Amtrak Train Collision with Maintenance-of-Way Equipment
Chester, Pennsylvania
April 3, 2016

Accident Report

NTSB/RAR-17/02
PB2018-100263

National Transportation Safety Board

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PB2018-100263
Notation 57150
Adopted November 14, 2017

Railroad Accident Report

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National
Transportation
Safety Board

490 L'Enfant Plaza, S.W.
Washington, D.C. 20594

National Transportation Safety Board. 2017. ***Amtrak Train Collision with Maintenance-of-Way Equipment, Chester, Pennsylvania, April 3, 2016*****. NTSB/RAR-17/02. Washington, DC.**

Abstract: On April 3, 2016, about 7:50 a.m. eastern daylight time, southbound Amtrak train 89 (train 89) struck a backhoe with a worker inside at milepost 15.7 near Chester, Pennsylvania. The train was authorized to operate on main track 3 (track 3) at the maximum authorized speed of 110 mph. Beginning on the morning of April 1, Amtrak had scheduled track-bed restoration—ballast vacuuming—at milepost 15.7 on track 2 on the Philadelphia to Washington Line. Track 2 had to be taken out of service between control points Baldwin (milepost 11.7) and Hook (milepost 16.8) for the 55 hour duration of the project. As train 89 approached milepost 15.7, the locomotive engineer saw equipment and workers on and near track 3 and initiated an emergency brake application. The train speed was 106 mph before the emergency brake application and 99 mph when it struck the backhoe. Two roadway workers were killed, and 39 other people were injured. Amtrak estimated property damages to be $2.5 million. The accident investigation focused on the following safety issues: roadway worker protection, communication between dispatchers and foremen, lack of job briefing, and safety management. As a result of this investigation, the National Transportation Safety Board makes safety recommendations to the Federal Railroad Administration, Amtrak, Brotherhood of Maintenance of Way Employes Division, American Railway and Airway Supervisors Association, Brotherhood of Locomotive Engineers and Trainmen, and Brotherhood of Railroad Signalmen. The National Transportation Safety Board also reiterates a recommendation to the Federal Railroad Administration.

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Abbreviations and Acronyms

ACSES	Advanced Civil Speed Enforcement System
Amtrak	National Railroad Passenger Corporation
ARASA	American Railway and Airway Supervisors Association
ARJET	Amtrak Roadway Joint Efficiency Testing
ATC	automatic train control
BMWED	Brotherhood of Maintenance of Way Employes Division
BRS	Brotherhood of Railroad Signalmen
CEO	chief executive officer
CFR	*Code of Federal Regulations*
Conrail	Consolidated Rail Corporation
CP	control point
DOT	Department of Transportation
EIC	employee-in-charge
FAA	Federal Aviation Administration
FAST Act	Fixing America’s Surface Transportation Act
FRA	Federal Railroad Administration
LDVR	locomotive digital video recorder
LED	light-emitting diode
MOW	maintenance-of-way
MP	milepost
ng/ml	nanograms per milliliter
NEC	Northeast Corridor
NORAC	North American Operating Rules Advisory Committee
NPRM	notice of proposed rulemaking
NTSB	National Transportation Safety Board
Penn Station	Pennsylvania Station
PTC	positive train control

PTS	positive train stop
RailVac	Loram RailVac vacuum excavation machine
RRR	retrospective regulatory review
RWP	roadway worker protection
SMS	safety management system
SSD	supplemental shunting device
SSP	system safety program
SSPP	system safety program plan
SSWP	site-specific work plan
THC	tetrahydrocannabinol
THC-COOH	carboxy tetrahydrocannabinol
Timetable Special Instructions	*Northeast Corridor Employee Timetable No. 6, Includes Special Instructions*
TOL	track occupancy light

Executive Summary

On April 3, 2016, about 7:50 a.m. eastern daylight time, southbound Amtrak train 89 (train 89) struck a backhoe with a worker inside at milepost 15.7 near Chester, Pennsylvania. The train was authorized to operate on main track 3 (track 3) at the maximum authorized speed of 110 mph. Beginning on the morning of April 1, Amtrak had scheduled track-bed restoration—ballast vacuuming—at milepost 15.7 on track 2 on the Philadelphia to Washington Line. Track 2 had to be taken out of service between control points Baldwin (milepost 11.7) and Hook (milepost 16.8) for the 55-hour duration of the project. As train 89 approached milepost 15.7, the locomotive engineer saw equipment and workers on and near track 3 and initiated an emergency brake application. The train speed was 106 mph before the emergency brake application and 99 mph when it struck the backhoe. 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 determines 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 that led to the company's deficient system safety program that resulted in part from Amtrak'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.

The accident investigation focused on the following safety issues:

- **Roadway Worker Protection:** Amtrak and the North American Operating Rules Advisory Committee have many ways to protect workers on maintenance-of-way projects. These include positive train control, which is designed, in part, to prevent incursions into work zones; using Form D and foul time to prevent train incursions into the work zone; supplemental shunting devices that activate track occupancy detection within the signal system and create a track occupancy light on the dispatcher's board, thus serving as an independent layer of safety; site-specific work plans that assess the risk of worksites to guide choices like the number of watchmen needed; and a job briefing conducted before each shift that includes the type of worker protection to be used.

- **Communication Between Dispatchers and Foremen:** This accident included several actions by dispatchers and foremen that affected the performance of their jobs and ultimately the safety of the work on the day of the accident. Most of the communications were made over cell phones instead of the radio. Because of this, no one else at Amtrak was able to hear the content of the conversations. Another listener

may have been able to identify errors or incorrect decisions or assumptions made during these conversations.

- **Lack of Job Briefing:** The day foreman did not conduct a job briefing for the roadway workers and contractors before the shift began. A job briefing is required and includes the form(s) of protection from intrusions onto out-of-service tracks that will be used during the upcoming shift. The track protection information included in the job briefing makes workers aware of the presence or absence of track protection and enables them to question the absence of that protection if the protection plan has not been followed.

- **Safety Management:** The Chester accident investigation revealed more than 2 dozen unsafe conditions—many involving safety rule violations and risky behaviors by workers. These safety shortcomings occurred across several levels of the Amtrak organization—maintenance of way, dispatchers, management—and reveal Amtrak's weak safety management. An inconsistent vision of safety throughout the organization, hostile attitudes between labor and management about no-tolerance rule violations, and ill-equipped work crews were among the observed safety culture. Moreover, it is disconcerting that three of the Amtrak employees involved in the accident tested positive for potentially impairing drugs. The company's safety program and its implementation at all levels of the company were found to be weak and focused on only the lowest level of employees: the roadway workers.

As a result of this investigation, the National Transportation Safety Board makes safety recommendations to the Federal Railroad Administration, Amtrak, Brotherhood of Maintenance of Way Employes Division, American Railway and Airway Supervisors Association, Brotherhood of Locomotive Engineers and Trainmen, and Brotherhood of Railroad Signalmen. The National Transportation Safety Board also reiterates a recommendation to the Federal Railroad Administration.

1 Factual Information

1.1 Amtrak

The Rail Passenger Service Act (Public Law 91-518, October 30, 1970), created the National Railroad Passenger Corporation (Amtrak). The Act directed Amtrak to develop and operate a modern rail service to meet intercity transportation needs. Amtrak began operations on May 1, 1971. On April 1, 1976, Amtrak acquired its Northeast Corridor (NEC) property from Conrail (Consolidated Rail Corporation). Amtrak's NEC is the busiest railroad in North America with about 2,200 commuter and freight trains operating on some portion of the Washington, DC, to Boston, Massachusetts, route each day. (See figure 1.) In fiscal year 2016, Amtrak carried about 17.8 million passenger trips on the NEC.[1] The Chester, Pennsylvania, accident occurred on the NEC.

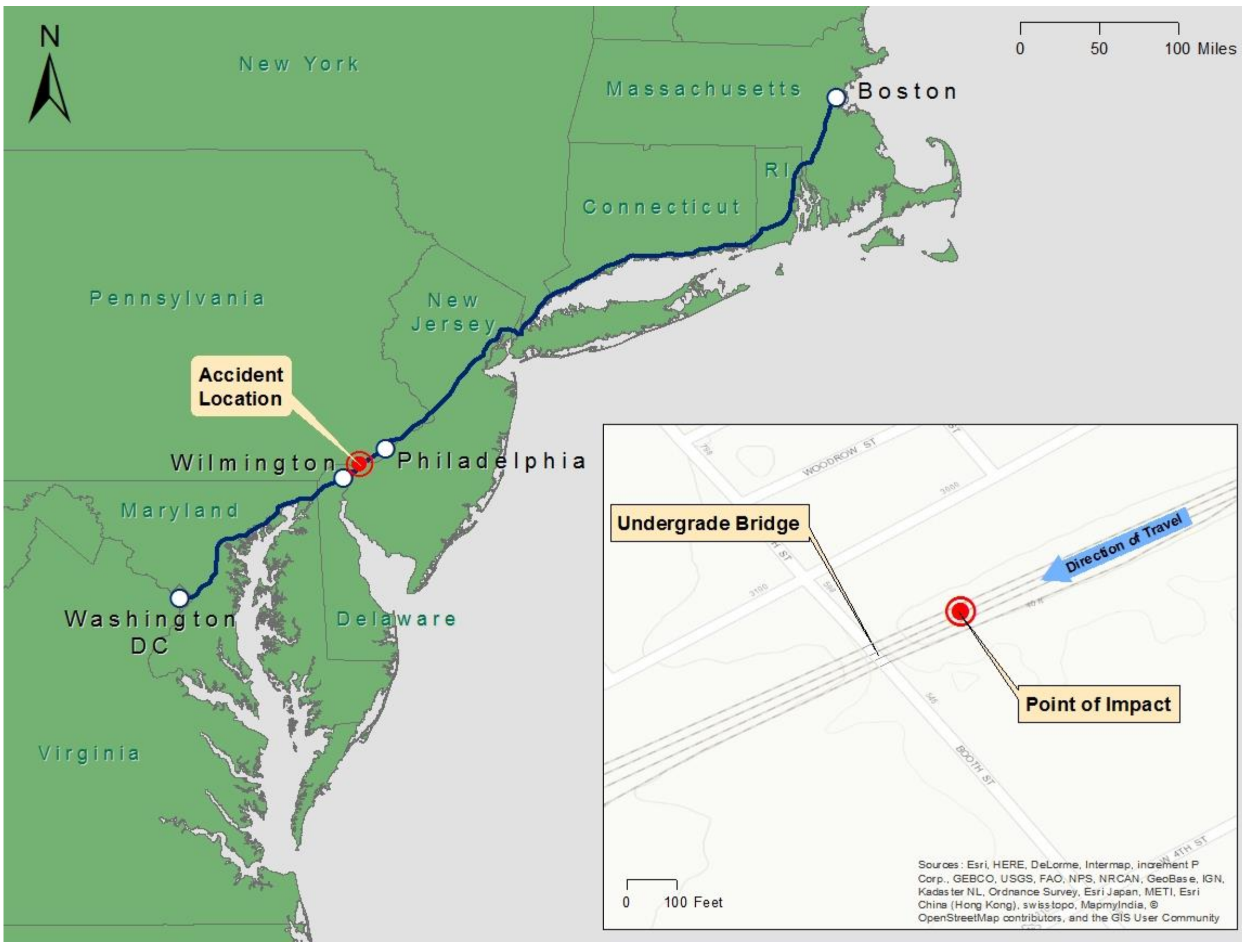

Figure 1. Amtrak Northeast Corridor showing train route and accident location.

[1] Amtrak, National Fact Sheet FY 2016.

Most of the Amtrak operating network of tracks is owned by other railroads. Amtrak has trackage rights agreements with freight railroads for about 20,549 route miles of track, which is 96 percent of the route miles traveled by its trains.[2] Amtrak owns about 791 route miles of track, which is about 4 percent of the route miles that Amtrak travels. On the 457-mile NEC, Amtrak owns and operates 363 miles. Of the portion of the NEC not owned by Amtrak, the New York Metropolitan Transportation Authority owns a 10-mile segment, the Connecticut Department of Transportation owns a 46-mile segment, and the State of Massachusetts owns a 38-mile segment.

Railroads are responsible for positive train control (PTC) installation where passenger trains operate and where poison or certain hazardous materials are transported.[3] PTC systems are designed to prevent train-to-train collisions, overspeed derailments, incursions into established work-zone limits, and movement of a train through a switch left in the wrong position; in particular, PTC is designed to prevent accidents caused by human error. Amtrak has activated the Advanced Civil Speed Enforcement System (ACSES) on the tracks it owns in the NEC and on the Amtrak-owned portion of the Michigan line. ACSES in combination with cab signaling meets the Federal Railroad Administration's (FRA) requirements of a PTC system. Amtrak has installed PTC on its locomotives and cab cars that operate over the NEC.

Amtrak has a president/chief executive officer (CEO) who reports to a board of directors. A vice president/chief operations officer is responsible for day-to-day operations of Amtrak, and a vice president/chief safety officer reports to the chief operations officer.

1.2 Accident Synopsis

On April 3, 2016, at 7:50 a.m. eastern daylight time, southbound Amtrak train 89 (train 89) struck a backhoe with a worker inside at milepost (MP) 15.7 near Chester, Pennsylvania.[4] Train 89 was authorized to operate on main track 3 (track 3) at the maximum authorized speed of 110 mph.[5] Beginning April 1, 2016, at 10:00 p.m., Amtrak had scheduled track-bed restoration—ballast-vacuuming—at MP 15.7 on track 2 on the Philadelphia to Washington Line. Track 2 had to be taken out of service between control points (CP) Baldwin (MP 11.7) and Hook (MP 16.8) for the 55-hour duration of the project. Additionally, adjacent tracks 1, 3, and 4 were intermittently out of service (fouled) because of equipment and workers supporting the RailVac and ballast vacuuming on track 2.

As train 89 approached MP 15.7, the locomotive engineer saw equipment and workers on and near track 3 and initiated an emergency brake application. Locomotive event recorder data showed that the train speed was 106 mph before the emergency brake application and 99 mph when it struck the backhoe. 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

[2] *Trackage rights* means permission for a railroad to use the tracks of another.

[3] Public Law 110-432. Rail Safety Improvement Act of 2008, Sec.104.

[4] All times in this report are eastern daylight time except the time in appendix B, which is eastern standard time.

[5] All tracks referred to in this report are main tracks, that is, main tracks 1, 2, 3, and 4. In this report they are called tracks 1, 2, 3, and 4.

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.

The Chester Fire Department was dispatched at 7:54 a.m. to the Amtrak tracks at Booth Street, where the tracks cross over the street. (See figure 1.) Fire department and emergency medical services personnel accessed the site through a field behind a church near Langley and 9th Streets. A Chester Fire Department battalion chief assumed command of the incident and established a command post at that location. A medic unit walked the tracks to locate and aid the work crew, and firefighters assisted passengers on the train, taking them to the church, which was used as a triage area and shelter. First responders transported 37 people to local hospitals.[6] Two roadway workers were killed, and 39 people were injured.[7]

The weather at the time of the accident was scattered clouds, wind from the west at 38 mph gusting up to 50 mph, and a temperature of 37°F. Visibility was unrestricted.[8] Amtrak estimated property damages to be $2.5 million.

1.3 Preaccident Activities

1.3.1 Amtrak Train 89

On April 3, 2016, the crew of train 89 reported for duty at 5:25 a.m. at Pennsylvania Station (Penn Station) in New York City. The crew consisted of an engineer, a conductor, two assistant conductors, and three on-board service attendants. Train 89, consisting of one locomotive, eight passenger cars, a café car, and one baggage car, departed about 6:06 a.m. and traveled southbound on the Amtrak Philadelphia to Washington Line destined for Savannah, Georgia. While in New York City, the train was inspected, and it passed all predeparture tests required by the FRA, including a Class I air brake test.

On the trip to Savannah, Georgia, train 89 made scheduled station stops in New Jersey at Newark, Metro Park, and Trenton. The next stop was at Philadelphia, which train 89 departed on track 3. The train crew reported no problems with the brake system throughout the trip.

The video from the inward-facing camera in the control cab, beginning with the train's departure from Philadelphia, showed the locomotive engineer seated in the engineer's seat facing forward, and he appeared to be alert.[9] As the train traveled toward Chester, train operations were routine and the engineer was operating the train at or near track speed, which was 110 mph. About 10 seconds before impact, about 7:49:31, the engineer moved his head and torso forward with his

[6] The number of people taken to hospitals by emergency responders does not match the number of hospital records, because some of the injured went to the hospital on their own.

[7] These numbers are based on hospital records received by the National Transportation Safety Board (NTSB).

[8] Unrestricted visibility is defined as "no obstructions to vision exist in sufficient quantity to reduce the visibility to less than 7 miles." http://glossary.ametsoc.org/wiki/Visibility Accessed July 31, 2017.

[9] The Amtrak locomotive cab had an inward facing image recorder that recorded video and internal audio.

gaze forward and moved his right hand toward the independent brake handle. About 7:49:32 the engineer moved his hand onto and activated the horn switch.

The engineer was first aware of an abnormal situation when he observed a large piece of equipment on the tracks ahead of him. Just afterward, he saw that the backhoe was on track 3. He detected the equipment from about the same distance from which investigators could first see it during the sight distance observations. Concurrently, the engineer stood up from his seat and leaned forward with his gaze fixed directly ahead of him and his right hand on the controls. He then began a series of horn blasts to warn workers at the site that his train was approaching, and he also made an immediate emergency brake application to slow the train to reduce the impact of the impending collision. He then knelt on the floor, continuing to sound the horn as the train approached the work site. Seconds before the collision, the engineer lay down on the floor of the operating compartment in anticipation of the impact.

1.3.2 Amtrak Ballast-Vacuuming Project

In the area where the ballast-vacuuming work was to be conducted, Amtrak owned, maintained, and operated on four tracks: tracks 1, 2, 3, and 4. Track 1 is the east track, track 4 is the west track, and tracks 2 and 3 are located in between. The maximum authorized speed on tracks 2 and 3 is 110 mph; it is 90 mph on tracks 1 and 4 between CPs Baldwin and Hook.

Also on April 1, track 2 was taken out of service with Form D track authority so the work could begin.[10] A Loram RailVac vacuum excavation machine (RailVac) occupied the track while the work was performed. (See figure 2.) To facilitate the ballast-vacuuming, Amtrak used a backhoe situated on track 3 that could reach over into track 2 to loosen the foul ballast before the vacuuming operation began. (See figure 3.) However, the backhoe cannot adequately loosen or move ballast from under the crossties, and additional hand work is often needed to rake the ballast into the space between the ties for better retrieval by the RailVac. When the RailVac was full of captured fouled ballast, it traveled to a preselected spot to off-load onto the right-of-way by extending its conveyor across, and thus fouling, track 1. Therefore, the foreman used foul time periodically on tracks 1, 3, and 4 to keep trains off those tracks to allow the backhoe and workers to foul tracks 1, 3, and 4.[11] To conduct the work safely, all four tracks had to be protected, because (1) the boom of the RailVac fouled track 1 when it off-loaded spoils, (2) the backhoe on track 3 could cross over any of the other tracks when it was operating, and (3) the workers could be on or near any of the four tracks at any time during the project.

[10] *Form D authorization* from a dispatcher removes a track from service to protect equipment and activities that cannot be removed readily, such as a RailVac. This is discussed in more detail in section 1.4, Roadway Worker Protection.

[11] *Foul time* authority prohibits the movement of trains or other on-track equipment onto working limits during a specific period and is intended to be used temporarily. This is discussed in more detail in section 1.4, Roadway Worker Protection.

Working limits refers to a segment of track with definite boundaries within which trains and engines may move only as authorized by the roadway worker in control of that segment of track.

Figure 2. RailVac vacuum excavation machine on track 2 at the accident site.

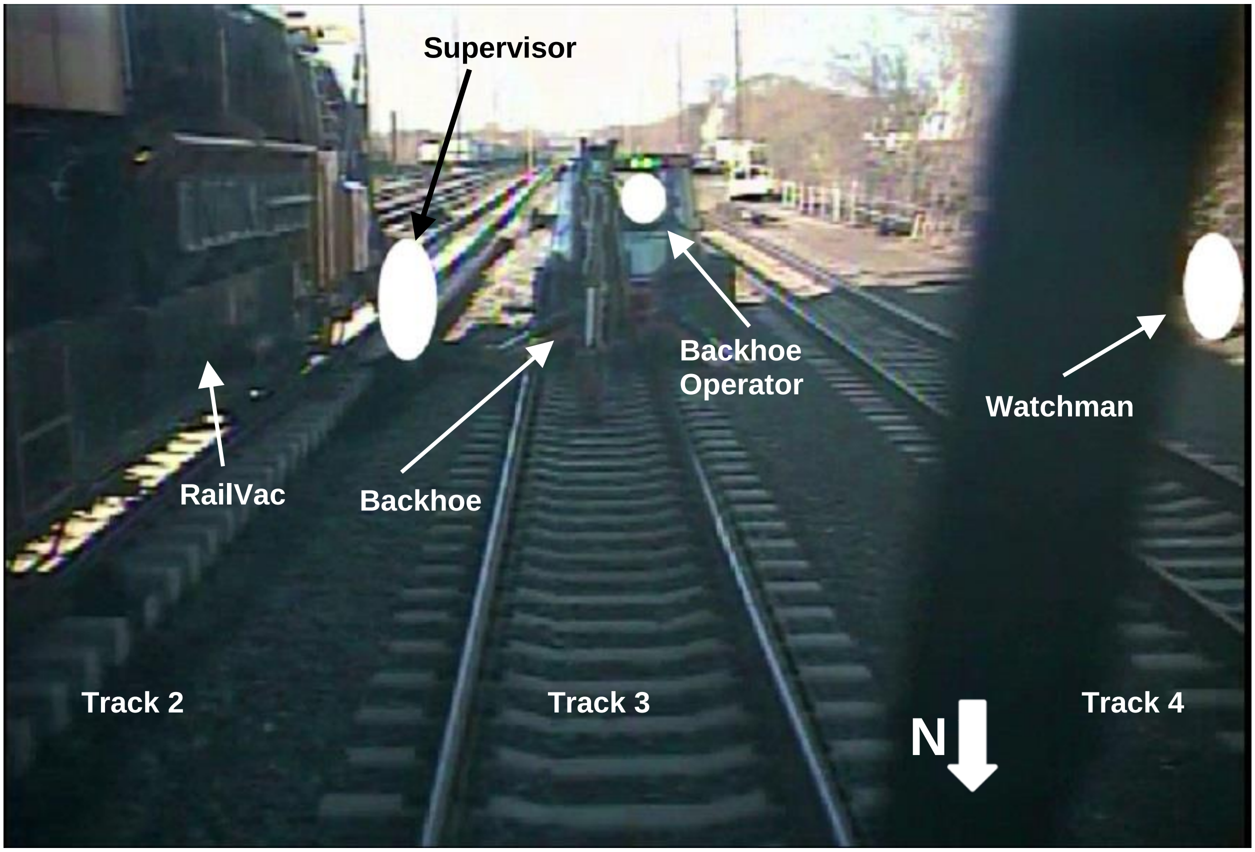

Figure 3. RailVac and backhoe taken from forward-facing video recorder just before accident.

