intervention to return to active positive train control (PTC) protection on main tracks, resulting in the potential for the engineer to leave PTC signal enforcement unnecessarily disabled within 5 miles of the switching operation initiation.

5. Miscommunications between dispatchers and roadway workers in charge can result in positive train control working limits being mistakenly removed, creating an unprotected work zone for personnel within established working limits.

6. Technology that supplements verbal communication along with engineering controls can be used to improve enforcement of work zone protection to eliminate the risk of miscommunication resulting in unauthorized or otherwise unsafe train incursions into established working limits.

# 8 Recommendations

## 8.1 New Recommendations

As a result of this investigation, the National Transportation Safety Board makes the following new safety recommendations:

**To the Federal Railroad Administration:**

> Complete and publish the results of current research into positive train control technologies to prevent train-to-train collisions during restricted speed operations. (R-23-7)
>
> Once the results of this research are available, develop a plan to implement any promising positive train control technologies for train-to-train collision avoidance. (R-23-8)
>
> Work with railroads to remove terminal exceptions currently granted under Title 49 *Code of Federal Regulations* 236.1019 using available improved positive train control–related technologies. (R-23-9)
>
> Require that railroads adopt engineering controls that automatically return positive train control to the active mode following switching operations. (R-23-10)
>
> Require railroads to implement technologies that eliminate the risk of miscommunication between dispatchers and roadway workers in charge regarding established working limits and positive train control protection. (R-23-11)

## 8.2 Previously Issued Recommendations Classified and Superseded in this Report

The National Transportation Safety Board classifies and supersedes the following safety recommendation to the Federal Railroad Administration:

> Review the software changes being developed by the Interoperable Train Control Application Committee regarding positive train control restricted mode and amend Title 49 *Code of Federal Regulations* Part 236 to require railroads to revise their positive train control systems to implement engineering controls that will automatically limit the use of restricted mode on main tracks. (R-20-18)

Safety recommendation R-20-18 is superseded by Safety Recommendation R-23-10 and is classified Closed—Superseded in section 5.4 of this report.

## BY THE NATIONAL TRANSPORTATION SAFETY BOARD

**JENNIFER HOMENDY**

Chair

**BRUCE LANDSBERG**

Member

**MICHAEL GRAHAM**

Member

**THOMAS CHAPMAN**

Member

**Report Date: September 28, 2023**

# Appendixes

## Appendix A: Referenced Investigations

**Collision of BNSF Coal Train With the Rear End of Standing BNSF Maintenance-of-Way Equipment Train, Red Oak, Iowa, April 17, 2011. NTSB/RAR-12/02**

On April 17, 2011, about 6:55 a.m. central daylight time, eastbound BNSF Railway (BSNF) coal train C-BTMCNM0-26, BNSF 9159 East, travelling about 23 mph, collided with the rear end of standing BNSF maintenance-of-way equipment train U-BRGCRI-15, BNSF 9470 East, near Red Oak, Iowa. The collision resulted in the derailment of 2 locomotives and 12 cars. As a result of collision forces, the lead locomotive's modular crew cab was detached, partially crushed, and involved in a subsequent diesel fuel fire. Both crewmembers on the striking train were fatally injured. Damage costs exceeded $8.7 million.

The National Transportation Safety Board determined that the probable cause of the accident was the failure of the crew of the striking train to comply with the signal indication requiring them to operate in accordance with restricted speed requirements and stop short of the standing train because they had fallen asleep due to fatigue resulting from their irregular work schedules and their medical conditions. Contributing to the accident was the absence of a positive train control system that identifies the rear of a train and stops a following train if a safe braking profile is exceeded. Contributing to the severity of collision damage to the locomotive cab of the striking coal train was the absence of crashworthiness standards for modular locomotive crew cabs.

**Metro-North Railroad Employee Fatality, West Haven, Connecticut, May 28, 2013. NTSB/RAB-14/10.**

On May 28, 2013, at 11:57 a.m. eastern daylight time, Metro-North Railroad passenger train 1559, which was traveling westbound at 70 mph on the New Haven Line main track 1, struck and killed a track foreman in West Haven, Connecticut. The accident location was about 100 feet west of catenary bridge 1021 at milepost 69.56.

