# Derailment of Amtrak Passenger Train 188
# Philadelphia, Pennsylvania
# May 12, 2015


**Accident Report**

NTSB/RAR-16/02
PB2016-103218

National
Transportation
Safety Board

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# 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. 2016.** ***Derailment of Amtrak Passenger Train 188 Philadelphia, Pennsylvania, May 12, 2015*****. Railroad Accident Report NTSB/RAR-16/02. Washington, DC.**

**Abstract:** At 9:21 p.m. eastern daylight time on May 12, 2015, eastbound Amtrak passenger train 188 derailed in Philadelphia, Pennsylvania, with 245 passengers and 8 Amtrak employees on board. The train had just entered the Frankford Junction curve—where the speed is restricted to 50 mph—at 106 mph. As the train entered the curve, the locomotive engineer applied the emergency brakes. Seconds later, the train derailed. Eight passengers died, and 185 others were transported to area hospitals.

This report addresses the following safety issues: crewmember situational awareness and management of multiple tasks; positive train control; passenger railcar window systems and occupant protection; and transportation of the injured after mass casualty incidents.

As a result of the investigation of this accident, the National Transportation Safety Board makes recommendations to Amtrak, the Federal Railroad Administration, the American Public Transportation Association, the Association of American Railroads, the Philadelphia Police Department, the Philadelphia Fire Department, the Philadelphia Office of Emergency Management, the mayor of the city of Philadelphia, the National Association of State EMS (Emergency Medical Services) Officials, the National Volunteer Fire Council, the National Emergency Management Association, the National Association of EMS Physicians, the International Association of Chiefs of Police, and the International Association of Fire Chiefs.



For more detailed background information on this report, visit http://www.ntsb.gov/investigations/dms.html and search for NTSB accident ID DCA15MR010. Recent publications are available in their entirety on the Internet at http://www.ntsb.gov. Other information about available publications also may be obtained from the website or by contacting: **National Transportation Safety Board, Records Management Division, CIO-40, 490 L'Enfant Plaza, SW, Washington, DC 20594, (800) 877-6799 or (202) 314-6551**

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# Abbreviations and Acronyms

| | |
|---|---|
| AAR | Association of American Railroads |
| ACSES | Advanced Civil Speed Enforcement System |
| AIS | Abbreviated Injury Scale |
| Amtrak | National Railroad Passenger Corporation |
| ATC | automatic train control |
| BLET | Brotherhood of Locomotive Engineers and Trainmen |
| *CFR* | *Code of Federal Regulations* |
| Conrail | Consolidated Rail Corporation |
| CT | computed tomography |
| CRM | crew resource management |
| DOT | US Department of Transportation |
| EMS | Emergency Medical Services |
| eTicketing | electronic ticketing |
| FAST | Fixing America's Surface Transportation |
| FRA | Federal Railroad Administration |
| GAO | Government Accountability Office |
| MARC | Maryland Area Regional Commuter |
| MCI | mass casualty incident |
| Metra | Northeast Illinois Regional Commuter Railroad |
| MP | milepost |
| NORAC | Northeast Operating Rules Advisory Committee (Operating Rulebook) |
| NPRM | notice of proposed rulemaking |
| NTSB | National Transportation Safety Board |

| | |
|---|---|
| OEM | Office of Emergency Management (Philadelphia) |
| PFD | Philadelphia Fire Department |
| PPD | Philadelphia Police Department |
| PTC | positive train control |
| SEPTA | Southeastern Pennsylvania Transportation Authority |
| *USC* | *United States Code* |

# Executive Summary

About 9:21 p.m. eastern daylight time on May 12, 2015, eastbound Amtrak (National Railroad Passenger Corporation) passenger train 188 derailed at milepost 81.62 in Philadelphia, Pennsylvania. The train had just entered the Frankford Junction curve—where the speed is restricted to 50 mph—at 106 mph. It was dark and 81°F with no precipitation; visibility was 10 miles. As the train entered the curve, the locomotive engineer applied the emergency brakes. Seconds later, the train—one locomotive and seven passenger cars—derailed. There were 245 passengers, 5 on-duty Amtrak employees, and 3 off-duty Amtrak employees on board. Eight passengers were killed, and 185 others were transported to area hospitals.