The engineering department of Amtrak's Mid Atlantic Division within the NEC worked with the transportation department to implement the Chester project's 55 hour track outage, but it did not prepare a site-specific work plan. This plan is an overall plan for the work project, covering such items as a statement of the work, staffing and equipment requirements, hazard assessment, and safety.[12] The engineering department also staffed the continuous operation of the ballast-vacuuming project with a foreman and a track supervisor for each 12-hour night shift, from 7:00 p.m. to 7:00 a.m., and each 12-hour day shift, from 7:00 a.m. to 7:00 p.m. For each shift of a project, the foreman is in charge of the on-track safety protection, and he conducts a job briefing and makes job assignments for the project for his shift. The on-site railroad engineering employees and contractors work under the direction of the foreman. The track supervisor is the highest ranking Amtrak employee on the work project and is responsible for overseeing overall on-site safety and the progress and quality of the work being performed at the work site. The supervisor's duties include overseeing job briefings, monitoring the foreman transfer between shifts, and ensuring proper and safe track protection procedures are followed. In addition, each shift had a watchman to alert the roadway workers of approaching trains, an electrical lineman to support the changes made to the track surface in relationship to the overhead catenary, a signal maintainer to check for any signal wire damages or other repairs, and a track laborer. Two RailVac operators (Loram contractors) were assigned to each shift, and a RailVac superintendent (Loram contractor) was at the work site during the day shift. An Amtrak backhoe operator began his shift at night and

[12] Site-specific work plans are discussed in more detail in section 1.4, Roadway Worker Protection.

continued into the day shift. Table 1 shows the roadway workers, contractors, and other workers involved in the Chester project.

Table 1. Workers on Chester ballast-vacuuming project.

Night Shift	Day Shift
Amtrak Assistant Track Supervisor	**Amtrak** Track Supervisor
Amtrak Foreman (Employee-in-Charge)[a]	**Amtrak** Foreman (Employee-in-Charge)[a]
Amtrak Laborer	**Amtrak** Laborer
Amtrak Backhoe Operator	**Amtrak** Backhoe Operator
Amtrak Watchman	**Amtrak** Watchman
Loram (contractors) Two RailVac operators	**Loram (contractors)** Two RailVac operators
	Loram (contractor) RailVac superintendent

[a]The foreman is the employee-in-charge of on-track safety.

The workers on each shift had varied reporting times spaced an hour apart, therefore not all workers were present at the shift change between the night-shift foreman and the day-shift foreman. On the day of the accident, the roadway workers' shifts officially changed at 7:00 a.m., but the day foreman was late, and the actual shift change occurred later. The shifts of other workers—electrical lineman and signal maintainer—began later than 7:00.

On the morning of April 3, before the accident, the RailVac was occupying track 2 (the out-of-service track); a backhoe, with an operator on board, occupied track 3; a roadway worker fouled track 1; a track supervisor was positioned in between tracks 2 and 3, and a watchman was standing just west of track 4. (See figure 3.) Ballast-vacuuming work was ongoing from before the time the foremen began their transfer from the night shift to the day shift until the time of the accident about 7:50 a.m. One RailVac operator was outside the cab of the RailVac actively running the machine. He was readjusting the arm to the center of the gauge of track 2 when the collision occurred. A Loram RailVac superintendent and a general laborer, as well as the Amtrak day foreman, were inside the cab.

The backhoe was positioned on track 3 facing north. The backhoe operator was in the cab but not actively maneuvering the bucket. The track supervisor was raking loose spoils of fouled ballast from underneath the crossties of track 2 next to the backhoe. An Amtrak laborer was watching the supervisor at the time of the collision.

The watchman was positioned on the western edge of track 4 in line with the backhoe. At the time of the accident, train approach warning on-track safety was not being used. The single watchman had an inadequate view to provide timely warning of approaching trains. The employee acting as the watchman told NTSB investigators that he blew his air horn and raised his banner when he saw the approaching train, and then he fled the track area.[13] Evidence from the

[13] Amtrak roadway worker protection (RWP) rules require that when using train approach warning the watchman alerts roadway workers to the approach of a train by raising an approved light or orange disc at arm's length above his head and blowing a horn or whistle. In this case, the watchman raised an orange disc, which he called a "banner."

forward-/outward-facing video camera on train 89 indicated that the watchman moved away from the track; the watchman's other actions were not discernible on the video. The Loram RailVac superintendent told investigators that he did not hear the watchman's horn or the train horn before the collision.

1.4 Roadway Worker Protection

Numerous methods are available to protect workers while they perform maintenance-of-way (MOW) activities. These include regulatory requirements and rules and policies specific to railroads that are signatories to the North American Operating Rules Advisory Committee (NORAC) *Operating Rules*. (NORAC 2011) These methods are discussed in this section. In addition, Amtrak has an operating policy, called "80 mph Slow By," that directs train dispatchers to slow trains as they pass by work zones where an undercutter or a track-laying machine is working on out-of-service track.[14] This policy was based on the acute hazards of construction work using these two machines. That is, operations using this equipment create noisy work areas where roadway workers may be unable to hear approaching trains, warning sounds, and verbal communications. The maximum authorized speed on track 3, where the collision occurred, was 110 mph, and the dispatcher authorized Amtrak train 89 to travel on track 3 at that speed. The day train dispatcher told investigators, "Every second that a train is delayed, we got the clerks [and] the manager of train operations calling saying, " 'what happened to train so and so?' " At the time of the accident, the "80-mph Slow By" policy applied only to work zones where undercutting or track-laying equipment was in use, and it did not apply to work zones using a RailVac ballast-vacuuming machine. As of the date of this report, the policy still does not apply to the RailVac. To be clear, this 80-mph Slow By policy is Amtrak's policy. Other railroads also have policies that require trains to reduce speed when operating past a work zone, but those policies are more restrictive than Amtrak's. That is, other railroads slow trains to speeds considerably lower than 80 mph when they operate past a work zone.

The NTSB is aware of-high speed passenger rail systems in Europe and Asia that prohibit workers from establishing work zones and using maintenance equipment during passenger train operation times. On those rail systems, maintenance work is performed during an overnight window when passenger trains are not operating.

1.4.1 Form D

To protect roadway workers, a MOW foreman must follow NORAC Rules 160–162 for requesting a Form D track permit line 4 authorization from the train dispatcher to remove a track from service. Form D authorization protects equipment and activities that cannot be removed readily, such as a RailVac. This authorization creates an exclusive track occupancy for the work crew, and trains are not allowed on the work crew's track segment, which is considered out-of-service track.

To request Form D, an employee tells the dispatcher the track and the limits for the Form D. The dispatcher repeats that information, and then the requesting employee confirms the

[14] An *undercutter* is an on-track machine that removes ballast from beneath the track so it can be cleaned.

information. The purpose of the repetition of information is to ensure accurate communication, which provides an additional layer of safety. After the train dispatcher authorized (issued) the Form D, he was required to make an entry into the train dispatcher’s log and in the dispatching system indicating that the track covered by Form D was occupied. This caused that area of track on the dispatcher’s board to show a red line indicating track occupancy by equipment.

An employee who is issued Form D by the train dispatcher must contact the dispatcher to release the Form D. The employee and the dispatcher request, repeat, and confirm the information as they did when the Form D was requested.

1.4.2 Foul Time

The foreman on a MOW project must request foul time for track that will be occupied temporarily. The rules for requesting and authorizing foul time are in NORAC Rule 140 and in Rule SI 140-S1 in Amtrak’s *Northeast Corridor Employee Timetable No. 6, Includes Special Instructions* (*Timetable Special Instructions*). (NORAC 2011; Amtrak 2016) Foul time is requested the same way a Form D is requested, with the requesting employee stating the track and the limits, the dispatcher repeats this information, and the employee confirms it. The foul time authorization from the dispatcher blocks the requested area from train traffic, providing what the FRA considers a form of “working limits” for the machinery and employees working in a protected area.[15] Specifically, foul time allowed the qualified employee to temporarily conduct “covered fouling activities” on track protected from train intrusions.[16]

After the train dispatcher authorized foul time, he was required to make an entry into the train dispatcher’s log and in the dispatching system indicating that the track covered by foul time was occupied, causing that area of track to show as blue on the dispatcher’s board indicating that a blocking device is applied, also called a “blue block.” Similarly, when an employee in the field placed a supplemental shunting device (SSD) on the track it caused that area of track to show as red on the dispatcher’s board indicating track occupancy, also called a track occupancy light (TOL). In his interview, the train dispatcher referred to magenta (or blue over red) when describing what the dispatcher’s board would indicate with a blocking device applied and a TOL.[17] At the time of the accident, the dispatcher had removed the electronic block from track 3, so it appeared without any color highlighting; it was white. Figures 4–7 illustrate the dispatcher’s display screen at critical times between 7:25 a.m. and 7:49a.m.

[15] Working limits refers to a segment of track with definite boundaries within which trains and engines may move only as authorized by the roadway worker in control of that segment of track.

[16] Amtrak defines *covered fouling activities* as equipment fouling a track in signaled territory or within interlocking limits for more than 5 minutes.

[17] The color magenta derives from the historical use of lights in train operations: a blue light placed over a red light appears to be magenta.

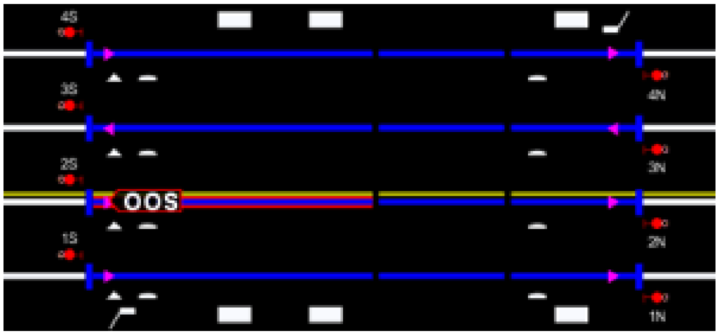

Figure 4. Dispatcher's display screen at 7:25 a.m. showing tracks 1–4 between Control Points Baldwin and Hook. Track 2 is out of service track (magenta), and tracks 1, 3, and 4 have electronic blocks (blue).

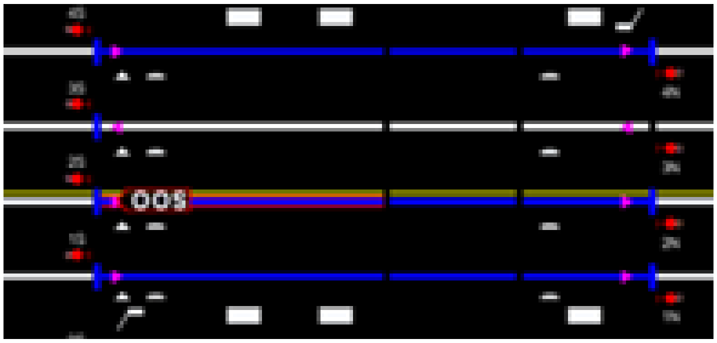

Figure 5. Dispatcher's display screen at 7:31 a.m. showing that the dispatcher has removed the electronic blocking device from track 3.

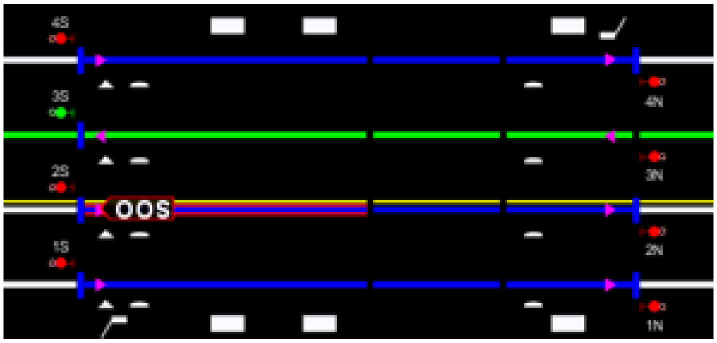

Figure 6. Dispatcher's display screen at 7:34 a.m. with a clear signal for train movement on track 3 indicated by the green highlight.

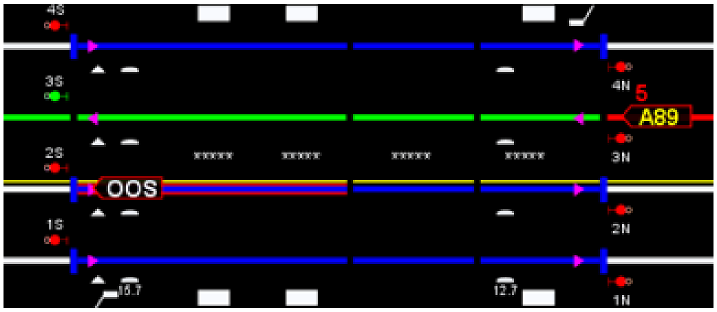

Figure 7. Dispatcher's display screen at 7:47 a.m. with train 89 on track 3 shown by the A89 designation.

Employees who are granted foul time by the train dispatcher must not release the foul time until they have ensured that all fouling activity under their authority has been cleared. The procedure for releasing foul time is similar to those for requesting foul time: the employee releasing foul time states the track and the limits, the dispatcher repeats that information, and then the requesting employee confirms the information.

Amtrak used a sequential procedure in which one foreman released his foul time with the dispatcher, and subsequently the other foreman would request foul time from the dispatcher. However, railroads could use a procedure for two foremen to simultaneously transfer their fouls with the train dispatcher when their shifts change. Amtrak's director of operating practices indicated that a process that allowed foremen to communicate with a train dispatcher to jointly transfer their fouls with a train dispatcher's knowledge and approval could be designed and implemented to be safe.

Employees who request foul time are required to be trained and to pass tests covering the NORAC *Operating Rules* and the content in Amtrak's *Timetable Special Instructions*. (NORAC 2011; Amtrak 2016)

1.4.3 Supplemental Shunting Devices

At the time of the accident, Rule SI 140-S2 required the use of an SSD when equipment fouls a track in signaled territory or within interlocking limits for more than 5 minutes. (Amtrak 2016) This instruction requires the employee-in-charge (EIC) of "covered fouling activities" to apply an approved SSD to the track to be fouled after receiving foul time from the train dispatcher. An SSD activates track-occupancy logic within the signal system and creates a TOL on the dispatcher's board, thus serving as a second layer of safety. The signal system interacts with the ACSES system that will cause trains to stop short of an area protected by blocking devices applied to the dispatcher's board and the shunt to the track structure provided by the SSDs.

SSDs provide redundant on-track protection. For example, if the blocking device is removed by the train dispatcher, the TOL will remain on the dispatcher's board if an SSD is on the track. In this situation, the dispatcher cannot route a train on that track, the signal system will display stop signals to tell the engineer to stop, and the PTC system will stop the train if the engineer does not. When an SSD is applied on the track, and a dispatcher cannot route a train through a length of track, the train dispatcher usually calls the foreman to find out why. Thus, roadway workers must use SSDs to attain the additional layer of safety that PTC can provide. Otherwise, roadway workers are entirely reliant on perfect performance from the dispatcher.

The NTSB has investigated three accidents where redundant signal protection in controlled-track territory would have prevented dispatchers from lining trains into work zones. The first occurred January 29, 1988, when northbound Amtrak train 66, the *Night Owl*, struck MOW equipment on track 2 in Chester, Pennsylvania. (NTSB 1989) (See a summary of the *Night Owl* accident at appendix B.) That earlier Chester accident was similar to the Chester accident discussed in this report in that postaccident toxicology testing indicated the use of drugs by Amtrak employees. Also similar was the lack of secondary protection for on-track equipment and out-of-service tracks. The second accident occurred in Woburn, Massachusetts, on January 9, 2007, when a passenger train was lined into a work zone resulting in two MOW employee fatalities and 12 injuries. (NTSB 2008) In the investigation report, the NTSB issued the following safety recommendation to the FRA:

R-08-06

> Require redundant signal protection, such as shunting, for maintenance-of-way work crews who depend on the train dispatcher to provide signal protection.

On August 20, 2012, the FRA published a notice of proposed rulemaking (NPRM), "Railroad Workplace Safety; Roadway Worker Protection Miscellaneous Revisions (RRR)," in the *Federal Register*, which addressed this safety recommendation.[18] (2012, 50323) Safety Recommendation R-08-06 is currently classified "Open—Unacceptable Response."

The NTSB investigated a third accident where redundant signal protection in controlled track territory would have prevented a dispatcher lining a train into a work zone. This accident occurred on Metro-North in West Haven, Connecticut, on May 28, 2013. (NTSB 2014a) A train was lined into a work zone and resulted in the death of a foreman who was working with a crane. On March 26, 2015, the NTSB sent a letter to the FRA that included the following:

> On October 19, 2012, we submitted comments regarding your [NPRM] titled Railroad Workplace Safety; Roadway Worker Protection Miscellaneous Revisions. [*Federal Register* 2012, 50323] Although the 2012 NPRM and Safety Advisory 2014-02 constitute positive steps toward satisfying this recommendation, we are disappointed that, after 7 years, you have yet to issue the requested regulation.
>
> Our 2014 special investigation report, *Organizational Factors in Metro-North Railroad Accidents*, highlights once again the need for this rulemaking. [NTSB 2014c] Accordingly, we request that you expedite action to issue the recommended requirement. Pending initiation of rulemaking, Safety Recommendation R-08-6 remains classified "Open―Unacceptable Response."

[18] *RRR* stands for retrospective regulatory review.

The FRA finalized and published in the *Federal Register* its "Railroad Workplace Safety; Roadway Worker Protection Miscellaneous Revisions (RRR)" on June 10, 2016. (2016, 37840)

The FRA's letter to the NTSB in response noted that these revisions included regulatory changes that include "requirements for roadway workers in controlled track territory to adopt redundant signal protection for their working limits." The NTSB and the FRA consider this change to be "risk mitigation measures or safety redundancies to ensure the proper establishment and maintenance of signal protections for controlled track working limits that are in effect." The FRA stated the following in its June 23, 2016, response to the NTSB:

> Specifically, the final rule requires Class I or II railroads and passenger railroads that establish on-track safety using controlled track working limits [49 *Code of Federal Regulations* (*CFR)* 214.321–214.323] in signalized territories to evaluate their particular operations and identify what type of redundant signal protection(s) is appropriate. This evaluation must be completed by July 1, 2017. After railroads conduct the required evaluation, railroads must adopt and comply with an appropriate method of redundant signal protections in their on-track safety program by January 1, 2018. FRA may object to a railroad's method of providing redundant signal protections under the review procedures specified in 49 *CFR* 214.307, or may take other appropriate enforcement action if a railroad neglects to evaluate, adopt, and comply with appropriate redundant protection procedures.
>
> In addition to addressing Safety Recommendation R-08-06, this final rule provision on redundant signal protections is intended to fulfill the rulemaking mandate contained in the Fixing America's Surface Transportation Act, Public Law 114-94, 129 Statute 1686 (December 4, 2015) (FAST Act). Section 11408 of the FAST Act requires FRA (as the Secretary of Transportation's delegate) to promulgate a rule requiring railroads to implement redundant signal protections. FRA believes this final rule provision governing redundant signal protections fulfills both the FAST Act mandate and Safety Recommendation R-08-06. FRA does not presently intend to take any further action, but will work with the railroad industry to provide guidance regarding appropriate redundant signal protections that must be in place by January 1, 2018.

The NTSB believes that the FRA's June 10, 2016, final rule, Railroad Workplace Safety; Roadway Worker Protection Miscellaneous Revisions, begins to address Safety Recommendation R-08-06 but is concerned about several aspects of the FRA's response to Safety Recommendation R-08-06 to date: not requiring railroads to submit to the FRA for review their evaluations and results for mitigating safety shortcomings, that is, appropriate redundant signal protection; delaying the adoption of the railroads' identified mitigations of safety shortcomings, and the ambiguity of the FRA's review and audit procedure for the railroads' implemented mitigations. Therefore, the NTSB reiterates R-08-06 to the Federal Railroad Administration.

Amtrak was unable to provide the NTSB with a specific evaluation plan and stated that its actions to enhance redundant protection were fully supported by the FRA through grant programs and an ongoing joint efficiency testing program. Amtrak stated that it could prepare a plan if specifically requested by the FRA.

1.4.4 Site-Specific Work Plans

Amtrak requires some engineering maintenance or renewal projects to have site-specific work plans (SSWP). Amtrak typically creates an SSWP for large production projects that have a large number of employees and equipment (extended exposure and activity over long stretches of the roadway). NTSB investigators reviewed several Amtrak SSWPs, which contained the following elements:

- Job summary/statement of work
- Scope of work
- Hazard assessment worksheet
- Manpower and additional departments
- Equipment and placement on job site
- Tools and training
- Job briefings
- Safety and personal protective equipment
- Emergency phone numbers
- Community/public impact
- Clean-up/disposal

According to Amtrak's SSWPs, determining the number of watchmen needed to alert roadway workers to train incursions into the worksite is a critical element of safety planning. After two fatalities on Southeastern Pennsylvania Transportation Authority in 2008, representatives from the Amtrak engineering department and from engineering unions formed a group to identify locations where additional watchmen should be considered because of environmental concerns like curvature or other sight limitations. These locations are called hot spots, and in 2008–09, the group developed Amtrak's Hot Spots Rule 360, which first appeared in the 2010 *Roadway Worker Protection Manual*:

> **Amtrak Rule 360**
>
> Definition: Hot spots are locations on the railroad where additional roadway worker protection (RWP) is required! These physical locations include a variety of conditions.
>
> <u>Hot Spot Examples</u>:
>
> 1. When a lone worker requires positive protection or a watchman to work safely at a given location, then that would qualify as a Hot Spot.