The National Transportation Safety Board determined that the probable cause of this accident was the student rail traffic controller's removal (while working without direct supervision) of signal blocking protection for the track segment occupied by the track foreman and the failure of Metro-North to use any redundant feature to prevent this single point failure. Contributing to the accident was the Federal Railroad Administration's failure to require redundant signal protection, as recommended by Safety Recommendation R-08-6.

**Amtrak Train Collision with Maintenance-of-Way Equipment, Chester, Pennsylvania, April 3, 2016. NTSB/RAR-17/02**

On April 3, 2016, at 7:50 a.m., southbound Amtrak train 89 struck a backhoe with a worker inside at milepost 15.7 near Chester, Pennsylvania. The locomotive derailed. The backhoe was destroyed, killing the operator. Debris from the collision hit and killed the track supervisor, and part of the backhoe damaged the sidewall of the first passenger car. According to the manifest, 337 passengers, including 2 Amtrak employee passengers and 7 Amtrak crewmembers, were on board train 89. First responders transported 37 people to local hospitals. Two roadway workers were killed, and 39 other people were injured. Amtrak estimated property damages to be $2.5 million.

The National Transportation Safety Board determined that the probable cause of the accident was the unprotected fouled track that was used to route a passenger train at maximum authorized speed; the absence of supplemental shunting devices, which Amtrak required but the foreman could not apply because he had none; and the inadequate transfer of job site responsibilities between foremen during the shift change that resulted in failure to clear the track, to transfer foul time, and to conduct a job briefing. Allowing these unsafe actions to occur were the inconsistent views of safety and safety management throughout Amtrak's corporate structure. This inconsistency led to Amtrak's deficient system safety program, which resulted in part from the organization's inadequate collaboration with its unions and from its failure to prioritize safety. Also contributing to the accident was the Federal Railroad Administration's failure to require redundant signal protection, such as shunting, for maintenance-of-way work crews who depend on the train dispatcher to provide signal protection, prior to the accident.

**New Jersey Transit Train Strikes Wall in Hoboken Terminal, Hoboken, New Jersey, September 29, 2016. NTSB/RAB-18/01.**

On September 29, 2016, about 8:38 a.m., New Jersey Transit train 1614 failed to stop at the end of track 5, overrode a bumping post, and struck a wall of the Hoboken Terminal. The train was traveling about 21 mph at the time of the accident. About 250 passengers and 3 crewmembers were on the train. One person on the passenger platform was struck by falling debris and died; 110 passengers and crewmembers were injured. Total damage to the train, track, and facility was estimated at $6 million.

The National Transportation Safety Board determined that the probable cause of the Hoboken, New Jersey, accident was the failure of New Jersey Transit train 1614's engineer to stop the train after entering Hoboken Terminal due to the engineer's fatigue resulting from his undiagnosed severe obstructive sleep apnea. Contributing to the accident was New Jersey Transit's failure to follow its internal obstructive sleep apnea screening guidance and refer at-risk safety-sensitive personnel for definitive obstructive sleep apnea testing and treatment. Further contributing to the accident was the Federal Railroad Administration's failure to require railroads to medically screen employees in safety-sensitive positions for obstructive sleep apnea and other sleep disorders. Also contributing to the accident was the lack of either a device or safety system that could have intervened to stop the train before the collision.

**Long Island Rail Road Passenger Train Strikes Platform in Atlantic Terminal, Brooklyn, New York, January 4, 2017. NTSB/RAB-18/02**

On, January 4, 2017, about 8:18 a.m. eastern standard time, Long Island Rail Road passenger train 2817, consisting of six cars, collided with the platform at the end of track 6 in the Atlantic Terminal in Brooklyn (a borough of New York City, New York). The lead end of the lead car came to rest on top of the concrete platform at the end of the track. As result of this accident, 108 people were injured. Total damage was estimated at $5.3 million.

The National Transportation Safety Board determined the probable cause of the Brooklyn, New York, accident was that the engineer of Long Island Rail Road train 2817 fell asleep due to his chronic fatigue. Contributing to his chronic fatigue was the engineer's severe undiagnosed obstructive sleep apnea, and Long Island Rail Road's failure to initiate obstructive sleep apnea screening for safety-sensitive personnel and refer at-risk safety-sensitive personnel for definitive obstructive sleep apnea testing and treatment before the accident. Further contributing to the accident was the Federal Railroad Administration's failure to require railroads to medically screen employees in safety-sensitive positions for obstructive sleep apnea and other sleep disorders. Also contributing to the accident was the lack of either a device or a safety system that could have intervened to stop the train before the collision.