2. When a roadway work group (gang) requires positive protection or advance gang watchman to work safely, then that would qualify as a Hot Spot.

3. When you have less than 15 seconds to clear the work limits (location) safely, then that would definitely qualify as a Hot Spot.

4. When your working limits (location) require more than 15 seconds to clear safely because of limited or no clearance areas nearby, then that would qualify as a Hot Spot.

    - Curves with limited visibility.
    - Tunnels with limited and close clearance.
    - Track locations with heavy outside noise.
    - Track locations with limited or no clearance.
    - Bridge locations with limited or no clearance.
    - Track locations with limited or no visibility due to obstructions.

Potential Hot Spots:

- Bridges—overhead, undergrade and movable—walkways, hand railings, and clearing bays
- Curves—simple (sharp/high degree of curvature), reverse, compound, brokenback, and vertical (grades)
- Roadbed—fill section (elevated) and cut section (rock cut)
- Tunnels—manholes (cut outs) and bench walls (ladders and handholds)
- Fencing—right of way, intertrack and high level platforms
- Overbuilts—manholes (cut outs) and clearing bays

Rule 360 was included in the manual each subsequent year until 2015, when Amtrak developed a separate handout containing Rule 360 for engineering employees to use as a reference guide.

1.4.5 Job Briefings

Title 49 *Code of Federal Regulations (CFR)* 214.315, “Supervision and communication,” requires that when an employer assigns duties to a roadway worker that call for that employee to foul a track, the employer shall provide the employee with a job briefing that includes information on the means by which on-track safety is to be provided, and instruction on the on-track safety procedures to be followed. Additional requirements, effective July 1, 2013, require the job briefing to include information about any adjacent tracks, on-track safety for such tracks, and MOW equipment that will foul the tracks; and a discussion of the nature of the work to be performed and the characteristics of the work location.[19] This information is to be communicated again any time the on-track safety procedures change during the work period.

The FRA publishes a compliance document, *Track and Rail and Infrastructure Integrity Compliance Manual Volume III Railroad Workplace Safety*, Chapter 3 Roadway Worker Protection (January 2014). The document is based on five fundamental safety principles:

1. A person who is not fouling a track will not be struck by a train.
2. A person who is fouling a track upon which a train will not move will not be struck by a train.
3. No person should foul a track unless that person knows either that
    a. No train will arrive or
    b. The person on the track will be able to move to a place of safety before a train arrives.
4. Each roadway worker bears the ultimate responsibility for his own on-track safety.
5. Each employer is responsible for providing the means for achieving on-track safety to each roadway worker employee.

The FRA's Roadway Worker Protection Compliance Manual provides the railroad industry with interpretations of and guidance on the railroad workplace safety regulations. The compliance manual regarding 49 *CFR* 214.315 stresses four points for roadway work group job briefings:

1. An employer shall provide a job briefing for workers fouling a track.
2. A job briefing for on-track safety shall be deemed complete only after workers have acknowledged understanding the on-track safety procedures and instructions presented.
3. Work groups that will foul a track shall have one qualified roadway worker designated to provide on-track safety for all members of the group.
4. The designated person shall inform all workers in the group of the on-track safety procedures to be followed and also shall inform them when any changes to the on-track safety procedures are made.

[19] *Adjacent tracks* mean two or more tracks with track centers spaced less than 25 feet apart.

1.5 Accident Narrative

On April 3, 2016, at 07:10:54, the night train dispatcher approved the fouling of track 1 in a radio communication with the night foreman.[20] Recalling the morning of April 3 around the time of the shift change, the day watchman told NTSB investigators that the night foreman was ready to leave after his night shift. It had been windy, snowing, and hailing during the night shift, the day foreman was late arriving at the job site, and the watchman got the impression that the night foreman was anxious to leave the work site.

About 7:16 a.m., while the day foreman was driving to the job site for his shift (scheduled to start at 7:00 a.m.), he called the day train dispatcher by cell phone to request Form D out-of-service track authority on track 2. The train dispatcher asked him to call back, which he did, at 07:24:09. The train dispatcher gave him Form D number A1401 at 7:26, taking track 2 out of service.[21] They discussed the night foreman’s clearing up fouls and whether the day foreman would pick them up. The day dispatcher told investigators that he asked the day foreman about needing fouls, because although it was Sunday, trains were still running: at least two trains in each direction an hour. The day foreman told the dispatcher that, at the time (about 7:26 a.m.), he was assessing “how much [he had] to do with this backhoe.” He explained that the presence of the backhoe at the jobsite required the fouling of tracks 3 and 4. Additionally, he preferred to maintain fouls for track 1 as well “as much as possible for now.” At that time, the day foreman was unable to provide the dispatcher with a precise estimate of how much longer those tracks would need to be fouled, indicating that he didn’t “know how much longer …’cause my backhoe operator should be getting out of here in about an hour or two.” At the time, all four tracks were out of service with either foul time or Form D authority.

At 07:27:23, the day train dispatcher made a personal phone call, using an Amtrak phone, to his spouse.[22] During the call, he mentioned that track 2 was out of service and tracks 1, 3, and 4 had fouls. Under Amtrak RWP Rules and FRA Roadway Work Place Safety, foul time is a means of establishing working limits on controlled track.

When the day foreman arrived at the job site, he met with the night foreman and they discussed their transfer. At that time, the night foreman explained that he had foul time on tracks 1, 3, and 4 and a Form D on track 2. According to the night foreman, he believed that he had reached an agreement with the day foreman: he would call the dispatcher and give up Form D and his fouls, and the day foreman would immediately call the dispatcher and pick them up.

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[20] Times given in the format hh:mm:ss are from Amtrak digital recordings of incoming and outgoing radio transmissions and telephone calls between Amtrak train dispatchers and employees in the field.

[21] Amtrak had taken track 2 out of service for the 55 hours of the ballast-vacuuming project, but each time the EIC changed, the train dispatcher issued a new Form D number. The night foreman had Form D number A1403, issued on April 2, 2016, at 7:13 p.m. The day train dispatcher issued Form D number A1401 to the day foreman on April 3, 2016, at 7:26 a.m. Following NORAC Rule 160, Form Ds are numbered consecutively each day beginning at midnight. (NORAC 2011)

[22] From the start of his shift to the time of the accident the train dispatcher made two outgoing personal phone calls to his spouse. During both calls they discussed both personal and railroad topics. The train dispatcher’s spouse is an employee of another railroad. These calls, made on an Amtrak telephone, are recorded.

About 7:29 a.m. after speaking with the day foreman, the night foreman called the day train dispatcher and cancelled Form D for track 2 and released the foul time on tracks 1, 3, and 4. In the same call, the night foreman told the train dispatcher that the day foreman would pick up his fouls on tracks 1, 3, and 4 between CPs Hook and Baldwin. However, workers and equipment were still fouling track 3, and NORAC Rule 140-S1 required the track to be clear of workers and equipment before foul time is released. (NORAC 2011)

According to the night foreman, directly after his telephone call with the dispatcher, the night foreman told the day foreman that he had released all of his track protections and the day foreman needed to call the train dispatcher to secure on-track protections. The day foreman responded, "I got it," which the night foreman interpreted to mean that the day foreman understood that he needed to immediately call the dispatcher and secure track protections. The night foreman then left the job site. The day watchman told investigators that he saw the night foreman driving away from the area 10 to 15 minutes before the collision. The day train dispatcher told investigators that after the night foreman released his fouls, he expected the day foreman to call right afterward to request fouls on the same tracks. The dispatcher had noted the pending foul time requests in his logbook and had not removed several of the blocking devices from the previous shift because he was expecting the day foreman to call to obtain the fouls "within seconds, if not a minute, after [the night foreman] cleared up his foul," and he had contemplated calling the day foreman to find out whether he wanted foul time.

The day foreman recalled that, after the night foreman had released, or cleared, his foul time on tracks 1, 3, and 4, he had told the night foreman, "when you are clear of all your fouls, don't bother getting any more fouls. I'll get them for the rest of the day." He said he did not see the night foreman after that time, and that he expected the night foreman to remain in the area until he ensured all the workers were cleared from the tracks. He also noted that he "didn't pay attention to what [the night foreman] was really doing." The day foreman also told the RailVac superintendent that tracks 3 and 4 were protected with foul time, and he told the watchman that tracks 1, 3, and 4 were protected with foul time. There was no evidence that the day foreman contacted the train dispatcher to request foul times on tracks 1, 3, and 4 on the morning of the accident.

After the day foreman began his shift, he collected signatures on a job briefing form from several workers. The job briefing form is shown in figure 8, and four items, each highlighted with a box around it, indicated that (1) foul time would be used during the shift to protect the tracks, but SSDs would not be applied; (2) only one watchman would be used, (3) railroad maintenance machinery would foul the tracks; and (4) no one had any questions or concerns.[23]

Between 7:30 a.m. and 7:50 a.m. the day foreman asked the RailVac superintendent to begin work, but the superintendent said that he would not work without a job briefing. The Amtrak watchman and the RailVac superintendent told investigators that the day foreman told them that the tracks were protected with fouls but failed to provide them with a job briefing.

[23] Title 49 *CFR* 214.311 (b) states, "Each employer shall guarantee each employee the absolute right to challenge in good faith whether the on-track safety procedures to be applied at the job location comply with the rules of the operating railroad, and to remain clear of the track until the challenge is resolved."

AMTRAK

On Track Safety Briefing Sheet

Job Briefing on front must be filled out before starting any job.

Date 4 / 13 / 16	Time: 7 : 15 ☑ AM ☐ PM	Days W/O Injuries:	Gang No.

Work Location: Hook to Baldwin

Nature of Work to Be Performed:

Characteristics of Work Location: Rail Vac

Employee in charge of providing on-track protection: Day Shift Foreman

Qualifications: ☑ Operating Rules (NORAC, GCOR, etc.) ☑ Physical Characteristics ☑ Base Line Characteristics

Track Speeds 100 ☑ Controlled Track ☐ Non-Controlled Track ☐ Adjacent Controlled Track Speed ___

☑ What form of protection will be used? ☑ Track out of Service ☑ Foul Time ☑ Watchmen ☐ Inaccessible
Who has the track out of service? Day Shift Foreman What are the out of service limits? Hook to Baldwin

☑ Are Adjacent Controlled Tracks Involved? ☑ Yes ☐ No
If yes, what is/are the track number(s) of the Adjacent Controlled Track(s)?
What form of Protection will be used for the Adjacent Controlled Track(s)?
☐ Track out of Service ☑ Foul Time ☑ Watchmen ☐ Inaccessible

☑ Discuss Location of Predetermined Place of Safety (PPOS): # 2 Track 2

☑ If track is out of service are the barricades up? ☑ Yes ☐ No If yes, on what tracks? 2 Track

☑ If Foul Time is being used will the SSD's be applied? ☐ Yes ☑ No
Shunt Confirmed? ☐ Yes ☐ No Time: ____
Have you requested and received foul time in accordance with Operating Rules (NORAC Rule 140)? ☐ Yes ☐ No

☑ If in an interlocking, is C&S providing us with Local Train Control? ☐ Yes ☑ No

☑ What is the normal direction of traffic? North & South
Remember – Any Time, Any Direction!

☑ Are the Whistle Boards up? ☐ Yes ☑ No ☐ N/A If yes, where are they located?

☑ Is the location considered a "Hot Spot"? ☐ Yes ☑ No If yes, why
If yes, what extra precautions have been taken?

☑ How many watchmen are needed? 1 Discuss where they will be located and the relief policy.

☑ Do all the watchmen have all of their required gear? ☑ Yes ☐ No
Remember, a Whistle Test **MUST** be done after the watchmen are in place!

☑ Are other crafts involved? ☑ Yes ☐ No If yes, discuss their involvement

☑ Does the Employee in Charge have a radio? ☑ Yes ☐ No Do all of the other radios work? ☑ Yes ☐ No

☑ Electronic Device Policy Reviewed? ☑ Yes ☐ No
No personal electronic devices may be used without written permission.

☑ If working around equipment the Operators **MUST** discuss: Dangers of Equipment
Spacing Speeds

☑ Will any part of an RMM foul any track? ☑ Yes ☐ No
Type of protection to be established on the fouled track? Foul Time

☑ Does anyone have any questions or concerns? ☐ Yes ☑ No
If yes, have they been addressed to everyone's satisfaction? ☐ Yes ☐ No

No one is required to sign this document until they have full understanding of the type of protection being provided and all on-track safety concerns have been addressed.

Employee Sign-Off *RWP Briefing must be signed on site! This form must be saved for 10 working days*

1 Loram RailVac Operator Night Shift	11	21 Day Shift Watchman	31 Day Shift Laborer
2	12	22	32
3	13	23	33
4	14	24	34
5 Loram RailVac Operator Day Shift	15 Loram RailVac Superintendent Day Shift	25	35
6	16	26	36
7 Loram RailVac Operator Day Shift	17	27	37
8	18	28	38 Loram RailVac Operator Night Shift
9	19	29	39
10	20	30	40

NRPC **3044** (Rev. 07/2014) back

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Figure 8. Day foreman's job briefing sheet circulated to and signed by roadway workers (signatures redacted, jobs identified by Amtrak).

RMM stands for roadway maintenance machine. Signatures of workers (redacted) and their jobs identified by Amtrak..

At 07:49:24, the day train dispatcher made another personal phone call to his spouse and said that he just saw something he did not like. He said it was a light on the display indicating an abnormal situation, but that no one was fouling that area. At 07:50:18, during the same call, the day train dispatcher said that someone was fouling tracks 1, 3, and 4, and track 2 was out of service.

At 07:50:25, someone said that they heard a radio transmission from an unknown source saying, "Emergency, emergency, emergency."

At 07:50:35, the day train dispatcher, on the same personal call, said that he hoped no one was fouling the track without telling him because a train was operating "through there on track 3." Then the day train dispatcher said he had an emergency and would call back.

At 07:51:34, the day foreman called the day train dispatcher and asked whether the night foreman had fouls on tracks 3 and 4. The day train dispatcher replied that the night foreman had given up his fouls. The day foreman then said that the backhoe was hit and that he needed ambulances.

As a result of the collision, the lead truck of the locomotive derailed; the backhoe was destroyed, killing the operator; debris from the collision struck and killed the track supervisor; and part of the backhoe struck the sidewall of the first passenger car. (See figure 9.) The sudden deceleration of the train threw passengers about inside the cars, causing injuries to 31 people. When the train came to a stop, the conductor radioed the train dispatcher to report the collision, and emergency responders arrived about 8:00 a.m.

The forward-facing video on the accident train showed the work area just before the accident occurred. On the video, the watchman can be seen running moving away from his position outside of track 4. The watchman told NTSB investigators that he saw the train approaching and attempted to warn the workers by sounding his air horn and waving a disc to the train above his head.

Figure 9. Damage to lead passenger car.

1.6 Personnel Information

1.6.1 Amtrak Roadway Workers

The 57-year-old day foreman was hired as a trackman March 17, 1977. He was promoted to qualified foreman on July 17, 1980. The night foreman, 41 years old, was hired March 18, 2013, as a trackman. He was promoted to qualified foreman on November 29, 2015. The 59-year-old supervisor was hired as a trackman on January 16, 1978. He was promoted to qualified supervisor on April 2, 1979. The 62-year-old backhoe operator was hired as a trackman August 9, 1976. The watchman, 36, was hired July 7, 2014, as a trackman.

1.6.2 Amtrak Train Engineer and Dispatchers

The locomotive engineer, 47, was hired on May 5, 2014. His last engineer certification was January 19, 2016. The 55-year-old day train dispatcher was hired January 19, 1988, as a block operator. He was promoted to qualified train dispatcher on January 24, 2001, and later qualified as assistant chief train dispatcher. Three days before the accident, on March 31, 2016, he completed Amtrak's refresher Block Training for Train Movement course. Course materials included the NORAC rules and the Amtrak *Timetable Special Instructions*. (NORAC 2011; Amtrak 2016) The night train dispatcher completed the same course on March 2, 2015.

1.7 Medical and Toxicology Information

After the accident, Amtrak obtained specimens for toxicology testing on key employees involved in the accident. Title 49 *CFR* mandates drug and alcohol screening after an accident.[24] Postaccident testing was required by the FRA for hours-of-service employees and any on-duty employee who dies in an accident; however, service employees are not subject to this drug testing. All of the specimens were screened for cannabinoids, cocaine, opiates, amphetamines, methamphetamines, phencyclidine, barbiturates, benzodiazepines, and ethyl alcohol. In addition, at the request of the NTSB, specimens from the deceased track workers were tested by the Federal Aviation Administration's (FAA) Bioaeronautical Sciences Research Laboratory for more than 1,300 substances including prescription, over-the-counter, and illicit drugs. The results of the toxicological tests are discussed in this section along with medical information about those employees from the Amtrak personnel records.[25] Amtrak personnel records indicated that the backhoe operator, track supervisor, train engineer, conductors, and the day watchman were medically qualified for their positions.

1.7.1 Backhoe Operator

The backhoe operator was subject to urine drug testing at the time of his occupational medicine examinations, but he was not subject to random drug testing. He tested negative in two Amtrak periodic drug tests conducted during occupational medicine examinations in 2014.[26] The backhoe operator's postaccident toxicological test results were positive for cocaine (a potent potentially impairing central nervous system stimulant) and its metabolites, levamisole (a chemical frequently used to dilute illicit cocaine), amlodipine (a prescription blood pressure medicine), chlorthalidone (a prescription blood pressure medicine), and gabapentin (a prescription pain control and anti-seizure medicine), in muscle and urine.

1.7.2 Track Supervisor

The track supervisor was subject to urine drug testing at the time of his occupational medicine examinations but not to random drug testing. Seven urine drug tests since 1996 conducted during periodic examinations were negative. His postaccident toxicology was positive for the prescription opioid pain medicines oxycodone at 8.1 nanograms per milliliter (ng/ml) and morphine at 34.5 ng/ml in cavity blood and codeine at 4.0 ng/g, morphine at 77.0 ng/g, and oxycodone in liver. Cavity blood is subject to changes in concentration after death due to movement of drugs from tissues back into the blood, and the blood may be subject to dilution by

[24] Parts 219 (Control of Alcohol and Drug Use), 240 (Qualifications and Certification of Locomotive Engineers), 242 (Qualifications of Conductors), and 382 (Controlled Substances and Alcohol Use and Testing).

[25] For additional detailed information about toxicology testing see the Medical Factual Report in the NTSB public docket for this investigation.

[26] Occupational preemployment and return-to-work urine testing varies but generally includes the following drugs: marijuana metabolites, phencyclidine, amphetamines, ecstasy, cocaine metabolites, and opiate metabolites. Occupational urine testing for the track supervisor and the backhoe operator was negative.

other fluids. These effects can result in blood levels that do not represent levels at the time of the accident.

1.7.3 Night Foreman

After the accident Amtrak tested the night foreman for drugs. His postaccident testing was negative.

1.7.4 Day Foreman

After the accident Amtrak tested the day foreman for drugs. His postaccident testing was negative.

1.7.5 Assistant Nighttime Supervisor

After the accident Amtrak tested the assistant nighttime supervisor for drugs. His postaccident testing was negative.

1.7.6 Watchman

After the accident Amtrak tested the day watchman for drugs. His postaccident testing was negative.

1.7.7 Train Engineer

The 47-year-old locomotive engineer had been subject to three urine drug tests: a preemployment test in 2014, a periodic test in 2015, and a rules violation test in February 2016. These tests were reported as negative. The postaccident toxicological tests for the engineer were positive for tetrahydrocannabinol (THC), a primary active impairing compound in marijuana, at 2.2 ng/ml and carboxy-tetrahydrocannabinol (THC-COOH, THC's inactive metabolite) at 16.1 ng/ml in blood collected 5 hours after the accident. Additionally, THC-COOH at 48.6 ng/ml and the sedating opioid morphine at 1,256 ng/ml were detected in urine also collected 5 hours after the accident. The engineer had been treated in the hospital with morphine for pain about 2 hours before urine was collected for postaccident testing.

1.7.8 Train Conductor and Assistant Conductors

FRA postaccident tests for drugs and alcohol were negative for the train conductor and the two assistant conductors.

1.7.9 Train Dispatcher

FRA postaccident tests for drugs and alcohol were negative for the train dispatcher.

1.8 Injuries

The track supervisor and the backhoe operator died in the collision. Emergency responders transported 37 people to local hospitals. Table 2 shows the injuries from the accident. This table is based on hospital records received by the NTSB.

Table 2. Injuries.

Injury Type[a]	Work Crew	Train Crew	Passengers	Total
Fatal	2	0	0	2
Serious	0	0	1	1
Minor	1	7	30	38
Total	3	7	31	41

[a] Title 49 *CFR* 830.2 defines *fatal injury* as "any injury which: results in deathwithin 30 days of the accident" and *serious injury* as "an injury which: (1) requires hospitalization for more than 48 hours, commencing within 7 days from the date the injury was received; (2) results in a fracture of any bone (except simple fractures of fingers, toes, or nose); (3) causes severe hemorrhages, nerve, muscle, or tendon damage; (4) involves any internal organ; or (5) involves second- or third-degree burns, or any burn affecting more than 5 percent of the body surface." The *minor injury* category includes all other people, not cited in the other injury categories, who were reported treated by area hospitals within 24 hours following the incident.

1.9 Damages

The accident damaged the locomotive and the first trailing passenger car. The undercarriages of other passenger cars were damaged.[27] The collision destroyed the backhoe. Amtrak estimated damages to be about $2.5 million. In the damage descriptions below, a reference to "right" refers to the right-hand side of a railcar with respect to its direction of travel at the time of the collision.

The impact with the backhoe crushed the lower right front of the locomotive; the pilot, also called a cowcatcher, was deformed rearward and under the locomotive, and the anti-climber was deformed downward.[28] Investigators noted a long vertical impact mark on the left side of the locomotive nose. The windshield shattered, dispersing shards of glazing on the consoles, floor, and seats inside the cab. The collision dislodged the radio, and it was inoperable afterwards.

The bottom sound diffuser portion of the bell on the front-end cab was missing after the collision, but the bell was fully functional. The auxiliary, or ditch, lights were not functional. The event recorder was downloaded, and it appeared that the event recorder lost power at the time of the collision, and no data was stored after the collision with the backhoe.

[27] NTSB investigators examined train 89, both before and after the train was moved during the recovery efforts. All railcars came to rest upright.

[28] (a) The *pilot,* colloquially known as the "snowplow" or "cowcatcher," is located at the front of a train to deflect objects on the tracks. (b) An *anti-climber* is a device mounted above the coupler of locomotives and passenger cars to prevent colliding objects from travelling up over the frame and through the locomotive cab or through the passenger car.

Debris from the backhoe struck the right side of the lead passenger car. The impact deformed the exterior right side, causing inward movement of the sidewall between the second and fourth windows. (See figure 10.) Damage above the second and third windows included a horizontal gouge mark on the side sheet, and the rear edge of the second window had been pushed partially inward. The collision pushed the third and fourth windows completely into the car. The side sheet between the third and fourth windows was torn, with gouge marks around the window opening. The ninth window was completely pushed into the car with a gouge mark at the upper rear corner of the window opening.

Figure 10. West (right) side of lead passenger car in Train 89.

Inside the lead passenger car, investigators found the right sixth-row and seventh-row seats separated from the wall and floor pedestal. (See figure 11.) Near the right eighth-row seat, the baggage rack was bent upward, the ceiling panels had fallen onto the seats, and the interior wall panels at the windows were cracked and torn. The right fifth- and the eighteenth-row seats had partially rotated. The first aid kit was empty, and all its supplies had been used.

Figure 11. Interior of lead passenger car.

1.10 Recorder Data

1.10.1 Video Recorder Data

The locomotive had two camera systems. One was a forward-/outward-facing video camera that recorded video in color and sounds captured by a microphone mounted on the exterior front of the locomotive.[29] The other camera was an inward-facing image recorder inside the locomotive cab that recorded video and audio. The locomotive digital video recorder (LDVR) captured both video and audio inside the control cab. Video and audio data from both cameras was recorded and stored by the LDVR.

1.10.2 Locomotive Event Recorder Data

The locomotive event recorder data showed that the train departed Penn Station in New York City at 06:06:30. It made four station stops before the accident. Between New York and

[29] This microphone captured sounds primarily of the train rolling over the track; the sound of the locomotive horn and the watchman's air horn were not discernible.

Philadelphia the train speed reached a high of 124 mph, and the train complied with all cab signals. After departing Philadelphia's 30th Street Station at 07:38:30, the train accelerated to 109 mph. The last 40 seconds of the data contained the following events:

- At 07:49:00, the train speed was steady at 107 mph. The throttle was in position T6, and the train was 6,272 feet from the final recorded point.[30] The cab signal was *Clear* 125 mph and remained at this signal setting through the end of the recording.

- At 07:49:02, the throttle was moved to the T5 position. Parameters were then stable for the next 28 seconds.

- At 07:49:31, the throttle was moved to the Idle position with the train 1,387 feet from the final recorded point.

- At 07:49:32, the horn was sounded, and it stayed active until the end of the recording. The train was 1,230 feet from the final recorded point.

- At 07:49:33, the train speed dropped to 106 mph (from 107 mph).

- At 07:49:35, the train was 760 feet from the final recorded point. An engineer-induced emergency was activated. Brake pipe pressure decreased to 0 psi in about 2 seconds and brake cylinder pressure began to rise. The train was moving at 106 mph, and began to decelerate.

- At 07:49:40, the final recorded data point, the train speed was 99 mph, brake pipe pressure was 0 psi, and brake cylinder pressure was 75 psi. At this time, the horn was recorded as active.

1.11 Method of Operation

The Philadelphia to Washington Line in the Mid–Atlantic Division of Amtrak's NEC extended from MP 0.0 at CP Zoo in Philadelphia, Pennsylvania, to MP 134.6 at CP Avenue, Washington Terminal in Washington, DC, in a timetable north-south direction. In the vicinity of the accident, Amtrak operated trains over the four tracks using a traffic control system controlled by a train dispatcher located at the Consolidated National Operations Center in Wilmington, Delaware. Amtrak Operating Rule 261 governs train movements on the Mid-Atlantic Division between CP Phil MP 3.6 to CP Holly MP 20.3.[31] Additionally, on tracks where Rule 261 is in

[30] The accident locomotive was equipped with a continuous power lever rather than a classic power lever with discrete notches, or throttle positions. The locomotive mapped this continuous power lever into notches for communication with other engines (if equipped). These mapped throttle notches were recorded by the event recorder and included in this description of events.

[31] Amtrak's Operating Rule 261: Track signaled in both directions. Signal indication will be the authority for a train to operate in either direction on the same track. At a hand-operated switch without an electric lock a train may clear the track only where the maximum authorized speed on the track over the switch is 20 mph or less.

effect, the automatic block signal system and cab signal system Rules 550-561 are in effect for movements in both directions.[32]

At the time of the accident, Amtrak authorized train movements using NORAC rules, supplemented with the following:

- Amtrak *Timetable Special Instructions,* effective February 22, 2016
- General Order No. 601, effective February 22, 2016
- Bulletin Orders NYW6-03 (sum), effective March 7, 2016; NYW6-06, effective March 28, 2016; and NYW6-01SCH-a, effective February 22, 2016
- Wilmington Dispatching Office Temporary Speed Restriction Bulletin, effective April 3, 2016 (5:00 a.m.)

Amtrak train dispatchers authorized all train movements and coordinated all work by roadway workers and equipment on the right of way. These authorizations included granting qualified roadway workers Form D (track out of service) and foul time authority. These authorizations were used to protect roadway workers and equipment from train movements. The authorization of trains through a work zone included determining the speed of the trains.

1.12 Signal System

The ACSES portion of the system includes civil speed enforcement and positive train stop (PTS) enforcement capabilities.[33] The civil speed enforcement feature of ACSES protects the locomotive from exceeding civil speed limits. The presence of permanent and temporary wayside transponders establishes civil speed limits. The PTS enforcement feature ensures that the locomotive stops at home signals when an absolute stop aspect is present.

The FRA-required automatic train control (ATC) and ACSES departure tests are required every calendar day or within 24 hours of departure. Before the day's initial service run the locomotive engineer must conduct or verify each test. The departure tests include a sequence of steps to verify the operational integrity of the equipment. Any equipment malfunction must be corrected before the locomotive's service run.

ACSES on the Amtrak NEC is currently applied as a complement to an existing wayside signaling system with cab signals that provides train detection through track occupancy logic, interlocking logic, broken rail protection, and on-board enforcement of signal speed. ACSES combined with the ATC Cab Signal System meets all requirements for high-speed passenger rail operation on the NEC and all FRA-mandated PTC requirements to prevent train-to-train collisions,

[32] (a) In the *automatic block signal system,* the use of each block is governed by an automatic block signal, cab signal, or both. (b) The *cab signal system* is interconnected with the fixed signal system to provide the engineer with continuous information on the occupancy and condition of the track ahead.

[33] *Civil speed* means maximum speed as set by the physical characteristics of the track structure and the mechanical capabilities of the train consist.

overspeed derailments, incursions into established work zone limits, and movement of a train through a switch left in the wrong position.

1.12.1 Locomotive Equipment

The ACS-64 locomotive was equipped with an ATC system. The system is a combined 9-aspect ATC and ACSES configuration that ensures safe operation of the locomotive.

The ATC portion of the system includes automatic speed control and automatic train supervision capabilities. The automatic speed control feature protects the locomotive from exceeding speed limits established by track signals. The automatic train supervision feature ensures that the locomotive engineer recognizes and acknowledges track signal (aspect) speed reductions.

1.13 Operational Testing

Title 49 *CFR* Part 217 required that railroads have a program to conduct operational tests and inspections periodically to determine compliance with their operating rules, timetables, and timetable special instructions. Amtrak monitored the effectiveness of and compliance with its operating rules by using field audits, inspections, and its program of operational tests. Amtrak stored records from its operational test program, TESTS, in a database, making them readily available for inspection and analysis. TESTS programs were detailed in *Supervisor's Guide to Efficiency TESTS*, which described how to conduct each test and outlined supervisor requirements and program oversight responsibility. The operational tests were based on railroad functions rather than railroad-specific rules or instructions. This permitted the same operational tests to be used throughout the Amtrak system, regardless of host railroad. The selection of available operational tests was keyed to employees' crafts. When recording noncompliance in an operational test of an employee, supervisors were required to view any previous noncompliance by the employee.

Four different types of observations are documented in TESTS:

- 1872 Efficiency Tests: Operating rules/instruction compliance (all operating crafts)
- 1875 Engineer Evaluations: On-the-job locomotive engineer train operating proficiency
- 1876 Student Engineer Evaluation: On-the-job student engineer train operating proficiency
- 1877 Conductor Evaluations: On-the-job conductor proficiency in train operations and customer interaction

During the 12-month period before the accident, Amtrak recorded 194,343 tests conducted on 8,343 different train and engine employees, train dispatchers, roadway workers, and equipment maintenance personnel on the NEC. These tests included those taken by employees of other railroads that Amtrak hosts on the NEC. Excluding tests of equipment maintenance personnel, Amtrak conducted 172,303 tests on 6,670 different train and engine employees, train dispatchers, and roadway workers on the NEC.

NTSB investigators learned that at the time of the accident, Amtrak did not have an efficiency test code for observing or evaluating compliance with Amtrak's SSD process. Supervisors and managers did have the ability to code noncompliance with the SSD process, but the code was placed in the "other" category of the database and thus would not be an item differentiated or assessed adequately for compliance.

1.14 Meteorological Information

At 7:00 a.m. the weather was sustained northwest wind of 38 mph gusting up to 50 mph and a temperature of 37°F. Visibility was unrestricted. Thunderstorms with heavy rain were reported between 11:16 p.m. (April 2) and 12:08 a.m. (April 3) at Philadelphia International Airport (KPHL), which is about 7 miles northeast of the accident site. The band of thunderstorms was associated with lightning and small hail and marked the leading edge of high wind that continued into the morning hours.

1.15 Sight Distance Observations

Investigators performed sight distance observations on June 12, 2016, from ground level, focusing on the movement of a train approaching the accident site from the north and traveling southbound at 106 mph. The purpose of the observations was to measure the distance at which an observer could first see the approaching train, as well as the distance at which the approaching train appeared clearly on track 3. The observations were made from positions representing the location of the watchman—from outside of track 4 and in the foul of track 4. The time it took the train to reach the accident location after it was first detected also was recorded.

From the viewing position located outside and clear of track 4, the first-detection distance ranged from 4,097 to 4,392 feet across the observers, or, equivalently at 106 mph, from 26 to 28 seconds from the accident site. Similarly, from a viewing location in the foul of track 4, the first-detection distance ranged from 4,190 to 4,425 feet, or 26 to 29 seconds from the accident site.

Additionally, from the viewing position located outside and clear of track 4, the recognition that the approaching train was on track 3 occurred between 1,788 and 2,150 feet, or between 11 and 14 seconds from the accident site. From the viewing location in the foul of track 4, the recognition that the train was on track 3 occurred between 1,598 and 1,853 feet, or between 10 and 12 seconds from the accident site.

Amtrak's *Roadway Worker Protection Manual*, System Safety (Rev. 4, January 1, 2015) requires that employees and equipment are in a place of safety, clear of the track, 15 seconds before the arrival of a train. A speed and distance table aids employees to determine the time and distance needed for watchmen to ensure compliance with the "15-second rule." (See table 3.) The maximum authorized speed for passenger trains on tracks 2 and 3 in the area of the accident is 110 mph; for the outside tracks, tracks 1 and 4, the maximum authorized speed is 90 mph.

Table 3. Speed versus distance.

Speed (mph)	Feet per Second	Feet per 15 Seconds
90	132.0	1,980
95	139.3	2,090
100	146.7	2,200
105	154.0	2,310
110	161.3	2,420

1.16 Safety Culture and Management

Safety culture is a term used to refer to an organization's attitudes and actions about safety. That is, the beliefs commonly held by all employees throughout a corporation about safety in their workplace, including their safety, that of their peers and colleagues, and that of customers during business activities. All organizations have a safety culture; however, safety cultures can be weak and ineffectual at fostering safe work practices by employees. Safety culture has been studied widely across business communities; organizations that prioritize safety within all business activities have a strong safety culture.

James Reason has indicated that organizations with a weak safety culture will have more active failures, as well as latent conditions that undermine safety. Active failures are the errors and violations committed by those in direct contact with the system. Latent conditions are created by system designers, builders, procedure writers, maintainers, and system managers and can lie dormant for many years before they combine with active failures and lead to an accident. (Reason 2013, pp. 82–83) Thus, one would expect employees of an organization with a weak safety culture to engage in more unsafe actions than employees of an organization with a strong safety culture. One would also expect managers of an organization with a weak safety culture to fail to seek and address upstream system factors, such as poor training and a lack of equipment. As Reason observes, perhaps the most insidious and far-reaching effects of a weak safety culture are shown by an organization's reluctance to proactively address known safety shortcomings. (Reason 2013)

An important concept related to safety culture is safety management. Generally, safe organizations have a system in place to manage safety, which is called a safety management system (SMS). The FAA, which has mandated the implementation of SMS, defines an SMS as a "formal, top-down, organization-wide approach to managing safety risk and assuring the effectiveness of safety risk controls.[34] It includes systematic procedures, practices, and policies for the management

[34] FAA Order 8000.369, FAA Safety Management System Initiative (FAA Safety Management System Initiative). Accessed August 15, 2017. The order applies to the Air Traffic Organization (ATO), Aviation Safety Organization (AVS), Office of Airports (ARP), Office of Commercial Space Transportation (AST), the Office of the Next Generation Air Transportation System (ANG), and the Hazardous Materials Safety Program Office in the Office of Security and Hazardous Materials Safety (ASH).

of safety risk." Further, "an SMS is a structured process that obligates organizations to manage safety with the same level of priority that other core business processes are managed." Safety culture and SMS programs are interconnected:

> A safety culture is the manifestation of the internalization of the SMS on the part of the employees that make up the organization. The SMS should take account of and shape the safety culture of the organization. Effective SMS instill and reinforce a safety culture among employees, and that safety culture ensures the effective implementation of the policies, principles, and practices set forth by the management system.[35]

SMS programs have four functional characteristics:

- Corporate policies and procedures for safety and safe operations. All SMS programs must define policies, procedures, and organizational structures to accomplish their goals. The policies and procedures must emanate from the top of the organization with clear support and expectations for compliance throughout all lower corporate levels. The corporate policies and procedures must align and implement senior management's vision for safety throughout the business operations.
- Safety assurance controls that serve as checks and balances for the implementation of safety policies and practices and also as a feedback mechanism to inform management about the effectiveness of the safety programs. These controls must be applied continuously and respected throughout the organization's operations, and employees must be encouraged to respect and work with the controls, even in changing work environments.
- Risk management is a formal system of hazard identification, analysis, and mitigation. It is an essential component of work project planning, and it should be performed for each job and for all work crews working in or for the corporation. Risk management techniques vary and, therefore, can be tailored to fit all jobs. The purpose of risk management is to inform workers about safety hazards and to provide sufficient insights to control risks to acceptable levels.
- Safety promotion. The safety policies, practices, and techniques of a safety culture will not influence the actions and decision-making of workers without management's guidance and support of compliance. The purpose of safety promotion is to convey to all workers that safety is a core value of the organization, which has established practices that support safety and in which management participates.

[35] 2011. Implementing Safety Management System Principles in Rail Transit Agencies (https://www.transit.dot.gov/regulations-and-guidance/safety/safety-management-systems-sms). Accessed August 22, 2017.

1.16.1 Amtrak Safety Management

NTSB investigators examined the first-line safety supervision at the Chester work site in relation to the unsafe practices found, which led to interviews with senior management personnel to learn about and understand Amtrak's safety program and safety management and how they affect roadway workers and train-operating employees. Investigators also interviewed senior managers of the unions that represented the roadway workers involved in the accident. The interviews included safety policies, procedures, and assurances; the collection of safety-critical information; risk management strategies; and promotion. Additional safety topics discussed include safety oversight, corporate safety knowledge and vision, and reliance on rule compliance.

At the time of the accident, Amtrak had a system safety program (SSP) in place. Amtrak's SSPP defines "system safety," as follows:

> Amtrak defines system safety as a detailed method of applying scientific, technical, operating, and management techniques and principles for the timely identification of hazard risk and initiation of actions to prevent or control these hazards throughout the system life cycle and within the constraints of operational effectiveness, time, and cost. The system to which the SSP applies is Amtrak and all of its organizational and physical components, people, procedures, facilities, and equipment.
>
> The Amtrak safety policy contained in the SSPP states the following:
>
> To be safer, Amtrak will use behavioral safety principles in developing and implementing safety risk reduction programs. The Safe-2-Safer Program and the SSPP will guide prevention efforts by identifying the policies, programs, and strategies that promote a safe work environment for employees and travelers alike. Safety principles are used to integrate safety into all phases of our business including design, construction, modification and rehabilitation, operation, maintenance, and procurement, and that we reduce risk and eliminate, to the extent possible, potentially hazardous activities and conditions.
>
> Amtrak's safety and occupational health goals can be achieved through a responsive, coordinated safety and risk management effort using the Safe-2-Safer process. We commit to:
>
> - Working with all employees to identify safety risks ….

According to Amtrak's deputy chief safety officer, the SSPP was initiated in 2006 and "was developed in accordance with the American Public Transportation Association standards, which are volunteer consensus elements."[36] In general, Amtrak's SMS programs, including the implementation of the strategies described in the SSPP, were described as "evolving." In addition

[36] There is no federal requirement for Amtrak to have an SSPP.

to the Safe-2-Safer Program, Amtrak had enacted two other safety programs: a close call reporting system and the Safety Liaison Program.

Safe-2-Safer was a peer-to-peer program intended to drive behavior-based safety. The program relied on employees to provide feedback to their peers to encourage them to engage in safer behaviors. Amtrak's management intended Safe-2-Safer to be a nonthreatening and confidential program for collecting safety-related information.

Amtrak adopted the FRA's Confidential Close-Call Reporting System—C^3RS—and anticipated collecting safety-critical information through it.[37] The FRA C^3RS website provides this description of the system:

> A[n] FRA sponsored voluntary confidential program allowing railroad carriers and their employees to report close calls. The program provides a safe environment for employees to report unsafe events and conditions. Employees receive protection from discipline and FRA enforcement. Railroads also receive protection from FRA enforcement for events reported within C^3RS.

The Safety Liaison Program relied on experienced labor personnel to visit work sites randomly to assess the safety of work activities. The safety liaisons were Amtrak employees who were given the authority to challenge workers when they observed unsafe acts and who were expected to counsel workers on proper, safe work techniques. Amtrak's Safety Division managers told NTSB investigators that because the safety liaisons were experienced in their trades, the workers likely would respect and accept their safety advice more readily than they would if the same advice were formalized in rules. However, Amtrak safety managers said that the Safety Liaison Program started about 3 1/2 years ago, was understaffed, and at the time of the accident many of its tools and procedures for observing and tracking safety issues had not been implemented throughout the company. NTSB investigators determined that no safety liaisons were present at the work site on the day of the accident.

Investigators also learned that all the unions that represented the roadway workers involved in the accident had opted out of Amtrak's Safe-2-Safer program and the C^3RS program during their respective labor-management contract negotiations. The union representatives told investigators that the work environment was hostile and made it difficult for workers to perform their jobs safely and to provide peer-to-peer protection for their colleagues, because Amtrak had instituted a "Cardinal Rules" program that could lead to workers' being fired for a single violation. (See figure 12.)

[37] FRA C^3RS website (http://www.fra.dot.gov/c3rs). Accessed September 25, 2017.

AMTRAK®

10 Cardinal Rules

The following actions constitute serious violations of Amtrak's Operating Rules and Standards of Practices that put life and limb at risk. Violations of these rules will be handled with zero tolerance. Discipline for any such violations will likely lead to immediate dismissal.

1. Any unauthorized tampering with or disabling of an approved safety device.
2. Any serious failure to comply with applicable Lock Out/Tag Out procedures and AMT-2 Electrical Operation System procedures.
3. Any serious failure to comply with confined space entry requirements for all permit required confined spaces.
4. Any unauthorized use of an electronic device when operating or riding moving equipment; directing equipment movement; assisting in preparing equipment for movement; and performing service on the ground, in yards, or on main track.
5. Falsification of inspection or maintenance documents.
6. Cheating on required exams.
7. Working on, under, between rolling equipment without proper Blue Signal Protection procedures.
8. Failure to comply with Shoving and Backing Movements procedures.
9. Failure to comply with approved Fall Protection Equipment procedures where required.
10. Failure to comply with applicable Roadway Worker Protection (RWP) Procedures.

All alleged violations shall be immediately and thoroughly investigated. Findings demonstrating violations of these rules shall warrant severe discipline, likely dismissal. Should extenuating circumstances arise that warrant variation in discipline, they will be reviewed, and discipline shall be approved by the Cardinal Rules Review Board consisting of our Chief Transportation Officer, equivalent officers as necessary, and Labor Relations as necessary.

Figure 12. Amtrak's 10 Cardinal Rules.

The general chairman of the Brotherhood of Maintenance of Way Employes Division (BMWED) expressed frustration with Amtrak's Cardinal Rules, which he suggested led to employees' being terminated for minor violations. He said—

> I can think of 8 or 10 people right now that were fired for minor violations of RWP rules, that probably, in my opinion, should not have been fired. … one guy was fired because he got out of a truck on a, basically a dead track, where the grass is this high, and [he] didn't get RWP protection. A train hasn't been on that track for 25 years.

The BMWED general chairman added that the fear of being fired "sends terror into every man's thought and family, when you're without that income…." The BMWED general chairman indicated that the revocation of an existing close-call policy, and the implementation of the Cardinal Rules, resulted in vital safety information not being reported. He said that "engineers were reluctant sometimes to report close calls with track gangs, because they didn't want to involve the track gang in discipline."