**Collision of Two CSX Transportation Freight Trains, Carey, Ohio, August 12, 2019. NTSB/RAR-20/03**

On August 12, 2019, about 5:09 a.m., local time, westbound CSX freight train H70211 collided with the side of eastbound CSX freight train W31411 at a switch near Carey, Ohio. The lead locomotive of westbound train H70211 and four railcars derailed onto their sides. The eastbound train W31411 derailed 21 railcars from mid-train. The eastbound and westbound train engineers suffered minor injuries. Collision damage was estimated at $4.9 million.

The National Transportation Safety Board determined that the probable cause of the train collision near Carey, Ohio, was the failure of the westbound train engineer to respond to the signal indications requiring him to slow and stop the train prior to Control Point Springs because of his impairment due to the effects of alcohol.

Contributing to the collision was the design of the positive train control system which allowed continued operation in restricted mode on the main track.

**BNSF Railroad Collision, Kingman, Arizona, June 5, 2018. NTSB/RAR-21/01**

On June 5, 2018, about 2:50 p.m., a westbound BNSF intermodal train, S MEMSCO1 02L, was operating in multiple main track in centralized traffic control territory when it collided with the rear of a slow-moving eastbound work train, WNEESGM1 05.1 The work train was making an eastbound reverse move to drop off an employee before traveling west to exit one of the two main tracks. The collision resulted in the death of one contracted Herzog Railroad Services, Inc. employee who was traveling on the work train. Another Herzog Railroad Services employee traveling on the work train was airlifted to a hospital in Las Vegas with serious injuries.

The National Transportation Safety Board determined that the probable cause of the accident was the failure of the BNSF Railway train crew of the intermodal train to operate in accordance with restricted speed requirements and stop short of the opposing train. Contributing to the accident was (1) BNSF Railway's failure to establish sufficient on-track safety and (2) the Federal Railroad Administration's interpretation of Title 49 Code of Federal Regulations Part 214 Subpart C that allows work trains to lay rail without using a form of on-track safety.

# Appendix B: Consolidated Recommendation Information

Title 49 *United States Code* 1117(b) requires the following information on the recommendations in this report.

For each recommendation–

(1) a brief summary of the Board's collection and analysis of the specific accident investigation information most relevant to the recommendation;

(2) a description of the Board's use of external information, including studies, reports, and experts, other than the findings of a specific accident investigation, if any were used to inform or support the recommendation, including a brief summary of the specific safety benefits and other effects identified by each study, report, or expert; and

(3) a brief summary of any examples of actions taken by regulated entities before the publication of the safety recommendation, to the extent such actions are known to the Board, that were consistent with the recommendation.

**To the Federal Railroad Administration:**

**R-23-7**

Complete and publish the results of current research into positive train control technologies to prevent train-to-train collisions during restricted speed operations.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 3.4, Safety Analysis. Information supporting (b)(1) can be found on pages 8-14; (b)(2) can be found on pages 9-14; and (b)(3) is not applicable.

**R-23-8**

Once the results of this research are available, develop a plan to implement any promising positive train control technologies for train-to-train collision avoidance.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 3.4, Safety Analysis. Information supporting (b)(1) can be found on pages 8-14; (b)(2) can be found on pages 9-14; and (b)(3) is not applicable.

**R-23-9**

Work with railroads to remove terminal exceptions currently granted under Title 49 *Code of Federal Regulations* 236.1019 using available improved positive train control–related technologies.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 4.4, Safety Analysis. Information supporting (b)(1) and (b)(2) can be found on pages 15-18; and (b)(3) is not applicable.

**R-23-10**

Require that railroads adopt engineering controls that automatically return positive train control to the active mode following switching operations.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 5.4, Safety Analysis. Information supporting (b)(1) and (b)(2) can be found on pages 19-21; and (b)(3) is not applicable.

**R-23-11**

Require railroads to implement technologies that eliminate the risk of miscommunication between dispatchers and roadway workers in charge regarding established working limits and positive train control protection.