Other union leaders expressed similar concerns. For instance, the general chairman of the Brotherhood of Railroad Signalmen (BRS) described a culture of fear at Amtrak: "There's no dialogue … it's fear. I mean you talk to the managers, they're afraid. And you can talk to the youngest guy. It's fear." The BRS chairman expressed concern that Amtrak threatened to fire employees for not following fall protection protocol, but failed to provide the necessary policy and resources to follow the protocol.

A representative for the American Railway and Airway Supervisors Association (ARASA) union indicated that Safe-2-Safer was "nothing but a program that drove down safety statistics," and that "nobody believed in the program, but if you spoke against [it], especially managers, they were deathly afraid to say anything because their superiors would take action against them." He said, "This company is driven by fear." The ARASA representative indicated that there were situations in which employees "reported track conditions that there should have been speed restrictions on, they were pressured into either overlooking it, or changing their reports."

The ARASA representative also expressed concern over training, saying, "we have no training other than the Safe-2-Safer Program, that was basically pushed on us, and then never followed through." He indicated that the classroom training was insufficient, and that the instructors lacked experience and could not effectively elaborate on classroom materials. He voiced concern that feedback from the field was not being incorporated into classroom training appropriately. The BMWE chairman also expressed concern over the training, indicating that the training instructors at one point were teaching an incorrect way to use SSDs.

Investigators reviewed Amtrak records pertaining to the Cardinal Rules to evaluate the extent to which the union representatives' concerns were consistent with objective data. Amtrak records indicated that the Cardinal Rules were enforced across the entire Amtrak system. In 2016, employees had been terminated in Berlin, Connecticut; Chicago; New York; Denver; Philadelphia; Wilmington, Delaware; and Newark, New Jersey. Investigators confirmed that multiple employees had been terminated for failing to establish RWP. In addition, Amtrak had considered terminating an employee for failing to use fall protection but decided not to because the "employee [was] not trained on fall protection, and did not understand [the] requirements."

Investigators spoke with Amtrak management to obtain additional information about the Cardinal Rules. Amtrak's chief operations officer indicated that "every single Cardinal Rule violation goes to a group that looks at the mitigating circumstances, and that group decides what the discipline is going to be, and there's a progressive discipline process." The chief operations officer later added that "The perception is, wrongfully so, and I think communication, again, could have been better, that you violate one of these rules, you're terminated. Nothing could be further from the truth."

Additionally, the chief safety officer provided information about the enforcement of the Cardinal Rules, indicating that the repercussions an employee experienced for violating a Cardinal Rule varied depending on who discovered the violation. That is, if a safety liaison discovered a Cardinal Rule violation, the employee would be counseled, but not reprimanded. However, if a supervisor discovered a Cardinal Rule violation, the incident would be reported to management, who would review the violation and consider termination of the employee.

Amtrak's chief operating officer did not acknowledge the unions' concerns with the Cardinal Rules and said that he did not understand their position. The disagreement between Amtrak and its unions over Amtrak's safety programs became a labor-management contract negotiating issue, putting roadway workers at risk every day. Amtrak acknowledged an awareness of the unions' refusal to participate in its Safe-2-Safer and close-call reporting programs yet continued to conduct its public transportation business without openly disclosing and proactively promoting resolutions to these safety shortcomings.

Investigators interviewed Amtrak senior executives and division heads to further examine safety management practices and efforts to improve safety management throughout the company. The managers had a variety of attitudes about best safety practices. Some managers showed little interest or concern about safety beyond the demands of their immediate job responsibilities, others expressed awareness of safety principles but lacked detailed knowledge of them or experience in applying them, and a few managers enthusiastically espoused their use of well-established and contemporary safety management techniques in performing their jobs.

In particular, there appeared to be a gap in Amtrak's safety training. The Amtrak director of training indicated that there was no field auditing process to evaluate the effectiveness of the classroom training that Amtrak foremen received. Thus, Amtrak could confirm that the workers involved in the accident had probably viewed a presentation pertaining to the use of SSDs. However, Amtrak could not confirm whether this presentation had sufficiently prepared the workers to consistently apply the safety devices in the field. Also, the director of operating practices recognized the fallibility of human performance (that is, humans do not perform error free 100 percent of the time) yet failed to acknowledge the inherent risks associated with train dispatchers initiating passenger train movements based solely on verbal communications that tracks are clear. He would not accept a proposal that train dispatchers can trust the safety-critical information communicated by track foremen, but they must verify that information through follow-up questions. Instead, he strongly relied on old railroad industry adages, such as foremen must follow the rules (report only when tracks are clear), and train dispatchers do not need to slow passenger trains through construction zones because there is no rule that requires it.

The senior manager of heavy construction (production programs) demonstrated his awareness and knowledge of safety practices by requiring his staff to prepare detailed SSWPs. The chief operating officer and the deputy chief safety officer were able to discuss system safety concepts in detail and conveyed clear visions to improve Amtrak's safety culture through contemporary system safety strategies.

Although the Amtrak managers had disparate views of safety management, they shared one common perspective: workers must follow the rules to remain safe. This was evident in interviews with employees throughout all levels of Amtrak's management. Amtrak's reliance on rule compliance, for instance, was highlighted in an interview with Amtrak's chief safety officer pertaining to construction zones:

Question: Do construction zones present any unique challenges from your point of view as chief safety officer?

Answer: Not if you follow the rules. You follow the rules, you follow the procedures out there. The rules, there are rules in place that allow the safe passage of trains. It's when you don't follow the rules that you get yourself in trouble. Obviously, Amtrak is a high-speed railroad, if you will. They do a lot of their work at nighttime. But nonetheless, if you follow the rules and procedures, I don't see it as much of an issue.

A second example of Amtrak's reliance on rule compliance is evident in a discussion with Amtrak's director of operating practices:

Question: We know rules probably can't be written to cover every scenario that's experienced out on the road. We know that people can't be relied upon as 100 percent rule followers. Is there a take-away from that that may help Amtrak make some improvements beyond what the NTSB recommends?

Answer: I would take exception to your statement that we can't depend on people to be 100 percent rule followers. Every employee's life depends on each and every other employee following the rules. As soon as one employee fails to follow the rules, it puts another employee or the riding public in jeopardy and that's unacceptable.

Many similar conversations unfolded as investigators spoke with Amtrak managers about their approach to managing safety.[38] The NTSB recognizes that rules and procedures are an essential element of transportation operations. Rules can be viewed as a 'soft' safety defense. James Reason (1997, p. 8) stated the following:

> 'Soft' defenses, as the term applies rely heavily upon a combination of paper and people: legislation, regulatory surveillance, rules and procedures, training, drills

[38] Transcripts of these interviews are available in the NTSB's public docket for this accident.

> and briefings, administrative controls (for example, permit-to-work systems and shift handovers), licensing, certification, supervisory oversight and—most critically—front-line operators, particularly in highly automated control systems.

Also—

> ‘Hard’ defenses include such technical devices as automated engineered safety features, physical barriers, alarms and annunciators, interlocks, keys, personal protective equipment, non-destructive testing, designed-in structural weaknesses (for example, fuse pins on aircraft engine pylons) and improved system design.

Rules and procedures can provide a layer of protection, but they do not constitute all the layers of protection that would be expected in a safe system. (Reason 1997, p. 7) Safety experts (for example, Reason 1997, pp. 49–51) do not support the notion that a focus on rules compliance can completely assure safety.

1.16.2 Federal Railroad Administration Role in Safety Management Systems

The FRA has introduced, but has not yet enacted, an SMS regulation for the intercity and commuter passenger railroads the FRA regulates. In 2012, the FRA published an NPRM that included a draft of 49 *CFR*, Part 270, System Safety Program. (*Federal Register* 2012, 55372) The FRA published the final rule on August 12, 2016. (*Federal Register* 2016, 53850) The regulation required intercity and commuter passenger railroads to provide a formal plan to implement key aspects of SMS, including risk management strategies. The FRA indicated that “an SSP provides a railroad with the tools to systematically and continuously evaluate its system to identify hazards and the resulting risks gaps in safety and to mitigate or eliminate these hazards and risks.” Although the effective date of the regulation initially was October 11, 2016, the regulation has been stayed four times. Most recently, the FRA published a stay of the regulation effective June 2, 2017, until December 4, 2017. (*Federal Register* 2017, 26359)

2 Postaccident Actions

2.1 Amtrak

Amtrak took immediate actions following this accident including creating a series of *Rules Alerts* pertaining to specific rules associated with the accident:

- Protocols for fouling a track: Actions taken before fouling, the use of SSDs, actions taken before returning a track to service
- Communication of mandatory directives: radio use is primary; telephone use is permitted in the event of a radio failure

Amtrak also issued a system-wide safety alert and conducted a safety stand-down that addressed the scenario of the accident and Amtrak's commitment to safety and the standards of excellence; explained the need for effective job briefings, communications, good faith challenge provisions, the good faith challenge process; and FAMES committee guidance; and the use of SSDs.[39]

Since the accident, Amtrak also has completed the following:

- Issued a bulletin clarifying and reiterating the protocols for fouling including a supplement to the *Roadway Worker Protection manual* regarding SSD instructions.
- Created an independent compliance group outside the engineering department that is composed of a director and four compliance officers augmented by contract support. The group reports to the senior vice president for operations with its initial focus on evaluating compliance with RWP regulations and making recommendations to improve compliance.
- Revised its drug and alcohol policy to (1) accommodate changes in regulations (MOW employee testing) and (2) "strengthen the disciplinary consequences of violating the drug and alcohol policy."[40]
- Created a shift transfer form for use by foremen to document critical protection information in extended outages. Amtrak finalized the form on September 16, 2017, and is developing training and the communication process for the form.

Also since the accident, Amtrak has been working on the following efforts to improve safety:

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[39] (a) *FAMES* is an acronym for the Fatality Analysis of Maintenance-of-way Employees and Signalmen Committee, which is an ad hoc committee to review roadway worker fatalities that was formed by the FRA in collaboration with railroad labor and management representatives. (b) Safety Alert.

[40] A *MOW employee* does MOW work and is called a *roadway worker* in this report.

- Enhanced Employee Protection System: Amtrak is working with Rockwell-Collins to enhance its dispatch system to provide redundant protection for fouling activities. This project is capital funded and will be completed by January 2018.
- Prototype Supplemental Shunting Device: Amtrak is working with an equipment supplier to develop a supplemental shunting device with light-emitting diode (LED) indication.
- Supplemental Shunting Device Storage: Amtrak is outfitting all roadway equipment with a dedicated box to store SSDs. A predeparture inspection form on each vehicle will include a question asking if SSDs are in the storage box on the vehicle.
- To enhance organizational alignment, Amtrak indicated plans to expand its efficiency testing program. Roadway Worker Joint Efficiency Testing: Amtrak is working in collaboration with the FRA to conduct joint efficiency testing. Actions to date include the following:
  - Creation of a Form O to capture other workgroups working within the authority of a roadway worker in charge.
  - Clarifying with conductor flagmen how to communicate their methods of protection properly. The term "Foul Time" now refers to any track authority.
  - Clarifying with large production gangs the proper procedure for assigning a sole roadway worker in charge. Multiple subgroups work under one very long Form D/Track Out-of-Service authority.
- System-wide 24/7 Site Visits: Amtrak is developing a process for targeted monitoring of FRA inspection data, TESTS observation data, ongoing systematic use of outward-facing video cameras on locomotives, and electronic communications for train dispatchers.
- Roadway Worker Protection: Amtrak will perform a third-party review of its *Roadway Worker Protection Manual* for readability and comprehension. Following the review, the manual will be revised as necessary and incorporate the FRA regulatory change resulting from this accident. In addition, Amtrak will assess the current initial and recurrent RWP. Another Amtrak initiative is to review equipment training to determine whether additional modifications pertaining to RWP provisions are necessary.
- Amtrak prepared and distributed a document, *[Amtrak] Post Incident Action Update June 2017*, to communicate its actions resulting from the Chester accident. As detailed above, the document described changes that Amtrak made to communications, training, drug and alcohol prevention programs, organizational alignment, and engineering improvements.

2.2 Federal Railroad Administration

In response to this accident, the FRA initiated a number of civil penalty actions against Amtrak for its engineering and operating practices. Additionally, the FRA investigated Amtrak's compliance with 49 *CFR* Part 272, Critical Incident Plans. The FRA also directed Amtrak to conduct a safety stand-down with all Amtrak roadway workers to review safety procedures and compliant safety briefings. Amtrak had begun the stand-down before the FRA directed Amtrak to conduct one.

In 2016, the FRA issued two final rules to improve the protection of railroad employees working on or near railroad tracks. The first was a final rule: 49 *CFR* Part 214, Railroad Workplace Safety, Roadway Worker Protection Miscellaneous Provisions.[41] On June 12, 2016, the FRA published amendments to its Roadway Worker Protection regulations at 49 *CFR* Part 214. The amendments to Part 214.19 required redundant protection for roadway workers who depend on train dispatchers to provide protection in signaled territories. The final Roadway Worker Protection rule became effective April 21, 2017.

The second rule addressed another safety issue identified in this accident: the use of potentially impairing substances by MOW workers. This rule, Control of Alcohol and Drug Use, first issued on May 25, 2016, revised the FRA's existing alcohol and drug testing regulations and expanded the requirements to cover MOW employees. On June 12, 2016, the FRA published amendments specifically including random drug screening for MOW employees. This was implemented on June 12, 2017, after this accident. The rule partially fulfilled NTSB Safety Recommendation R-08-07 that stemmed from an accident where a Massachusetts Bay Transportation Authority passenger train struck a track maintenance vehicle in Woburn, Massachusetts. (NTSB 2008) In that accident, the fatally injured track foreman tested positive for marijuana. Safety Recommendation R-08-07 recommended that the FRA include "all employees and agents performing safety-sensitive functions" in the mandated drug and alcohol testing program; the Control of Alcohol and Drug Use rule covers only MOW employees, not all of those performing safety-sensitive functions. As a result, this recommendation is currently classified "Open—Unacceptable Response." However, the backhoe operator's use of cocaine and the maintenance supervisor's use of codeine and morphine (both MOW employees) in this accident could have been detected and addressed through the now mandated drug and alcohol screening program.

In addition, the FRA and the NTSB held a joint meeting with the senior leadership of the Class I and commuter railroads on September 1, 2016, regarding concerns about increasing rates of positive postaccident drug testing results in rail (FRA/NTSB Drug and Alcohol Forum). This was a closed meeting to give industry an opportunity to understand the scope of the problem and to share best practices with each other.

On June 12, 2016, the FRA published amendments to its RWP regulations at 49 *CFR* Part 214 and its drug and alcohol regulations at 49 *CFR* Part 219. The amendments to Part 214 required redundant protection for roadway workers who depend on train dispatchers to provide protection in signaled territories. The amendments to Part 219 added roadway employees to the drug and alcohol testing program. Specifically, random drug screening for MOW employees was added to the drug and alcohol testing program and implemented June 12, 2017.

[41] The miscellaneous provisions final rule included regulatory language to address redundant signal protection recommended in Safety Recommendation R-08-06.

FRA Regions 1 and 2 completed a Corridor On-Track Safety Initiative consisting of five inspection teams that conducted the equivalent of 59 days of field inspections on the Amtrak NEC.[42] This project ran from April 25, 2016, through May 20, 2016. The teams inspected 120 work groups totaling more than 1,000 roadway worker contacts (some roadway workers were contacted more than once). In addition to the field inspections, the FRA monitored several dispatching centers.

Beginning July 18, 2016, FRA Regions 1 and 2, in cooperation with Amtrak, initiated an Amtrak Roadway Joint Efficiency Testing (ARJET) project. This effort was intended to ensure a consistent understanding and application of RWP rules, railroad operating rules, and railroad safety rules. The FRA inspectors granted "safe haven" to Amtrak (withheld violations) following the FRA's Safe Harbor policy, whereby the FRA would not use enforcement against Amtrak during these inspections as long as the Amtrak manager took proper corrective action. According to the FRA, the goal of this effort was to perform joint inspections of roadway workers throughout the NEC and branch lines. Inspections covered every shift and every work team possible to look for proper application of roadway worker safety and operating rules. This project was completed at the end of December 2016.

The FRA stated that Amtrak management at all levels had been fully cooperative and proactive during this effort.

Regions 1 and 2 have reallocated significant resources toward Amtrak activities. In 2015, Region 2 allocated and filled an additional full-time inspector position. This track inspector has an assigned territory largely consisting of the NEC.

Two audits of Amtrak's TESTS program conducted in February 2016 by the FRA in Regions 1 and 7 revealed numerous deficiencies and several areas of concern with respect to Amtrak's implementation of its TESTS program.[43] On March 9, 2016, Amtrak submitted a corrective action plan for the FRA's review and comment. On March 29, 2016, FRA representatives met with ranking Amtrak operating officers to discuss and determine an appropriate corrective action. As a result of that meeting, Amtrak on April 7, 2016, submitted a revised corrective action plan that addressed the FRA's concerns. That plan was scheduled for implementation on or before May 15, 2016, and Amtrak has implemented the plan. The corrective action plan addresses several key areas related to Amtrak's TESTS program including application modifications, training, tracking, rule violation followup, testing officer accountability, foreign crew observations, and enhanced oversight.

According to the FRA, Amtrak has revised training, rules, and standard operating practices based on the FRA's findings. Amtrak employees now use SSDs as intended, and Amtrak changed training, reconciled rules, and revised RWP manuals to include instructions for using SSDs.

[42] FRA Region 1 consists of Maine, New Hampshire, Massachusetts, Vermont, New York, Rhode Island, Connecticut, and New Jersey. Region 2 consists of Pennsylvania; Delaware; Maryland; Washington, DC; Virginia; West Virginia; and Ohio.

[43] FRA Region 7 consists of California, Nevada, Utah, and Arizona.

3 Analysis

3.1 Exclusions

NTSB reviewed the signal system data logs, which indicated that the signals were functioning properly at the time of the accident. Review of the forward-facing video from the Amtrak locomotive determined that the signals were *Clear* (proceed). Interviews with the train crew and postaccident mechanical inspections indicated that the equipment was operating as designed on the day of the accident. Therefore, the NTSB concludes that the track structure, signals, and mechanical equipment did not contribute to the accident.

3.2 Toxicology and Medical Information

The postaccident toxicology findings for the backhoe operator and the supervisor were positive, while the surviving roadway workers (including the night and day foremen, the assistant nighttime supervisor, and the watchmen) as well as the dispatcher had negative urine test findings. For the Amtrak train crew, the Amtrak postaccident toxicology tests and the FRA-mandated tests for the engineer were positive; but the conductor's and the assistant conductors' test findings were negative. The implications of the positive toxicological findings for the roadway workers and the engineer in this accident are discussed below.

3.2.1 Backhoe Operator

The backhoe operator's actions did not contribute to the circumstances of this accident but toxicology testing identified his use of cocaine and gabapentin (a potentially impairing prescription medication) as well as blood pressure medications. Current US Department of Transportation (DOT) random testing can identify urinary metabolites of cocaine but does not test for gabapentin or many other potentially impairing prescription, over the counter, and illicit drugs.

3.2.2 Track Supervisor.

At the time of the accident, the track supervisor was working, rather than performing his supervisory and safety duties, and had not stopped work and challenged the day foreman when he did not provide a safety briefing. His toxicological testing was positive for codeine, morphine, and oxycodone. However, the detected drug levels may not have been indicative of preaccident levels because of postmortem redistribution, and although opioid drugs may be impairing, users can become tolerant of the impairing effects. This means there is no direct way to relate levels and impairment. As a result, the NTSB was unable to determine whether the track supervisor's actions were the result of the effects of his use of opioids. Therefore, the NTSB concludes that the track supervisor had used two different opioids at some point before the accident, but based on behavioral evidence, drug-induced impairment of his job performance could not be determined.

3.2.3 Locomotive Engineer

Train 89's last stop before the accident was Philadelphia's 30th Street Station, which the train departed at 07:38:30. During about 11 minutes between the train's departing Philadelphia and the accident, the video from the locomotive's inward-facing video showed the engineer seated in the engineer's seat performing routine train operations, with the train speed at or near track speed, which was 110 mph. After the engineer saw the backhoe on track 3 ahead of him, he began a series of horn blasts and made an immediate emergency brake application. In apparent anticipation of the impact with the backhoe, he knelt on the floor while continuing to sound the horn until, just before the collision, he lay down on the floor.

Because the engineer's train was on the same track as the backhoe, there were no other maneuvers he could have taken to prevent the accident or lessen its severity. Therefore, the NTSB concludes that the Amtrak engineer took timely and appropriate actions to stop the train and to warn the roadway workers about the train approaching their work area.

Although the Amtrak train engineer responded appropriately to the impending collision, postaccident toxicology testing detected 2.2 ng/ml of THC (the primary impairing compound in marijuana) and 16.1 ng/ml of THC-COOH (THC's inactive metabolite) in blood collected 5 hours after the accident. These results indicate he had used marijuana at some point before the accident. However, calculation of the exact THC level in the engineer's blood at the time of the crash is not possible. In addition, the relationship between drug concentrations found in toxicological tests and degraded or impaired behavior is complex and depends on the mode of use of marijuana (eaten versus smoked), the amount (dose) used, and the frequency of use. As a result, whether the engineer was experiencing any effects from his marijuana use at the time of the accident could not be determined. However, marijuana use of any type (prescribed or recreational) is expressly forbidden for use by transportation operators subject to DOT-mandated drug testing.[44] The NTSB therefore concludes that although there was no operational evidence of impaired performance by the engineer, his use of marijuana was illicit and had not been deterred by his participation in the DOT drug testing program, and any previous marijuana use had not been detected by random drug testing.