Information that addresses the requirements of 49 USC 1117(b), as applicable, can be found in section 6.4, Safety Analysis. Information supporting (b)(1) and (b)(2) can be found on pages 22-25; and (b)(3) is not applicable.

# Appendix C: Previously Issued Safety Recommendations

Table A-1 provides the number; overall classification as of May 26, 2023; date closed; and recommendation text for all NTSB recommendations related to PTC. For recommendations issued to multiple recipients, the classification status shown in the table below reflects the overall status and is determined by the plurality status of the open recipients. Further information about the recommendations in this table can be found using a CAROL Query and searching the recommendation number listed below.

**Table A-1.** NTSB recommendations related to positive train control.

| Number | Overall Classification | Date Closed | Recommendation |
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| **R-70-20** | Closed–Acceptable Action | November 17, 1975 | To the Federal Railroad Administration (FRA): If it receives additional statutory authority under legislation now in progress, study the feasibility of requiring a form of automatic train control at points where passenger trains are required to meet other trains. |
| **R-71-45** | Closed–<br>No Longer Applicable | November 17, 1975 | To the FRA: Develop a comprehensive program for future requirements in signal systems and operating rules that will require as a minimum: (a) that all mainline trains be equipped with continuous cab signals in conjunction with automatic-block signals; (b) that all passenger trains be equipped with continuous automatic speed control (train control); (c) that engineers, in order to nullify a train control device, be required to take a prescribed positive action which would be recorded for later reference; (d) that a system be devised to protect trains which stop within 1,000 feet after entering a block from being struck by following trains; and (e) that an optimum number of aspects be specified as standard, with deviations allowed only where cause is shown. |
| **R-73-08 (alerters)** | Closed–Superseded | June 18, 1984 | To the FRA: In cooperation with the Association of American Railroads (AAR), develop a fail-safe device to stop a train in the event that the engineer becomes incapacitated by sickness or death, or falls asleep. Regulations should be promulgated to require installation, use, and maintenance of such a device. (Superseded by R-84-31) |

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| **R-73-30** | Closed—Unacceptable Action | July 29, 1985 | To the FRA: Cooperate with the Urban Mass Transportation Administration in sponsoring an independent study to justify or disprove the need for a requirement that high-speed commuter train operations be governed by some form of automatic train-control system or some special procedures that will prevent a collision of two trains. |
| **R-75-06** | Closed—Acceptable Alternate Action | November 28, 1986 | To multiple recipients:[1] Equip all rail lines with a system that will control the speed of the train in compliance with signals when an engineer fails to do so. |
| **R-75-36** | Closed—Superseded | February 25, 1985 | To the FRA: Promulgate regulations that will ensure that commuter trains will be controlled as required by the signal system in the event that the engineer fails to do so. (Superseded by R-84-30A) |
| **R-76-03** | Closed—Unacceptable Action/Superseded | May 22, 1987 | To the FRA: Promulgate regulations to require an adequate backup system for mainline freight trains that will insure that a train is controlled as required by the signal system in the event that the engineer fails to do so. (Superseded by R-87-16 and R-84-30) |
| **R-76-24** | Closed—Unacceptable Action | July 29, 1985 | To the FRA: Establish regulations on mainlines used by passenger trains that will require trains to stop if the block in front of them is occupied. |
| **R-78-39** | Closed—Acceptable Alternate Action | September 30, 1982 | To the National Railroad Passenger Corporation (Amtrak): Require all trains that operate on the Northeast Corridor to be equipped with an automatic train control system. |
| **R-82-98** | Closed—Unacceptable Action | February 21, 1984 | To the Family Lines Rail System: Establish a complementary protective system to the automatic block signals for trains stopped in automatic block signal territory against a following train. |
| **R-87-01** | Closed—Acceptable Action | March 10, 1992 | To Amtrak: Immediately initiate a program which will assure that all locomotives operating on the high speed passenger train trackage of the northeast corridor are equipped with a device which will control the train automatically as required by the signal if the engineer fails to do so. |
| **R-87-02** | Closed—Unacceptable Action | June 28, 1988 | To Amtrak: Pending the installation of the automatic train control devices or an equivalent positive control system on all locomotives operating on the high speed passenger train trackage of the northeast corridor, require that the operators of locomotives and trains not equipped with such devices stop before entry onto the high speed tracks regardless of signal aspect, and to request and receive permission before proceeding. (Urgent) |
| **R-87-16** | Closed—Acceptable Action/Superseded | May 1, 2001 | To the FRA: Promulgate federal standards to require the installation and operation of a train control system on mainline tracks which will provide for positive separation of all trains. (Supersedes R-76-003 and R-84-031; superseded by R-01-6) |
| **R-87-19** | Closed—Acceptable Action/Superseded | November 17, 1993 | To Union Pacific: Install a train control system which will provide for positive separation of trains. (Superseded by R-91-25, R-91-31, R-91-32, R-93-12, R-93-13, and R-93-15) |
| **R-91-25** | Closed—Acceptable Action | November 15, 1994 | To the FRA: In conjunction with the AAR and the Railway Progress Institute, expand the effort now |

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| | | | being made to develop and install advanced train control systems for the purpose of positive train separation. (Supersedes R-87-019; superseded by R-94-013) |
| **R-91-31** | Closed–Reconsidered | May 13, 1998 | To the AAR: In conjunction with the Railway Progress Institute and the FRA, expand the effort now being made to develop and install advanced train control systems for the purpose of positive train separation. (Supersedes R-87-19) |
| **R-91-32** | Closed–Acceptable Action | January 5, 2001 | To the Railway Progress Institute, Inc.: In conjunction with the FRA and the AAR, expand the effort now being made to develop and install advanced train control systems for the purpose of positive train separation. (Supersedes R-87-019) |
| **R-92-09** | Closed–Acceptable Action | February 1, 1993 | To Norfolk Southern Corporation: Review and revise your programs for traincrew supervision, locomotive cab discipline, and training of student engineers in light of the circumstances of this accident, and make necessary improvements. |
| **R-93-12** | Closed–Acceptable Action/Superseded | May 1, 2001 | To the FRA: In conjunction with the AAR and the Railway Progress Institute, establish a firm timetable that includes, at a minimum, dates for final development of require advanced train control system hardware, dates for implementation of a fully developed advanced train control system, and a commitment to a date for having the advanced train control system ready for installation on the general railroad system. (Supersedes R-87-19; superseded by R-01-06) |
| **R-93-13** | Closed–Superseded | August 28, 1997 | To the AAR: In conjunction with the FRA and the Railway Progress Institute, establish a firm timetable that includes, at a minimum, dates for final development of required advanced train control system hardware, dates for implementation of a fully developed advanced train control system, and a commitment to a date for having the advanced train control system ready for installation on the general railroad system. (Supersedes R-87-19; superseded by R-97-39) |
| **R-93-14** | Closed–Acceptable Action | May 13, 1998 | To the AAR: Advise your membership of the facts and circumstances of this accident and encourage them to implement and install an advanced train control system. |
| **R-93-15** | Closed–Acceptable Alternate Action | July 3, 1997 | To the Railway Progress Institute, Inc.: In conjunction with the FRA and the AAR, establish a firm timetable that include, at a minimum, dates for final development of required advanced train control system hardware, dates for implementation of a fully developed advanced train control system, and a commitment to a date for having the advanced train control system ready for installation on the general railroad system. (Supersedes R-87-19) |
| **R-94-13** | Closed–Acceptable Action | January 26, 2001 | To the FRA: As part of your monitoring and oversight activities on the Burlington Northern and Union Pacific Railroad's train control demonstration project, identify and evaluate all potential safety and |