3.2.4 Drugs in the Workforce

The toxicological test findings in this accident are very disconcerting to the NTSB—three of the employees involved tested positive for drug usage. The presence of metabolites of codeine and morphine in the backhoe operator, cocaine in the supervisor, and THC in the engineer could have been found during random DOT urine drug testing. These employees performed regular job duties that directly affected the safety of the traveling public, as well as the welfare of their work colleagues. The NTSB believes that employees, especially those in safety-sensitive positions, should be drug- and alcohol-free while on duty, and that employers should enforce a zero-tolerance policy for illicit use of misuse of potentially impairing drugs and alcohol as a tenet of their safety

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[44] (a) DOT Office Of Drug And Alcohol Policy And Compliance Notice, Medical Marijuana. (2009) (https://cms.dot.gov/sites/dot.gov/files/images/ODAPC%20Medical%20Marijuana%20Notice.pdf). Accessed October 27, 2017. (b) US Department of Transportation. DOT "Recreational Marijuana" Notice. (2012) (https://www.transportation.gov/odapc/dot-recreational-marijuana-notice). Accessed October 27, 2017.

management programs. Indeed, the presence of employees on duty who might be unable to pass a DOT urine drug test is a marker of Amtrak's ineffective safety culture. The NTSB concludes that Amtrak did not effectively assure that its employees, especially those in safety-sensitive positions, were drug-free while performing their public transportation duties.

Since the accident, the FRA implemented rulemaking that became effective in June 12, 2017, requiring DOT random urine drug screening for MOW employees. The NTSB concludes that had the two roadway workers used cocaine, codeine, or morphine with some regularity, been subject to random urine drug screening, and been selected for testing, their use of cocaine, codeine, or morphine may have been detected before the accident. According to the Substance Abuse and Mental Health Services Administration, "Drug testing is a prevention and deterrent method that is often part of a comprehensive drug-free workplace program," and "random tests are the most effective for deterring illicit drug use." Before the accident, MOW employees participated in a drug testing program where the date and time of the test was known to the employee ahead of time. These were preemployment, return to duty, and postaccident drug testing, and the results of their periodic testing were negative. The NTSB concludes that the absence of a random drug testing program for MOW employees at the time of the accident meant there was no effective program to deter the MOW employees from using drugs. The use of marijuana by the engineer, who was subject to random testing (that tested for marijuana), demonstrates that the deterrent effect of random testing is not 100 percent. Nonetheless, the NTSB also concludes that the participation of the two roadway workers in the pool for random testing might have deterred them from using cocaine and opiates.

3.3 Survival Factors

Train 89 struck the backhoe at 99 mph. After the initial impact, parts of the backhoe struck the right side of the train, causing a disruption to the occupied passenger space. The NTSB investigated another Amtrak accident that damaged the side wall of a passenger car. A grade crossing accident demonstrated the need for improved side impact standards. On June 24, 2011, a 2008 Peterbilt truck-tractor failed to stop and struck the left side of Amtrak train no. 5, which was passing through a grade crossing. (NTSB 2012) The collision destroyed the truck-tractor and two passenger railcars. The train came to a stop without derailing; however, a fire ensued, engulfing two railcars and damaging a third railcar. The accident killed the truck driver, the train conductor, and 4 train passengers; 15 train passengers and 1 crewmember were injured. The NTSB determined that insufficient passenger railcar side impact strength contributed to the number of fatalities and the severity of injuries. As a result, the NTSB issued the following safety recommendation to the FRA:

<u>R-12-39</u>

> Develop side impact crashworthiness standards (including performance validation) for passenger railcars that provide a measurable improvement compared to the current regulation for minimizing encroachment to and loss of railcar occupant survival space.

In response, the FRA reported that it was directing the Volpe Center to conduct simulations of passenger cars undergoing significant side impacts with increasing side strengths to determine the adequacy of the current designs and the predictable safety implications of increasing the side strength. The FRA stated that Volpe's findings may provide a basis for new regulations specifically addressing side impact crashworthiness. As of the date of this report, the recommendation is classified "Open—Acceptable Response."

3.4 Foremen's Shift Transfer

The night foreman and the day foreman had a discussion at 7:27 a.m. on the day of the accident. They discussed the ongoing work and the protection in place at the time. The day foreman had obtained a Form D for Track 2 before discussing the shift transfer with the night foreman.[45]

The night foreman believed that he had reached an agreement with the day foreman; he was going to cancel his fouls and his Form D, and then the day foreman was going to immediately call the dispatcher and obtain the fouls. Thus, the workers, who were actively engaged in track work at the time, with a backhoe positioned on track 3, would be subject to a minimum amount of disruption in their work.

Amtrak's procedure to transfer fouls was cumbersome, because it would have required both foremen to stop the track work and remove the backhoe. Thus, the shortcut (release of fouls followed by the request and approval of those fouls) would allow them to quickly finish the transfer process. In his interview, the night foreman appeared to suggest that this was a common shortcut, describing the rule-violating transfer procedure as "just like it's always done."

The night foreman's actions after his conversation with the day foreman were consistent with the shortcut described above. That is, he called the dispatcher and canceled his fouls (and his Form D) and told the dispatcher that the day foreman would be picking up his fouls. According to the night foreman, he then reengaged the day foreman and suggested that he call the dispatcher, and drove away from the job site.

The day foreman did not call the dispatcher to obtain fouls at any point on the morning of the accident.[46] The day foreman's inaction appears surprising considering the night foreman's statement that he told the day foreman to pick up the fouls and the day foreman said, "I got it." But the day foreman told investigators that during his job transfer conversation with the night foreman, "All I told him was when you are clear of all your fouls, don't bother getting any more fouls …." The day foreman told investigators that he expected the night foreman to remain at the worksite and clear the workers and equipment from the tracks before giving up his foul time and departing. He also said that he did not pay attention to what the night foreman was doing, and that he "assumed everything was still fouled." However, the day foreman circulated a job briefing sheet indicating that he was the EIC and had secured foul time to protect the employees and equipment (backhoe). Amtrak training stipulated that only one employee can be the EIC, and FRA regulations state that only one employee be assigned as EIC. Accordingly, the day foreman's account of the incident is neither consistent nor compliant with Amtrak's training or FRA regulations. Therefore,

[45] Two foremen can hold Form Ds for a track simultaneously but cannot hold foul time simultaneously.

[46] The day foreman did call the dispatcher, before he arrived at the work site, to obtain a Form D for track 2 that the RailVac was occupying.

the NTSB concludes that the result of the night foreman's actions and the day foreman's inactions based on their conversation was that tracks 1, 3, and 4 were not protected with foul time from about 7:30 a.m. until 7:50 a.m. when the accident occurred. After their conversation, the day foreman went to the job site and began interacting with several of the workers. The watchman and the RailVac superintendent reported that the day foreman told them that the tracks were protected with fouls, although a job briefing was not provided. At one point (between 7:30 a.m. and 7:50 a.m.), the day foreman asked the RailVac superintendent to initiate work, and the RailVac superintendent responded that he would not without a job briefing. The day foreman had the RailVac superintendent sign a job briefing form, although he failed to provide a job briefing. The day foreman was in the cab of the RailVac when the accident occurred at 7:50 a.m. He told investigators he intended to complete the foul time log eventually while he was in the cab. Thus, the day foreman's actions and statements in his interviews suggest that he felt no urgency to call the dispatcher to obtain foul protections. There is no evidence verifying that the day foreman thought that the job site was still protected by the night foreman's fouls or that he forgot to call the dispatcher while he was working.

Several factors likely affected the way the night and day foremen conducted the shift handoff:

- Amtrak did not have an efficient procedure for transferring fouls. The Amtrak rules required the night foreman to stop the work being performed and clear the track of workers and equipment—moving the backhoe and the workers on track 3 into the wayside—before releasing his fouls. In compliance with Amtrak rules, the day foreman could then request foul time and, when foul time had been granted, the day foreman could return the backhoe and workers to track 3. This procedure, which includes stopping and starting the work and moving workers and equipment, is inefficient and slows the work.
- The night foreman described to investigators a procedure that required less time than complying with the Amtrak rule: first the night foreman releases his fouls without removing the backhoe and workers from track 3, and immediately afterward the day foreman requests fouls on track 3. The night foreman said that this "shortcut" procedure was "just like it's always done."
- According to the watchman, the night foreman was ready to go home after his shift, and the day foreman arrived late at the job site. The shortcut procedure allowed the foremen to conduct the shift transfer quickly, and it caused minimal disruption to the ongoing ballast-vacuuming work.
- The day foreman had 36 years of experience, and the night foreman had been a foreman for 4 months. And, the two foremen had not conducted a shift change before. Thus, a lack of rapport may have contributed to their failure to execute the shortcut procedure.
- Before the accident in the morning, the supervisor was actively engaged in labor and not participating in or overseeing the shift transfer. Thus, there was no third party to verify that the job transfer process was unfolding as intended.

Amtrak's director of operating practices provided information about the foremen's actions, their options during the shift transfer, and avenues for potential safety improvements (increasing the safety layering and diminishing single points of failure). Amtrak did not have a procedure for two foremen to jointly transfer their fouls with the train dispatcher when their shifts change. Such a procedure would be one in which the fouls would not be released but kept in force with the relieving foreman responsible for those fouls. The director of operating practices indicated that a process that allowed foremen to communicate with a train dispatcher to jointly transfer their fouls with a train dispatcher's knowledge and approval could be designed and implemented to be safe.

The NTSB believes that the absence of a procedure allowing foremen to transfer foul time with the oversight of the train dispatcher increases the opportunity for a single point failure by one or both of the foremen. According to Reason (2016, p. 33), "Good procedures should tell people the most efficient and safest way of carrying out a particular task. It should be noted that clumsy procedures are among the main causes of human violations." Planning engineering work on the NEC is hazardous because the number of train movements and the speeds at which trains operate too often prove to be so unforgiving that the need for every safety layer is critical; there is no room for error, and single points of failure must be eliminated.

Good communication is especially important during transfers between shifts. The NTSB concludes that 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. A procedure that allows foremen to transfer their fouls jointly with the train dispatcher could avoid the loss of track protection. Therefore, the NTSB recommends that Amtrak establish a method to ensure that on-track protection in an active work zone is not lost during shift transfer.

3.5 Positive Train Control

Amtrak had installed PTC on the track territory where this accident occurred. The PTC system functioned as designed, but human activities before the accident rendered it useless for preventing the train incursion into the work area.

When a train dispatcher provides track protection as requested by a foreman, information is entered into the PTC system and an electronic block is applied that prevents a train from being routed into the protected area. However, when a train dispatcher removes the track protection, as done when clearing foul time, the electronic block is removed and a train can be routed into the track. The latter scenario occurred in this accident when the night foreman released his foul time at 7:29 a.m. and the dispatcher removed the electronic block at 7:31 a.m. Thus, human directives removed PTC-based protection for the workers and equipment still positioned on the track.

A safeguard for dispatcher removal of track protection is SSDs. Roadway workers on the ground place the physical SSDs on the track, which is interpreted by the PTC system as occupied track. Thus, SSDs provide redundant signal protection to ensure that tracks are protected, even when a dispatcher removes the electronic blocks. In this accident, however, the work crew did not use SSDs, and the dispatcher did not challenge the crewmembers about the absence of SSDs when they discussed foul time. Thus, the human inactions removed the opportunity for PTC to provide track protection.

The accident in Chester occurred, despite the presence of the PTC system, because human activities rendered it incapable of automatically controlling the train movement. The NTSB therefore concludes that the inadequate and inconsistent use of SSDs by Amtrak engineering personnel effectively defeated the RWP component of Amtrak's ACSES and thereby placed MOW employees, equipment, and the traveling public at greater risk of harm. The NTSB further concludes that had the foremen ensured SSDs were in place, the accident would not have occurred. To add another layer of protection for roadway workers, the NTSB recommends that the FRA require railroads to install technology on hi-rail, backhoes, other independently operating pieces of MOW equipment, and on the leading and trailing units of sets of MOW equipment operated by maintenance workers to provide dispatchers and the dispatch system an independent source of information on the locations of this equipment to prevent unauthorized incursions by trains onto sections of track where maintenance activities are taking place in accordance with the Congressional mandate under the Rail Safety Improvement Act of 2008.

Investigators sought to discover why the foremen, who were responsible for providing track protection for the other roadway workers, failed to use SSDs. The night foreman, the day foreman, and the train dispatcher had specific duties to perform in the proper application and use of SSDs. To be clear, the nature of the work at the job site, on the day of the accident and before the incident, required the day and night foremen to establish foul time with the train dispatcher because the equipment being used occupied either a specific track or the envelope of the equipment extended beyond the track that it occupied; that fact necessitated foul time protection. The night foreman determined that track 1 needed to be protected using foul time, because the track ballast-vacuum train's equipment extended beyond the track it occupied on both sides. The same rule was in force when the foreman elected to use the backhoe by placing it on track 3; it required that track 4 be protected as well. Therefore, there were times when all four tracks required protection by either a Form D or foul time. Moreover, Amtrak Rule 140-S2 requires the use of SSDs when an EIC engages in covered fouling activities (for example, uses machinery that will foul a track in signaled territory for more than 5 minutes). (Amtrak 2016)

However, the night foreman told investigators that he did not have SSDs to use. Thus, it would have been impossible for the foreman to follow Amtrak's own rules. Therefore, it is reasonable to presume that no SSDs were used the entire time that he provided on-track protection for the project. Nor did the train dispatcher ask the night foreman about his not applying SSDs. The track supervisor on the day of the accident did not insist that SSDs be applied. The NTSB therefore concludes that there was wide acceptance at Amtrak of not using SSDs.

Upon discovering that Amtrak management failed to issue SSDs to the night foreman, despite their own rules mandating the use of the safety equipment, investigators sought to discover why this was the case. The evidence collected suggested that the lack of an efficiency test code may have reduced awareness of the issue. During the project, Amtrak had assigned one supervisor per shift to the project, and at the time of the accident Amtrak did not have an efficiency test code for the observation or evaluation of compliance with Amtrak's SSD process. Even without a code, supervisors and managers had the ability to code noncompliance with the SSD process, but the code was placed in the "other" category of the database, so that SSD compliance was not differentiated or assessed adequately. Without the ability to measure SSD compliance alone, Amtrak cannot verify that SSDs are being used, and without verification, it is possible that SSDs are not being used. The NTSB concludes that a specific efficiency test code for the foul time process that assesses SSD use would give Amtrak the ability to monitor and improve SSD compliance and change the culture of noncompliance.

Upon discovering that Amtrak did not have an effective method of monitoring SSD use, investigators examined SSD regulations and discovered that, despite an NTSB recommendation, the FRA did not require the use of redundant signal protections. Thus, Amtrak, faced no regulatory consequences for failing to use SSDs. The NTSB concludes that had the FRA required shunting as recommended by the NTSB in Safety Recommendation R-08-06, the accident would not have occurred.

3.6 Site-Specific Work Plans

Amtrak required SSWPs for repair and restoration projects that are large, with many employees and equipment and that occupy large stretches of track over a long period of time, for example, a project replacing many miles of track. However, Amtrak does not have specific, measurable criteria for "large" in this context, and determining whether a project requires an SSWP depends on the project manager. Although the ballast-vacuuming project at Chester did not occupy a large stretch of track or more than about 10 workers during each shift, it was complex in several areas. The non-stop work over 55 hours required good communication and coordination during shift changes and between train dispatchers and foremen, careful adherence to foul time and Form D procedures—critical for roadway work projects of all sizes and complexity; strategic positioning of the appropriate number of watchmen to ensure close monitoring of track(s) so an approaching train is seen as soon as possible; and comprehensive assessment of the work site as a whole to ensure that equipment does not block a watchman's view or a worker's view of a warning of an approaching train and that the warning can be heard over noisy equipment.

Of the four examples of hot spots listed earlier in this report, two related to the requirement that employees and equipment are clear of the track 15 seconds before the arrival of a train. An SSWP was not prepared for the ballast-vacuuming project, and so the work area was not identified as a potential hot spot. However, the examples and descriptions of hot spots do not include the situation of monitoring multiple main tracks where equipment obstructs the view as at Chester. A large, stationary piece of equipment can obstruct sight distance and pose a safety risk similar to those of identified hot spots. These sight distance limitations should be identified when an SSWP is performed.

The day watchman at Chester saw the approaching train and attempted to warn the workers by sounding an air horn and waving an orange disc, although the watchman's actions other than moving away from the track were not discernible on the video. However, it is unclear whether an air horn could be heard over the noise of the RailVac and that the orange disc could be seen by workers with the backhoe creating a visible obstruction. Even if the warnings were heard and seen, however, those potentially in harm's way likely were not able to clear the track with sufficient time to avoid injury. The backhoe and the operator would not have had sufficient time to clear the track. A watchman was never intended to provide that level of warning because clearing the backhoe from the track would take too long. Protection for a backhoe on a main track had to rise to the level of the issuance of foul time properly authorized and discussed with the work group—all elements that should have been covered in a job briefing. Those risks should have been identified through the preparation of an SSWP and a thorough SSWP review before the project began.

The primary safety layer that a watchman adds to the protection of a work group is to make a timely warning to workers and equipment of the approach of a train. Amtrak did not consider the accident area to be a hot spot, and there was no plan for the use of multiple watchmen to protect against an approaching train. In addition, the postaccident sight distance observations show that when the watchman could determine that a train was approaching on track 3 there was not enough time for the watchman to communicate to the work crew so that they could be in the clear 15 seconds before the train arrived. This safety issue includes an interpretation that is not always discussed: the 15-second train approach time does not include the time taken for a roadway worker to move clear of the track and into a place of safety. If that movement takes 15 seconds, then a train must be visible in time for a warning to be given 30 seconds before the train arrives.

The ballast-vacuuming work was a complicated and significant work project that needed thorough planning and management review to protect the roadway workers, equipment, and the traveling public using Amtrak's passenger service. Therefore, the NTSB concludes that Amtrak management should have recognized that the project rose to a heightened level of hazard that required a detailed review or SSWP before it began. An SSWP review likely would have identified that a serious hazard existed, since employees would be working in both an Amtrak passenger train and commuter operations environment with the passage or simultaneous movement of trains on adjacent tracks. If an SSWP had been completed, the following hazards at the worksite would have been identified:

- A single watchman assigned to the ballast-vacuuming project was inadequate to monitor approaching trains on tracks 1, 3, and 4 at any time and on any track in both directions.

- The night shift foreman did not have SSDs to apply, and clearly the night track supervisor did not check to see whether SSDs had been placed on the tracks.

- The staggered reporting times of the three different departments supporting the project presented a problem in conducting and completing one comprehensive job briefing for all employees immediately after the shift change between the foremen.

Amtrak typically applies the SSWP process to large production projects where it believes the increased number of employees and equipment constitutes a heightened risk. However, the Chester project, although not a large project based on the number of employees and equipment, had the complexity and thus the safety hazards of a larger project. Therefore, the NTSB concludes that safety hazards exist at complex smaller projects, and these hazards should be assessed and addressed with SSWPs. The NTSB recommends that Amtrak develop and implement an engineering safety procedure for preparing SSWPs for maintenance projects on the NEC main line tracks spanning multiple shifts or multiple workdays to reduce or mitigate the inherent risks of MOW work in a high-speed train operations environment.

3.7 Job Briefings

The FRA regulations require that the EIC of work on tracks must conduct a job briefing, which provides workers with information to improve their safety in an otherwise potentially unsafe situation. A job briefing must be timely and provide all workers present for the job briefing the opportunity to thoroughly discuss not only the on-track protection secured but the hazards present at the job site. At Chester, on the day of the accident, the day foreman circulated an Amtrak two-sided Job Briefing Documentation Sheet and On-Track Safety Briefing Sheet for employees to sign without first conducting a job briefing. He said he did this because he intended to conduct the job briefing after all the other project support workers gathered at the work site. The accident occurred within the first 30 minutes after the foreman arrived. The practice of delaying a job briefing is not in compliance with the FRA regulations or the Amtrak RWP training.

Another example of the breakdown of on-the-job safety was the track supervisor's performing laborer tasks at the job site, so he was unable to do his own job of supervising. He was busy while the job briefing sheet was circulated for signatures without the foreman's conducting the briefing, and therefore he could not ensure that a safety briefing was conducted. When a supervisor does not perform his duties and responsibilities, the wrong signal is sent to the work force. The NTSB concludes that disengagement by a supervisor from a critical and regulated safety communication process reduces safety layering and at a minimum encourages other lax safety habits. The NTSB further concludes that had the supervisor been engaged with his duties and responsibilities, a proper and thorough job briefing would likely have been conducted and the employees would have had an opportunity to ask the day foreman how on-track safety was to be provided.

On September 24, 2014, the NTSB adopted its *Special Investigation Report on Railroad and Rail Transit Roadway Worker Protection*. (NTSB 2014b) The following excerpt on job briefings is from that report:

> Federal regulations contained in 49 *CFR* 214.315 require job briefings, and it is likely that the accidents may not have happened had more comprehensive job briefings been conducted beforehand. All except one of the accidents discussed in this special investigation report were preceded by some type of job briefing, safety meeting, or toolbox safety meeting.[47] The evidence shows that the briefings omitted essential and job-specific elements related to hazard recognition and mitigation. The NTSB believes it is critical that all members of roadway worker groups actively participate in hazard recognition and ensure that hazards are adequately mitigated before work begins.
>
> Title 49 *CFR* 214.315, "Supervision and communication," requires that when an employer assigns duties to a roadway worker that call for that employee to foul a track, the employer shall provide the employee with a job briefing that includes information on the means by which on-track safety is to be provided, and instruction on the on-track safety procedures to be followed. Additional

[47] NTSB investigators were unable to confirm that a job briefing was conducted before the BART Walnut Creek accident.

> requirements, effective July 1, 2013, require the job briefing to include information about any adjacent tracks, on-track safety for such tracks, and identification of any roadway maintenance machines that will foul the tracks and a discussion of the nature of the work to be performed and the characteristics of the work location. This information is to be communicated again anytime the on-track safety procedures change during the work period.
>
> Although on-track protection and procedures are vital elements of a job briefing, a comprehensive job briefing that included an analysis of the task and environmental conditions with appropriate hazard recognition and mitigation would likely have prevented many of these accidents. General discussion of safety and toolbox safety meetings should never suffice for a job briefing. Further, the FRA regulations covering job briefing pertain only to MOW workers' on-track method of protection and do not go far enough to ensure a comprehensive job briefing for all types of roadway work.

In response to the NTSB's special investigation report, the then president/CEO of Amtrak sent a letter to the NTSB dated September 25, 2014, stating the following:

> Safety remains Amtrak's top priority. … Amtrak's roadway worker safety program exceeds the minimum requirements in 49 *CFR* Part 214. … Amtrak will review the best practices for comprehensive job briefings in Occupational Safety and Health Administration standards contained in 29 *CFR* Parts 1910 and 1926 and will revise our programs where required.

Although the Amtrak president/CEO's response to the NTSB's special investigation report was encouraging, real and effective changes were lacking 18 months later, as this accident shows.

The employees who signed the job briefing sheet should have been aware of their responsibility to not sign the sheet unless the foreman had conducted a job briefing, thus they contributed to a lax safety environment (another reduction in the safety layering concept was employees not acting responsibly to ensure their safety). The NTSB concludes that had the day foreman conducted a thorough job briefing for all workers on the day shift, including the supervisor, before the work began, foul time protection or the lack thereof and which foreman had the foul time likely would have been discussed and then rectified or mitigated by removal of the backhoe from track 3. The NTSB further concludes that each employee present at the work site had the obligation to demand that a proper job briefing be conducted before they signed the safety briefing sheet.

3.8 Train Dispatching

Both the day and the night dispatchers received training that included the requirement to ensure that SSDs are used when tracks are fouled for longer than 5 minutes. They had completed training that covered NORAC rules and the Amtrak *Timetable Special Instructions,* both of which contain rules for foul time and application of SSDs. However, despite this training, neither the day nor the night train dispatcher ensured that SSDs were applied. Information from the interviews with the night train dispatcher and from phone conversations between the day train dispatcher and the day foreman indicate that both train dispatchers knew that a backhoe was being used on track 3 for longer than 5 minutes. In addition, neither train dispatcher asked the night foreman why he had not used SSDs.

The NTSB reviewed the dispatchers' foul time log sheets for the duration of the work outage. Those log sheets did not include a section to denote the indication of a TOL (indicating the use of SSDs) as part of the application of foul time. Several foul time entries were for time slots longer than 5 minutes, and dispatchers were aware that a backhoe was being used as part of the work project. The foul time entries longer than 5 minutes suggest a lack of supervisory oversight of foul time log sheets in the dispatcher center. After the accident, Amtrak revised its foul time log sheet to include a section to indicate the use of SSDs. The NTSB concludes that the supervisory oversight in Amtrak's dispatcher center did not adequately monitor dispatcher responsibilities to ensure that SSDs were used. The NTSB therefore recommends that Amtrak require supervisors to review train dispatchers' foul time log sheets to verify whether SSDs are being adequately applied.

The day train dispatcher ran train 89 on track 3 without calling the day foreman to ask whether track 3 was clear. The day train dispatcher had released the night foreman's fouls and Form D, and the night foreman had told the dispatcher that the day foreman was going to request foul time for tracks 1, 3, and 4. The dispatcher put the pending foul time requests in his logbook and had not removed several of the blocking devices from the previous shift, because he was expecting the day foreman to call to obtain the fouls. Although the dispatcher said he had contemplated calling the day foreman to find out whether he wanted foul time or not, he did not call the day foreman either to ask whether he wanted fouls or to verify that track 3 was clear before authorizing a train to operate on the track.

On the day of the accident, the day train dispatcher engaged in two personal phone conversations (via an Amtrak recorded land line) while he was on duty and controlling the railroad, but these calls did not violate any rules. The NORAC *Operating Rules* prohibit the use of personal electronic devices by railroad employees but do not address the use of a railroad's business phone to engage in personal phone conversations. (NORAC 2011) The goal of this rule is to eliminate the distraction caused by personal electronic devices in the railroad environment. Train dispatchers are responsible for operating the railroad in their assigned territories efficiently and safely. This responsibility places a significant cognitive demand on a train dispatcher to remain alert, aware, and engaged while in control of one or more train movements. The NTSB has investigated transportation accidents where personal use of business phones by operations personnel has led to distraction and pertinent information that was not conveyed. (NTSB 2010) On the day of the accident, the dispatcher put the pending foul time requests in his logbook and left on his board several blocking devices from the previous shift, and he thought about calling the day foreman to ask about foul time requests or to verify that track 3 was clear before authorizing a train, but he did not call the foreman. The NTSB therefore concludes that the personal phone calls made by the day train dispatcher while he was on duty distracted him from performing his job. The NTSB recommends that Amtrak revise its train dispatcher rules so that potentially distracting activities, such as making personal telephone calls, are not allowed while dispatchers are on duty and responsible for safe train operations.

Amtrak's 80-mph Slow By policy, requiring the train dispatcher to slow trains to 80 mph when they pass some construction zones, did not apply to the equipment used in the ballast-vacuuming project. But the project required the use of a RailVac and a backhoe on out-of-service track. This equipment was noisy, like an undercutter and a track-laying machine, and in this case the equipment was on out-of-service track, like the work conditions covered by the "80-mph Slow By" policy. An organization focused on risk management would acknowledge the safety risks of the work conditions of the Chester project and advise train dispatchers to make safety-conscious decisions, such as slowing trains or using slower tracks, to move passenger trains by work areas.

Postaccident interviews revealed that the NEC is undergoing a long-term infrastructure project. The project is estimated to last 5 to 8 years and encompass nearly every portion of the NEC. The level of maintenance and programmed capital improvements will be constant and pervasive along the NEC, significantly raising the risk of the work as engineering department projects progress in an environment of dense passenger train traffic. Additionally, passenger trains operate at much higher speeds than freight trains, and thus the time needed to safely clear on-track personnel when a passenger train approaches is greater than that for a freight train. The NTSB therefore concludes that Amtrak's ongoing infrastructure work creates an increased exposure of roadway workers to incidents like the one at Chester.

Other railroads that host Amtrak passenger trains employ various methods to reduce the speed of trains passing by work zones, including slow orders, conditioning stops, and restricted speed. Amtrak complies with these speed limitations on hosts' properties, and it could apply the same restrictions on its own properties. However, Amtrak typically uses its "slow by" policy only when track undercutting or track-laying machinery is in a defined work zone. Thus, Amtrak has recognized the risks associated with trains passing some construction zones at full track speed, but not others (that is, ballast-vacuuming work). But the 80-mph speed restriction that Amtrak imposes in some situations is still too fast for a train to pass a work zone safely. The NTSB concludes that had Amtrak instructed dispatchers to operate trains at significantly slower speeds through the Chester work zone, the severity of the accident would have been diminished. The NTSB recommends that Amtrak conduct a risk assessment for all engineering projects and use the results to issue significant speed restrictions for trains passing any engineering project that involves safety risks for workers, equipment, or the traveling public, such as ballast vacuuming, as part of a risk-mitigation policy.

The evidence from the Chester accident suggests that the operating environment for Amtrak dispatchers was not optimized for safety. Amtrak's rules did not require that trains be slowed by ballast-vacuuming projects, nor did they restrict dispatchers from engaging in personal phone calls while responsible for safe train operations. In addition, first-line supervisors of dispatchers were not ensuring that dispatchers verified SSD use. It appeared that the only supervisor expectation that the day train dispatcher sought to meet was on-time performance. Therefore, the NTSB concludes that Amtrak's rules and supervisor expectations for dispatchers did not adequately emphasize safety.

3.9 Safety Oversight

Numerous unsafe conditions were uncovered in the investigation that contributed to the hazards of the work environment on the day of the accident. These safety shortcomings ranged from individual and crew actions to procedural and oversight work practices that facilitated unnecessary risks and increased the likelihood of the accident. These unsafe active failures and latent conditions combined to result in a fatal accident. While mistakes are expected in human work systems, the multitude of unsafe conditions observed indicates a systemic problem. The active failures that occurred indicate that safety was consistently a low priority in the decision-making process of the employees involved. The presence of the unsafe latent conditions indicates that management failed to proactively identify and mitigate unsafe conditions. Indeed, no fewer than 29 active failures and latent conditions were identified:

Medical Active Failures

1. The backhoe operator ingested drugs that could have negatively impacted his ability to perform his work safety.

2. The track supervisor ingested drugs that could have negatively impacted his ability to fulfill his supervisory responsibly of ensuring that his subordinates were following safe work practices.

3. The train engineer ingested drugs that could have negatively impacted his ability to operate the train safety.

Medical Latent Conditions

4. Roadway workers were not subject to random drug screening.

Maintenance of Way Active Failures

5. The night foreman released foul time with workers and equipment on the track.

6. The night foreman communicated with a cell-phone instead of a radio, which prevented other workers from discovering that he was releasing his foul time authority.

7. The day foreman did not request foul time authority, even though the night foreman had departed the work site and workers and equipment were fouling track 3.

8. The day foreman did not conduct a meaningful job briefing.

9. Several employees signed a job briefing signature sheet, even though they were not given a job briefing, and did not exercise their right to make a good-faith challenge.

10. The day foreman circulated a job briefing signature sheet while the track was unprotected.

11. The RailVac superintendent (a contractor) requested a job briefing before initiating work, but even upon being prompted, the day foreman did not conduct a job briefing.

12. The day foreman told the RailVac superintendent that several tracks were protected with foul time when they were not.

13. The day foreman told the watchman that several tracks were protected with foul time when they were not.

14. Neither the night foreman nor the day foreman applied SSDs.

15. The day track supervisor did not stop the ongoing work due to the lack of SSDs.

16. The day track supervisor was actively performing the job of a roadway worker, rather than ensuring that his subordinates were following safe work practices.

17. The watchmen did not have adequate sight distance to see approaching trains and could not provide adequate protection. He did not stop the ongoing work with a good faith challenge.

Maintenance-of-Way Latent Conditions

18. Amtrak did not require or encourage an SSWP be prepared for the 55-hr track work.

19. Amtrak did not have a formal shift transfer procedure for the dispatcher and the foremen that verified the use of SSDs.

20. Workers reported that radios did not work well in the area, which resulted in cell phone communications and reduced situation awareness for track workers.

21. Amtrak management did not assure that roadway workers were equipped, properly trained, and diligently used SSDs. Amtrak management did not have an efficiency testing code for SSD use.

22. Without applying SSDs to the track as a redundant safety protection, the track occupancy logic of the signal system was not enabled at the time of the accident.

Dispatcher Active Failures

23. The day train dispatcher did not verify that SSDs had been applied.

24. The day train dispatcher engaged in personal phone calls while on duty.

25. The day train dispatcher did not call the day foreman to verify that track 3 was clear before authorizing a train to proceed on it, even though he was anticipating that the day foreman was going to call and request foul time for the track “within seconds.”

26. The day train dispatcher authorized a train to proceed through the work area at maximum authorized speed, rather than requiring a slower speed as a precaution.

Dispatching Latent Conditions

27. Amtrak rules did not require speed restrictions for trains passing ballast vacuuming work, and the speed restrictions that they did have required that trains proceed at 80 mph, which is not slow enough to significantly mitigate the risk associated with construction zones.

28. Amtrak rules did not prohibit dispatchers from engaging in personal phone calls while on duty.

29. Amtrak supervisor expectations for dispatchers emphasized on-time performance over safety.

As discussed earlier, Reason (2013, pp. 82–83) has maintained that an increased number of active failures and latent conditions are a manifestation of a weak safety culture. Therefore, the NTSB concludes that the 29 active failures and latent conditions indicate a systemic problem with Amtrak's safety culture. Consistent with this conclusion, further investigation revealed several safety deficiencies at various organizational levels at Amtrak. This section of the report details these issues.

3.9.1 First-Line Safety Oversight

Amtrak had three safety programs at the time of the accident—Safe-2-Safer, C^3RS, and the Safety Liaison Program—but none of these programs ensured the safety of the workers involved in the accident. The workers belonged to unions that had chosen not to participate in Safe-2-Safer and C^3RS. According to the union representatives, the Safe-2-Safer program was inferior to a previous safety program, and they preferred an older close-call policy, which had been cancelled in 2014, over C^3RS. Also, the union representatives indicated that the implementation of the Cardinal Rules had contributed to labor employees' fearing that they would lose their jobs if they reported rule violations. Amtrak management indicated that the Cardinal Rules were not new concepts; they were fundamental railroad safety principles. Beyond this, Amtrak management generally did not acknowledge the union concerns.

It is concerning that Amtrak and its unions allowed safety to become a labor-management contract negotiating issue. The lack of participation in the C^3RS and Safe-2-Safer programs trivialized safety and made the work environment less safe for everyone, including Amtrak employees, contractors, and the traveling public. It is also concerning that Amtrak was aware of the unions' refusal to participate in Safe-2-Safer and C^3RS, yet the company failed to resolve the unions' objections and effectively mitigate these safety shortcomings.

Amtrak's third safety program, the Safety Liaison Program, was ineffective, which likely was a consequence of the program's being understaffed; there was no safety liaison present at the work site on the day of the accident. Although the Safety Liaison Program could be an effective safety management program if implemented and resourced properly, it is concerning that Amtrak's senior leadership tolerated the ineffective, under-resourced program and failed to collaboratively establish a pervasive and robust safety solution for all jobs potentially encroaching on its passenger railways, especially the busy NEC.

This concern is heightened by the recognition that Amtrak knew that its two other safety programs were rendered defunct and inoperable by their labor management practices. That is, Amtrak's senior leaders should have recognized the serious system safety deficiency of nonparticipation in the safety programs. Collaboration is needed to maximize safety in systems, because safety issues often involve interactions among parts of the system. It is important to understand how a change in one subsystem of a complex system may affect other subsystems within that system. As NTSB Board member Christopher A. Hart said in his October 10, 2017, presentation to the ORCHSE Strategies Executive Business Issues Forum in Arlington, Virginia, *Using Collaboration to Improve Workplace Safety*, collaboration improves the processes of identifying potential issues, prioritizing the issues, developing solutions, and evaluating whether the solutions are effective.[48] For these safety-critical processes to occur, a shared trust between the stakeholders is imperative.

NTSB Board member Christopher A. Hart provided an example of the effectiveness of collaboration in the aviation industry in a September 28, 2017, key note address to the National Association of State Motorcycle Safety Administrators in Burlington, Vermont. Hart noted that in the 1990s, the FAA, airlines, air traffic controllers, airports, and pilots all began a collaborative effort to reduce the fatal accident rate. By coordinating their safety management efforts, the fatality rate was decreased by more than 80 percent in only 10 years, and the last fatal crash of a US airliner was in 2009.[49]

At the time of the accident in Chester, a weak relationship between Amtrak's management and the unions undermined the effectiveness of Amtrak's system safety efforts. Specifically, a lack of collaboration between Amtrak's management and labor resulted in two programs' being inoperable. A third program was understaffed and underdeveloped. Therefore, the NTSB concludes that Amtrak's safety programs were deficient and failed to provide effective first-line safety oversight. The NTSB recommends that Amtrak work with labor to achieve full participation in all applicable safety programs. The NTSB also recommends that Brotherhood of Maintenance of Way Employes Division, American Railway and Airway Supervisors Association, Brotherhood of Locomotive Engineers and Trainmen, and Brotherhood of Railroad Signalmen work with Amtrak to improve the effectiveness of all applicable safety programs.

3.9.2 Reporting Systems

Several Amtrak managers and executives told NTSB investigators that they believed rule compliance was the central tenet of safe railroad operations. Amtrak's reliance on rule compliance was also reflected in their policies. For instance, the Cardinal Rules were implemented with the goal of increased rule compliance. Interviews with Amtrak leaders and a review of the Cardinal Rules policy suggest that Amtrak endorses a Person Model of error, which, as noted by James Reason, is the most commonly held view of errors. (Reason 2013, p. 101) The Person Model places the origin of error squarely on the people in direct contact with the system. Reason observes

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[48] Christopher A. Hart, presentation slides, Executive Business Forum Presentation, Using Collaboration to Improve Workplace Safety (https://www.ntsb.gov/news/speeches/CHart/Documents/hart-20171010.pdf).

[49] Christopher A. Hart, Transcript, Keynote Address to the National Association of State Motorcycle Safety Administrators, Burlington, Vermont) (https://www.ntsb.gov/news/speeches/CHart/Pages/hart_20170928.aspx).

that typical remedial measures derived from this model include “naming, blaming, shaming, retraining, fear appeals, and writing another procedure.” He notes that “managers like the model because it separates the errant individuals from the organization in which he or she works.”

As Reason (1990) observes, the Person Model is ineffective because it isolates the person from the context in which the error was made. The Cardinal Rules program was ineffective for the same reason. The rules placed the burden for safety on workers, and did not hold supervisors or managers accountable for safety. For instance, consider the 10th Cardinal Rule—Failure to comply with applicable RWP procedures. Under this rule, the foremen involved in the accident could have been terminated for failing to use SSDs. However, the foremen did not have access to SSDs, and so it would have been impossible for them to follow the rule. In addition, Amtrak management should have been aware of the need to provide training and reliable equipment to shunt track; this was identified in 1988 after the *Night Owl* accident. Thus, the lack of SSDs was an upstream system safety shortcoming that Amtrak management failed to address. Using the Cardinal Rules to terminate the foremen would not have addressed the underlying safety problem. In addition to being ineffective, Amtrak’s Cardinal Rules program led to incompatibility with Amtrak’s other safety programs.

If an effective reporting system had been in place, management would have been aware of the systemic failures to use SSDs. However, many employees were not participating in Safe-2-Safer or C^3RS, and the Safety Liaison Program was still “evolving.” In addition, the unions reported frustration over the incompatibility of the Cardinal Rules with the other three safety programs, which were intended to be nonpunitive. However, Amtrak records revealed that employees had been terminated for violating Cardinal Rules. Also, it was unclear how the Cardinal Rules were intended to synchronize with the other Amtrak safety programs. For instance, discussions with Amtrak management revealed that the likelihood of reprimand for rule violations depended largely on who discovered the violation. That is, if a safety liaison discovered a safety rule violation, counseling would occur, but not reprimand. On the other hand, if a supervisor discovered the violation of a Cardinal Rule, the incident would be reported to management, which would review the violation and consider termination.

It does not appear that Amtrak management considered the negative impact the Cardinal Rules have when implemented alongside the other safety programs. Employees who fear that they may lose their jobs for violating a rule have a disincentive to report safety issues. Also, this fear discourages employees from reporting the unsafe behaviors of others, because employees likely fear that they will get their coworkers in trouble. Although Amtrak’s Cardinal Rules, many of which stem from FRA regulations and common safety practices, may have been intended to enforce safety on the railroad, an unintended consequence of their implementation was the reduction of reporting of safety-critical information.

Amtrak and FRA rules and their rule enforcement play essential roles in safe railroad operations. However, the establishment and enforcement of rules can undermine workers’ perception that Amtrak has a just culture, which is “an atmosphere of trust in which people are encouraged, even rewarded, for providing essential safety-related information.” (Reason 1997, p. 195) After Amtrak’s leadership penalized Cardinal Rule violators by automatically considering their firing, union workers perceived Amtrak as unfair and became unwilling to report safety-critical information. The reaction of the unions placed Amtrak's management in a weak position to identify and mitigate hazards.

A System Model of error, as opposed to the Person Model, is more effective. (Reason 2013, p. 102) From a systems perspective, it is recognized that humans are fallible and errors are to be expected, even in the best organizations. As Reason (2013, p. 102) observed, when taking a system perspective, "errors are seen as consequences rather than causes," and therefore, organizations must examine system factors to understand the origin of errors. To successfully identify and address system factors, it is imperative that safety data are accurately collected and acted upon. Viable reporting systems are necessary to collect safety-critical information. Two factors affect the viability of reporting systems: (1) Employees must not be afraid that they (or their coworkers) will experience reprisal for using them and (2) Employees must trust that their using reporting systems will be rewarded with improvements in safety, because management will act on the information they provide to address identified hazards in a timely manner. Union representatives reported high levels of fear among employees and indicated that they did not believe Amtrak's reporting systems (particularly Safe-2-Safer) were effective. Therefore, the NTSB concludes that Amtrak did not have a viable reporting system in place to collect safety-critical information. The NTSB therefore recommends that Amtrak work collaboratively with labor to develop and implement a viable safety reporting system (for example, C^3RS); ensure that employees do not experience reprisal for using the system; respond quickly to the data collected; and communicate any resulting safety improvements to all employees. The NTSB also recommends that Brotherhood of Maintenance of Way Employes Division, American Railway and Airway Supervisors Association, Brotherhood of Locomotive Engineers and Trainmen, and Brotherhood of Railroad Signalmen work collaboratively with Amtrak to develop and implement a viable safety reporting system (for example, C^3RS).

3.9.3 Corporate Safety Knowledge and Vision

NTSB investigators examined the state of safety management across Amtrak's management at the time of the accident. Investigators discovered that substantial differences in attitudes and beliefs regarding safety existed among division managers and corporate executives. Some of these individuals conveyed to investigators a strong commitment to safety, as well as a deep knowledge of system safety principles, while others did not convey that they clearly understood or implemented safety management.

The inconsistent knowledge and views of safety among Amtrak's managers and executives indicates a significant shortcoming in the company's safety culture. It is well established in the literature that effective safety cultures emanate from the top of an organization, embody a set of clear and measurable objectives, and engender shared values and attitudes about safety throughout all levels of an organization. (Reason 1997, 191–220) However, the differing visions of safety within Amtrak have contributed to a failure to establish effective assurances that safety objectives are understood and achieved in a common, progressive manner. Therefore, the NTSB concludes that the lack of consistent knowledge and vision for safety across Amtrak's management created a culture that facilitated and enabled unsafe work practices by employees.

The numerous unsafe behaviors that occurred at the work site leading up to the accident are symptomatic of a deficient safety culture at Amtrak. Although each of the unsafe behaviors can be linked to the catastrophic event, the behaviors were enabled by and attributable to failures in the safety attitudes of the individuals involved and the safety management provided by Amtrak. For Amtrak to address the safety issues identified in this report, a systemwide overhaul likely will be required. Amtrak must address the organizational deficiencies that allowed all the active failures to occur. The most logical and effective way for Amtrak to improve safety is to develop and implement a comprehensive SMS program.

The importance of SMS programs in improving safety is widely recognized in transportation, and there are numerous resources available from this industry. The FAA and the Federal Transit Administration have provided guidance on the implementation of SMS programs.[50] Also, Amtrak has already voluntarily developed an SSPP, which contains elements of an SMS program. Amtrak's existing SSPP could provide the foundation to meet pending FRA regulation (49 *CFR* Part 270, System Safety Program). Thus, Amtrak has an existing platform and resources upon which to expand its system safety efforts.