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| | | | business benefits of the positive train control system currently proposed for the Northwest Region of the United States. Consider the value of these benefits in your overall assessment of the system. |
| **R-94-14** | Closed–Acceptable Action | January 26, 2001 | To the FRA: In conjunction with the AAR, identify and evaluate all of the potential benefits of positive train separation and include them in any cost benefit analysis conducted on positive train separation control systems. |
| **R-94-15** | Closed–Acceptable Action | November 8, 1995 | To the FRA: Identify possible uses for positive train separation control systems data and information and conduct a study to identify ways in which this information can be used to enhance grade crossing safety. |
| **R-94-16** | Closed–Acceptable Action | July 16, 2002 | To the AAR: In conjunction with the FRA, identify and evaluate all of the potential benefits of positive train separation and include them in any cost benefit analysis conducted on positive train separation control systems. |
| **R-94-17** | Closed–Acceptable Action | February 12, 2001 | To BNSF Railway Company (formerly Burlington Northern and Santa Fe Railway Company): In conjunction with the Union Pacific Railroad, identify and evaluate all potential safety and business benefits of the positive train control system currently proposed for the Northwest Region of the United States. Consider the value of these benefits in your overall assessment of the system. |
| **R-94-18** | Closed–Acceptable Action | February 12, 2001 | To Union Pacific: in conjunction with Burlington Northern Railroad, identify and evaluate all potential safety and business benefits of the positive train control system currently proposed for the Northwest Region of the United States. Consider the value of these benefits in your overall assessment of the system. |
| **R-97-13** | Closed–Acceptable Action/Superseded | June 12, 2001 | To the FRA: Require the implementation of positive train separation control systems for all trains where commuter and intercity passenger railroad operate. (Superseded by R-01-06) |
| **R-97-14** | Closed–Acceptable Action | July 27, 2001 | To the FRA: Require all passenger cars to have easily accessible interior emergency quick-release mechanism adjacent to exterior passageway doors and take appropriate emergency measures to ensure corrective action until these measures are incorporated into minimum passenger car safety standards. (Supersedes R-96-07) |
| **R-97-25** | Closed–Reconsidered | April 2, 1998 | To the Federal Transit Administration: Cooperate with CSX Transportation Inc. in the development and installation of a positive train separation control where Maryland rail commuter equipment operates on CSX Transportation Inc. tracks. |
| **R-97-26** | Closed–Acceptable Action | January 6, 2021 | To CSX Transportation, Inc.: Develop and install a positive train separation control system on track segments that have commuter and intercity passenger trains. |
| **R-97-32** | Closed–Reconsidered | July 23, 2007 | To State of Maryland, Transit Administration: Cooperate with CSX Transportation Inc. in the development and installation of a positive train |

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| | | | separation control system Maryland rail commuter equipment operates on CSX Transportation Inc. tracks. |
| **R-97-39** | Closed–Acceptable Action | July 16, 2002 | To the AAR: Assist the railroad industry with the development of positive train separation control systems through a continuing review of nonrailroad technology and assess its adaptability to railroad communication-based control systems. (Supersedes R-93-13) |
| **R-97-40** | Closed–Acceptable Action | July 16, 2002 | To the AAR: Assist the railroad industry with the development of positive train separation control systems by acting as a clearinghouse for info on the status and results of pilot projects and by disseminating that info to the railroad industry and the federal and participating state transportation organizations. |
| **R-97-41** | Closed–Acceptable Action | July 16, 2002 | To the AAR: Assist the railroad industry with the installation and operation of positive train separation control systems by maintaining industry standards to ensure open architecture and an interoperability of equipment for train control systems. |
| **R-01-06** | Closed–No Longer Applicable | December 9, 2008 | To the FRA: Facilitate actions necessary for development and implementation of positive train control systems that include collision avoidance, and require implementation of positive train control systems on main line tracks, establishing priority requirements for high-risk corridors such as those where commuter and intercity passenger railroads operate. (Supersedes R-93-12, R-87-16, and R-97-13) |
| **R-03-23** | Closed–Acceptable Action | October 7, 2005 | To the AAR: Report to the National Transportation Safety Board the milestones and activities needed for completion of the interoperability standards for positive train control systems and your priorities for completion of this effort. |
| **R-05-13** | Closed–Acceptable Action | January 6, 2021 | To Metra (Northeast Illinois Regional Railroad Corporation): Install a positive train control system on your commuter train routes. |
| **R-07-01** | Closed–Acceptable Action | April 24, 2012 | To the FRA: Require railroads to ensure that the lead locomotives used to operate trains on tracks not equipped with a positive train control system are equipped with an alerter. |
| **R-07-07** | Closed–Acceptable Action | January 5, 2021 | To Canadian National Railway: Develop and implement a positive train control system that includes collision avoidance capabilities on main line tracks, establishing priority requirements for high-risk corridors such as those where passenger trains operate. |
| **R-12-20** | Closed–Unacceptable Action | September 16, 2019 | To the FRA: Require the use of positive train control technologies that will detect the rear of trains and prevent rear-end collisions. |
| **R-12-24** | Open–Unacceptable Response | | To the AAR: Develop a standard that specifies the use of suitable crash-protected memory modules for all new and existing installations of on-board video and audio recorders. The memory modules should meet or exceed the survivability criteria |