However, it is important to recognize that an SSPP is only a written plan, and cannot ensure safety without adequate promotion from senior leadership. In the current accident, unions were allowed to opt out of safety programs, that is, Safe-2-Safer and C^{3}RS. Without employee participation, the SSPP was ineffective, because Amtrak was not able to work with employees to identify and mitigate hazards.

For an SMS program to be effective, Amtrak's leadership must fully endorse it, fund it, and promote it with a comprehensive communication strategy that reaches all levels of the organization. In addition, the unions must fully endorse and promote the SMS for it to be effective. An SMS program must start with a clear vision of safety. A core safety doctrine based on safety principles and best practices, promoted as a corporate value for all workers, is needed. Senior leadership could endorse the core safety doctrine and its safety guidance by making it a requirement for employment for all workers.

Amtrak also must address the specific organizational deficiencies identified in this report. To address the weak safety culture at Amtrak, senior leadership must stop blaming employees for errors and adopt a system perspective. Senior leadership must address employee fear and engage with workers to correct safety issues. Employees and contractors cannot experience reprisals or negative outcomes for their use of any safety management initiative that incorporates a reporting system intended to collect information on safety vulnerabilities and weaknesses.

With respect to safety initiatives, Amtrak must improve existing programs, or develop new ones, for all employees and contractors that facilitate employee acceptance of and adherence to best safety practices, and that provide effective first-line supervision. To ensure the effectiveness of these safety management initiatives, Amtrak must continuously collect, analyze, and act on safety performance metrics. The data collected should be work-process oriented and include leading indicators of employee acceptance and adoption of the safety initiatives (for example, utilization of reporting systems). Reports of these programs should be provided to Amtrak's senior

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[50] (a) See FAA Safety Management System Initiative (https://www.faa.gov/about/initiatives/sms/).

(b) FTA Safety Management System Page (https://www.transit.dot.gov/regulations-and-guidance/safety/safety-management-systems-sms).

leadership and to those who should promote the safety initiatives, confirm that they are effective, and ensure that the data derived from them is acted upon in a timely manner. Additionally, senior leadership must ensure that its safety initiatives are not rendered ineffective because of insufficient funding, staffing, or labor-management negotiations.

The evidence uncovered over the course of the investigation revealed that Amtrak's strategies to manage safety were deficient. Therefore, the NTSB concludes that Amtrak did not have an effective SMS program. The NTSB recommends that Amtrak work collaboratively with labor in an effort to develop a comprehensive SMS program that complies with pending FRA regulation 49 *CFR* Part 270, System Safety Program, and that vitalizes safety goals and programs with executive management accountability; incorporates risk management controls for all operations affecting employees, contractors, and the traveling public; improves continually through safety data monitoring and feedback; and is promoted at all levels of the company. The NTSB also recommends that once Safety Recommendation R-17-26 is completed, Amtrak implement the SMS program throughout the company with resources sufficient to ensure that all levels of management and all labor unions involved with Amtrak operations accept and comply with the system. The NTSB also recommends that Brotherhood of Maintenance of Way Employes Division, American Railway and Airway Supervisors Association, Brotherhood of Locomotive Engineers and Trainmen, and Brotherhood of Railroad Signalmen work collaboratively with Amtrak in an effort to develop a comprehensive SMS program that complies with pending FRA regulation 49 *CFR* Part 270, System Safety Program, and that vitalizes safety goals and programs with executive management accountability; incorporates risk management controls for all operations affecting employees, contractors, and the traveling public; improves continually through safety data monitoring and feedback; and is promoted at all levels of the company.

3.9.4 Government Regulation of Safety Management

The FRA has introduced, but has not enacted, a regulation to mandate formal system safety program plans at 49 *CFR* Part 270, System Safety Program. (*Federal Register* 2016, 53850) (*Federal Register* 2017, 26359) This regulation would help improve passenger rail safety by advancing system safety standards in the industry. However, after four delays, these safety improvements have yet to materialize. Therefore, the NTSB concludes that by delaying progressive system safety regulation, the FRA has failed to maximize safety for the passenger rail industry and the traveling public. The NTSB recommends that the FRA enact 49 *CFR* Part 270, System Safety Program without further delay.

4 Conclusions

4.1 Findings

1. The track structure, signals, and mechanical equipment did not contribute to the accident.

2. The track supervisor had used two different opioids at some point before the accident, but based on behavioral evidence, drug-induced impairment of his job performance could not be determined.

3. The Amtrak engineer took timely and appropriate actions to stop the train and to warn the roadway workers about the train approaching their work area.

4. Although there was no operational evidence of impaired performance by the engineer, his use of marijuana was illicit and had not been deterred by his participation in the US Department of Transportation drug testing program, and any previous marijuana use had not been detected by random drug testing.

5. Amtrak did not effectively assure that its employees, especially those in safety-sensitive positions, were drug-free while performing their public transportation duties.

6. Had the two roadway workers used cocaine, codeine, or morphine with some regularity, been subject to random urine drug screening, and been selected for testing, their use of cocaine and opiates may have been detected before the accident.

7. The absence of a random drug testing program for maintenance-of-way employees at the time of the accident meant there was no effective program to deter the maintenance of way employees from using drugs.

8. The participation of the two roadway workers in the pool for random testing might have deterred them from using cocaine and opiates.

9. The result of the night foreman's actions and the day foreman's inactions based on their conversation was that tracks 1, 3, and 4 were not protected with foul time from about 7:30 a.m. until 7:50 a.m. when the accident occurred.

10. 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.

11. The inadequate and inconsistent use of supplemental shunting devices by Amtrak engineering personnel effectively defeated the roadway worker protection component of Amtrak's Advanced Civil Speed Enforcement System and thereby placed maintenance-of-way employees, equipment, and the traveling public at greater risk of harm.

12. Had the foremen ensured supplemental shunting devices were in place, the accident would not have occurred.

13. There was wide acceptance at Amtrak of not using supplemental shunting devices.

14. A specific efficiency test code for the foul time process that assesses supplemental shunting device use would give Amtrak the ability to monitor and improve supplemental shunting device compliance and change the culture of noncompliance.

15. Had the Federal Railroad Administration required shunting as recommended by the National Transportation Safety Board in Safety Recommendation R-08-06, the accident would not have occurred.

16. Amtrak management should have recognized that the project rose to a heightened level of hazard that required a detailed review or site-specific work plan before it began.

17. Safety hazards exist at complex smaller projects, and these hazards should be assessed and addressed with site-specific work plans.

18. Disengagement by a supervisor from a critical and regulated safety communication process reduces safety layering and at a minimum encourages other lax safety habits.

19. Had the supervisor been engaged with his duties and responsibilities, a proper and thorough job briefing would likely have been conducted and the employees would have had an opportunity to ask the day foreman how on-track safety was to be provided.

20. Had the day foreman conducted a thorough job briefing for all workers on the day shift, including the supervisor, before the work began, foul time protection or the lack thereof and which foreman had the foul time likely would have been discussed and then rectified or mitigated by removal of the backhoe from track 3.

21. Each employee present at the work site had the obligation to demand that a proper job briefing be conducted before they signed the safety briefing sheet.

22. The supervisory oversight in Amtrak's dispatcher center did not adequately monitor dispatcher responsibilities to ensure that supplemental shunting devices were used.

23. The personal phone calls made by the day train dispatcher while he was on duty distracted him from performing his job.

24. Amtrak's ongoing infrastructure work creates an increased exposure of roadway workers to incidents like the one at Chester.

25. Had Amtrak instructed dispatchers to operate trains at significantly slower speeds through the Chester work zone, the severity of the accident would have been diminished.

26. Amtrak's rules and supervisor expectations for dispatchers did not adequately emphasize safety.

27. The 29 active failures and latent conditions indicate a systemic problem with Amtrak's safety culture.

28. Amtrak's safety programs were deficient and failed to provide effective first-line safety oversight.

29. Amtrak did not have a viable reporting system in place to collect safety-critical information.

30. The lack of consistent knowledge and vision for safety across Amtrak's management created a culture that facilitated and enabled unsafe work practices by employees.

31. Amtrak did not have an effective safety management system program.

32. By delaying progressive system safety regulation, the FRA has failed to maximize safety for the passenger rail industry and the traveling public.

4.2 Probable Cause

The National Transportation Safety Board determines 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 that led to the company’s deficient system safety program that resulted in part from Amtrak’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.

5 Recommendations

As a result of its investigation of the April 3, 2016, Amtrak train collision with MOW equipment in Chester, Pennsylvania, the National Transportation Safety Board makes the following safety recommendations:

5.1 New Recommendations

To the Federal Railroad Administration:

Enact Title 49 *Code of Federal Regulations* Part 270, System Safety Program, without further delay. (R-17-17)

Require railroads to install technology on hi-rail, backhoes, other independently operating pieces of maintenance-of-way equipment, and on the leading and trailing units of sets of maintenance-of-way equipment operated by maintenance workers to provide dispatchers and the dispatch system an independent source of information on the locations of this equipment to prevent unauthorized incursions by trains onto sections of track where maintenance activities are taking place in accordance with the Congressional mandate under the Rail Safety Improvement Act of 2008. (R-17-18)

To Amtrak:

Establish a method to ensure that on-track protection in an active work zone is not lost during shift transfer. (R-17-19)

Develop and implement an engineering safety procedure for preparing site-specific work plans for maintenance projects on the Northeast Corridor main line tracks spanning multiple shifts or multiple workdays to reduce or mitigate the inherent risks of maintenance-of-way work in a high-speed train operations environment. (R-17-20)

Require supervisors to review train dispatchers’ foul time log sheets to verify whether supplemental shunting devices are being adequately applied. (R-17-21)

Revise its train dispatcher rules so that potentially distracting activities, such as making personal telephone calls, are not allowed while dispatchers are on duty and responsible for safe train operations. (R-17-22)

Conduct a risk assessment for all engineering projects and use the results to issue significant speed restrictions for trains passing any engineering project that involves safety risks for workers, equipment, or the traveling public, such as ballast vacuuming, as part of a risk-mitigation policy. (R-17-23)

Work with labor to achieve full participation in all applicable safety programs. (R-17-24)

Work collaboratively with labor to develop and implement a viable safety reporting system (for example, C^3RS); ensure that employees do not experience reprisal for using the system; respond quickly to the data collected; and communicate any resulting safety improvements to all employees. (R-17-25)

Work collaboratively with labor in an effort to develop a comprehensive safety management system program that complies with pending Federal Railroad Administration regulation Title 49 *Code of Federal Regulations* Part 270, System Safety Program, and that vitalizes safety goals and programs with executive management accountability; incorporates risk management controls for all operations affecting employees, contractors, and the traveling public; improves continually through safety data monitoring and feedback; and is promoted at all levels of the company. (R-17-26)

Once Safety Recommendation R-17-26 is completed, implement the safety management system program throughout the company with resources sufficient to ensure that all levels of management and all labor unions involved with Amtrak operations accept and comply with the system. (R-17-27)

To Brotherhood of Maintenance of Way Employes Division, American Railway and Airway Supervisors Association, Brotherhood of Locomotive Engineers and Trainmen, and Brotherhood of Railroad Signalmen:

Work with Amtrak to improve the effectiveness of all applicable safety programs. (R-17-28)

Work collaboratively with Amtrak to develop and implement a viable safety reporting system (for example, C^3RS). (R-17-29)

Work collaboratively with Amtrak in an effort to develop a comprehensive safety management system program that complies with pending Federal Railroad Administration regulation Title 49 *Code of Federal Regulations* Part 270, System Safety Program, and that vitalizes safety goals and programs with executive management accountability; incorporates risk management controls for all operations affecting employees, contractors, and the traveling public; improves continually through safety data monitoring and feedback; and is promoted at all levels of the company. (R-17-30)

5.2 Recommendation Reiterated in This Report

To the Federal Railroad Administration:

R-08-06

Require redundant signal protection, such as shunting, for maintenance-of-way work crews who depend on the train dispatcher to provide signal protection.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

ROBERT L. SUMWALT, III
Chairman

EARL F. WEENER
Member

CHRISTOPHER A. HART
Member

T. BELLA DINH-ZARR
Member

Adopted: November 14, 2017

Member Christopher A. Hart and Member T. Bella Dinh-Zarr filed the following concurring statements.

Board Member Statements

Member Christopher A. Hart filed the following concurring statement on November 20, 2017.

I concur with the report and its findings, probable cause, and recommendations, and I would like to add some additional comments.

One of the advantages of investigating accidents in all modes of transportation is that it provides an opportunity for cross-modal comparisons. One cross-modal comparison from this accident is that labor-management relations are far more adversarial and caustic in railroads than in any other mode that we investigate. I would submit that adversarial labor-management relations are a major safety issue, and that safety issue reared its ugly head in this accident.

Given that management needs labor, and labor needs management, in order to get the job done, it has never been clear to me why labor-management relations have historically been so adversarial. Because neither can get the job done alone, harping between labor and management is somewhat akin to “Your end of the ship is sinking.” That said, query why the relations appear to be so much worse in railroads than in any other transportation mode.

Putting my legal hat on, I wonder if a major cause of the adversarial relationship is the compensation scheme regarding workplace injuries. In very general terms, most worker’s compensation programs in this country provide for compensation without the need to prove fault, i.e., the worker must show only that he or she was at work and that he or she was injured. Not so for railroad employees. Under the Federal Employers' Liability Act (FELA), the employee must also show that (a) the injury was due to the employer’s negligence, and (b) there was no contributory negligence by the employee. Query whether this compensation scheme for workplace injuries contributes to an inherently adversarial relationship between labor and management.

This accident provides examples of why this adversarial relationship is a safety issue. For example, Amtrak unions opted out of two programs that, in theory, are intended to help improve safety for employees—C^3RS, the Confidential Close Call Reporting System for the reporting of near misses and other potential hazards, and Safe-2-Safer, the program in which employees would be their “brother’s keeper” and inform each other about hazardous conditions and practices. Given that these programs were created to improve safety, something has gone awry when the very employees whose safety is most at risk, and whose safety stands to benefit most from these programs, choose not to participate.

One thing that has gone awry is the inherent inconsistency between these types of reporting programs and the existence of the “10 Cardinal Rules” list. Violation of any item on the list often results in dismissal. If these violations are inherently dangerous, query why management has chosen to go after them with punishment rather than establishing a program to collect information to help (a) identify why employees sometimes do things that they know will probably increase the likelihood of injury, and (b) provide a basis for determining what to do about the problem.

A similar situation exists with the C^3RS. It was modeled after the Aviation Safety Reporting System, ASRS, which was created to help the aviation industry identify potential hazards in the system and fix them. One of the incentives of the program is the protection from enforcement that is provided for those who report potential hazards. As with ASRS, C^3RS does not provide protection for near miss reports regarding action that reflects criminal or intentional wrongdoing. Unlike ASRS, however, C^3RS has an exception for a certain type of event, namely, running red signals. There is no type of event for which ASRS denies protection. Given that employees obviously know that running red signals increases the likelihood of injury, this should be a type of event that management would want to know most about, and management would want to keep the information door open in order to figure out why it is happening and how to remedy it, rather than closing the door on any information flow.

Another example of the adversarial labor-management relations is that when the NTSB made recommendations regarding in-cab cameras after the tragic commuter rail accident in Chatsworth, California, in 2008, I made a presentation at an annual railway labor union convention that included reference to the recommendations. Needless to say, the idea was not well received. It was very interesting, however, that the primary concern about the cameras was that management would use the information against employees. When the concept of in-cab cameras was presented to airline pilots, on the other hand, their primary concern was privacy. This difference speaks volumes about differences between the labor-management relationships in the two industries.

The airline industry has demonstrated the power of collaboration, including collaboration between labor and management, to improve safety. That collaboration has helped to create the amazing result that no airline passenger has been fatally injured in a U.S. airline accident since 2009. I would submit that collaboration between labor and management, and a more robust information flow about things that can go wrong, can generate safety improvements and improve labor-management relations much more effectively than strict and severe punishment. Query whether a first step in that direction is eliminating the requirement to prove fault in order to recover for workplace injuries.

Member T. Bella Dinh-Zarr filed the following concurring statement on November 21, 2017.

Often, in the accidents we investigate, the biggest safety challenge is human error, and increasingly, there is a solution in the form of some type of technology. Positive train control (PTC) is one such technology. We know that PTC is an effective safety system that will prevent rail accidents, especially in cases of human error or oversight. For 40 years, the NTSB has concluded that PTC would have prevented overspeed accidents, train-to-train collisions, and work zone incursions.

The accident in Chester, Pennsylvania, is especially tragic because Amtrak had completed installation of PTC on this track, but a series of human factors circumvented the PTC system, in large part because the area was no longer designated as an established work zone. This circumvention of the PTC system took the lives of two of Amtrak's own employees.

Since 2008, we have been recommending that the Federal Railroad Administration (FRA) require the railroads to provide redundant signal protection for roadway workers. It was not required after the accident in Woburn, Massachusetts. It was not required after the accident in West Haven, Connecticut. It was not required when this accident happened. Unless the railroads are required to take steps to make PTC truly effective, PTC cannot have the meaningful impact on safety that it should. The railroads can, as in this accident, simply fail to "establish" a work zone, which would circumvent PTC requirements. In this accident, the train was traveling at 99 mph at the time of impact. Amtrak is hoping to reach speeds of more than 220 mph on this corridor. We need effective measures to ensure that PTC protects roadway workers making these infrastructure improvements, as well as the traveling public.

We routinely add the regulator to the probable cause when its long-time failure could have prevented an accident. We held the FRA accountable in the probable cause in the West Haven accident in 2014. In conclusion #15 of this report, we found that if the FRA had required shunting, this accident would not have occurred. Therefore, I am pleased the Board voted to add the FRA's failure to provide redundant signal protection prior to the accident as contributing to this accident.

I also am very pleased that the Board voted to approve an additional recommendation for the FRA to require the railroads to use other technology, such as Global Positioning Systems (GPS), on maintenance-of-way (MOW) equipment to provide dispatchers and dispatch systems with an independent source of information on the locations of this equipment to prevent unauthorized incursions of trains onto sections of track where maintenance work is taking place. I am concerned that even with requiring shunting, we will not prevent accidents. While shunting is necessary and important, it requires human input just like making a phone call to request foul time. PTC is designed to help prevent these human errors. If you review Amtrak's PTC Implementation Plan (IP) revisions 3 (prior to Chester) and 4 (after Chester) – there are no changes made to prevention of MOW incursions. Their plan (and perhaps others) fails to meet the Congressional mandate and will not prevent these accidents.

Our report cites Dr. James Reason. As Dr. Reason advocates, we need hard defenses to prevent recurrence of these roadway worker incursions. A call from a foreman to a dispatcher requesting foul time is not vital field blocking. A shunt—if failed to be installed—is not vital field blocking. A technological solution to equip MOW equipment with automatic blocking would provide vital field blocking. This solution is nothing new. As discussed at NTSB's own PTC Forum in 2013, Burlington Northern Railroad successfully used such a system to protect its MOW workers. This additional recommendation is a positive step forward to truly protect the workers who maintain and improve our country's rail infrastructure.

I also commend the NTSB staff for suggesting during the Board Meeting that they provide the Board with a standalone recommendation within three months' time to further enhance MOW worker safety. Staff intends to recommend that the FRA (1) reevaluate their system for approval of PTCIPs and (2) conduct a study of available technologies to better protect MOW workers. I look forward to reviewing these additional recommendations to meaningfully improve roadway worker safety. This will be a crucial step to ensure that roadway workers stop dying and that passengers are not put at risk. The future of rail safety is technology that will protect everyone.

Chairman Robert L. Sumwalt, III, and Member Earl F. Weener joined in this statement.

Appendix A: Investigation

The NTSB Response Operations Center was notified of the accident on April 3, 2016. The NTSB launched a go-team from headquarters in Washington, DC, and locations in Chicago and New York City. The parties to the investigation were the Federal Railroad Administration, Amtrak, Brotherhood of Maintenance of Way Employes Division, American Railway and Airway Supervisors Association, Brotherhood of Locomotive Engineers and Trainmen, and SMART (International Association of Sheet Metal, Air, Rail and Transportation Workers).

Appendix B: The *Night Owl* Accident

The *Night Owl* accident (NTSB 1989) occurred almost 30 years ago, and many parallels can be drawn to the Chester accident on April 5, 2016. Both accidents occurred in Chester, Pennsylvania, on Amtrak-operated territories with an Amtrak passenger train striking on-track maintenance equipment. In both accidents, postaccident toxicology testing indicated the use of drugs by Amtrak employees (Chester 1: marijuana, cocaine, and methamphetamines, Chester 2: marijuana, cocaine, opioids/opiates [morphine, oxycodone, codeine]). Contributing to both accidents was the lack of secondary protection because of a failure of the operating rules. Evidence in both accidents shows that Amtrak management had failed to provide employees with the equipment and training to reliably shunt track. Further, in both accidents organizational issues included employee fear of disciplinary actions that rendered safety management systems ineffective caused by a fear of disciplinary actions, prioritizing on-time performance over safety, overreliance on operating rules, and ineffective utilization of the safety department.

On January 29, 1988, about 12:36 a.m. eastern standard time, northbound Amtrak Train 66, the *Night Owl*, struck MOW equipment on track 2 in Chester, Pennsylvania. The accident caused serious injuries to the engineer of train 66, and 8 crewmembers and 15 passengers received minor injuries.

The major safety issues identified in this accident concerned the manner in which Amtrak provided protection from intrusions onto out-of-service tracks. The specific issues include Amtrak's use of blocking devices and train orders to take tracks out-of-service; Amtrak's use of insulated maintenance-of-way equipment; the lack of redundancy in the operating rules to provide protection from undesired intrusions into out-of-service tracks; the failure of the tower operator and train dispatcher to comply with Amtrak's operating rules; Amtrak efficiency checks of tower operators and train dispatchers; Amtrak's selection standards and procedures for the position of tower operator; and the injury-producing features of the interior of Amtrak passenger cars.

The National Transportation Safety Board determined that the probable cause of that accident was the failure of the third-shift tower operator at Hook tower, because of impairment by drugs or distraction or both, to operate the 7 switch to allow train 66 to cross over from track 2 to track 1 and the failure of Amtrak to provide positive protection for on-track equipment and out-of-service tracks. Contributing to the accident was Amtrak's failure to adequately monitor the activities and job performance of the tower operator.

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