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| | | | specified in Title 49 *Code of Federal Regulations* 229.135, Appendix D, Table 2. |
| **R-12-27** | Open—Unacceptable Response | | To the FRA: Require railroads to install, along main lines in non-signaled territory not equipped with positive train control, appropriate technology that warns approaching trains of incorrectly lined main track switches sufficiently in advance to permit stopping. (Supersedes R-05-14) |
| **R-13-23** | Closed—Acceptable Alternate Action | June 9, 2016 | To the FRA: Publish the positive train control implementation update reports submitted by all railroads subject to the positive train control provisions of the Rail Safety Improvement Act of 2008 (RSIA 2008) and make the reports available on your website within 30 days of report receipt. |
| **R-13-27** | Closed—No Longer Applicable | June 4, 2020 | To multiple recipients:[2] Provide positive train control implementation update reports to the FRA every 6 months until positive train control implementation is complete. The update reports should consist of two sections: components and training. The components section should include a description of the positive train control component to be implemented, the number of components, the number of components completed on the report date, the number of components that remain to be completed, the overall completion percentage, and the estimated completion date. Components are defined as locomotives, wayside units, switches, base station radios, wayside radios, locomotive radios, and any new and novel technologies that are part of a positive train control system. The training section shall include the number of safety-related employees and equivalent railroad carrier contractors and subcontractors that need to be trained, by class and craft; minimum training standards for those employees and contractors, meaning the knowledge of and ability to comply with federal railroad safety laws and regulations and carrier rules and procedures to implement positive train control; the percentage of employees who have completed training; the percentage of employees who remain to be trained; and the estimated date that training will be completed. |
| **R-18-02** | Open—Acceptable Response | | To the FRA: Include the Collision Hazard Analysis Guide for Commuter and Intercity Passenger Rail Service as part of the regulation or part of a detailed compliance manual to assist railroads in implementing Title 49 *Code of Federal Regulations* Part 270. |
| **R-19-11** | Open—Acceptable Response | | To the FRA: Prohibit the operation of passenger trains on new, refurbished, or updated territories unless positive train control is implemented. |
| **R-20-18** | Open—Acceptable Response | | To the FRA: Review the software changes being developed by the Interoperable Train Control Application Committee regarding positive train control restricted mode and amend Title 49 *Code of Federal Regulations* Part 236 to require railroads to revise their positive train control systems to |

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| | | | implement engineering controls that will automatically limit the use of restricted mode on main tracks. |
| **R-20-19** | Open–Await Response | | To multiple recipients:[3] Inform your members of circumstances of this collision and request they undertake a review of their training and managerial oversight programs as they relate to restricted speed operations on territories that operate positive train control systems in restricted mode to identify opportunities for training improvement and to implement appropriate mitigating actions. |
| **R-20-20** | Open–Initial Response Received | | To CSX Transportation, Inc.: Review and revise your training program to ensure employees are properly qualified on positive train control, including restricted mode. |

[1] The individual recipients and classifictions are as follows: Metropolitan Transportation Authority New York City Transit (Closed– Acceptable Alternate Action) and Metro-North Railroad (Closed–Acceptable Alternate Action).

[2] The recommentation is addressed to "all railroads subject to the positive train control provisions of RSIA 2008"; a total of 42 recipients. For more information on individual recipients and classifications, visit https://data.ntsb.gov/carol-main-public/sr-details/R-13-027.

[3] The individual recipients and classifictions are as follows: Association of American Railroads (Closed–Acceptable Action), American Short Line and Regional Railroad Association (Closed–Acceptable Action), Amtrak (Open–Await Response), Alaska Railroad Corporation (Closed–Acceptable Action), and the American Public Transportation Association (Closed–Acceptable Action).

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For more detailed background information on this report, visit the NTSB investigations website and search for NTSB accident ID DCA21SR003. Recent publications are available in their entirety on the NTSB website. Other information about available publications also may be obtained from the website or by contacting—

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