This report addresses the following safety issues:

- **Crewmember situational awareness and management of multiple tasks.** The National Transportation Safety board (NTSB) found that the Amtrak engineer accelerated his train to a high rate of speed in a manner consistent with how he habitually manipulated the controls when accelerating to a target speed, suggesting that he was actively operating the train rather than incapacitated moments before the accident. However, he accelerated to 106 mph without slowing the train for the curve at Frankford Junction, where the speed was restricted to 50 mph. After evaluating the circumstances of the accident, the NTSB found that the most likely reason the engineer failed to slow for the curve was he believed he was beyond the curve where the authorized speed was 110 mph, because of his loss of situational awareness. He lost his situational awareness because his attention was diverted to an emergency situation with a nearby Southeastern Pennsylvania Transportation Authority (SEPTA) train that had made an emergency stop after being struck by a projectile. This type of situation could be addressed by better crewmember training that focuses on preventative strategies for situations that could divert crewmember attention.
- **Positive train control.** In the accident area, positive train control had not yet been implemented at the time of the accident, but it has since been implemented. The NTSB found that the accident could have been avoided if positive train control or another control system had been in place to enforce the permanent speed restriction of 50 mph at the Franklin Junction curve.
- **Passenger railcar window systems and occupant protection**. The NTSB found that if the passenger car windows had remained intact and secured in the cars, some passengers would not have been ejected and would likely have survived the accident. Further, the passengers were not protected from serious injuries resulting from being thrown from their seats when the cars overturned. The NTSB concluded that the current passenger equipment safety standards are not adequate.

- **Transportation of the injured after mass casualty incidents.** The NTSB found that, as a result of victims being transported to hospitals without coordination, some hospitals were over utilized while others were significantly underutilized during the response to the derailment. The NTSB further found that current Philadelphia Police Department, Philadelphia Fire Department, and Philadelphia Office of Emergency Management policies and procedures regarding transportation of patients in a mass casualty incident need to be better coordinated.

The NTSB determines that the probable cause of the accident was the engineer's acceleration to 106 mph as he entered a curve with a 50 mph speed restriction, due to his loss of situational awareness likely because his attention was diverted to an emergency situation with another train. Contributing to the accident was the lack of a positive train control system. Contributing to the severity of the injuries were the inadequate requirements for occupant protection in the event of a train overturning.

As a result of this investigation, the NTSB makes recommendations to Amtrak, the Federal Railroad Administration, the American Public Transportation Association, the Association of American Railroads, the Philadelphia Police Department, the Philadelphia Fire Department, the Philadelphia Office of Emergency Management, the mayor of the city of Philadelphia, the National Association of State EMS (Emergency Medical Services) Officials, the National Volunteer Fire Council, the National Emergency Management Association, the National Association of EMS Physicians, the International Association of Chiefs of Police, and the International Association of Fire Chiefs.

# 1. Investigation and Analysis

## 1.1 Synopsis

About 9:21 p.m. eastern daylight time on May 12, 2015, eastbound Amtrak (National Railroad Passenger corporation) passenger train 188 derailed at milepost (MP) 81.62 in Philadelphia, Pennsylvania.[1] (See figure 1.) The train had just entered the Frankford Junction curve—where the speed is restricted to 50 mph—at 106 mph. It was dark and 81°F with no precipitation; visibility was 10 miles. As the train entered the curve, the locomotive engineer (engineer) applied the emergency brakes. Seconds later, the train—one locomotive and seven passenger cars—derailed. There were 245 passengers, 5 on-duty Amtrak employees, and 3 off-duty Amtrak employees on board. Eight passengers were killed and 185 others were transported to area hospitals. (See table 1.) Amtrak estimated its damages to be more than $30.84 million; an adjacent Consolidated Rail Corporation (Conrail) track sustained about $330,000 in damages.


**Figure 1.** Accident scene.

[1] In this report, the accident train direction will be referred to as eastbound. Amtrak timetables refer to trains heading toward New York as eastbound and trains going in the opposite direction as westbound.

**Table 1.** Injuries.

| Injuries[a] | Number |
|---|---|
| **Fatal** | 8 |
| **Serious** | 46 |
| **Minor** | 113 |
| **None** | 8 |
| **Condition unknown** | 18[b] |
| **Total** | **193** |

[a] This table contains the injury information available as of the date of this report for the 193 people on board the train who either died or were transported to an area hospital on the night of the accident. The remaining 60 people survived the accident but did not go to a hospital, and no injury information is available.

[b] Medical records were not available for 18 patients transported and treated at area hospitals.

## 1.2 Accident Scenario

The Amtrak engineer, conductor, and an assistant conductor went on duty at 1:20 p.m. at New York's Pennsylvania Station; they worked on a train that arrived in Washington, DC, at 5:19 p.m. They went off duty for dinner and went back on duty about an hour and 10 minutes later at 6:30 p.m. At that time, another assistant conductor, who had worked on an earlier train from New York, was added to train 188's crew.

Train 188 departed Washington for New York at 7:15 p.m. (See figure 2.) It made scheduled stops at stations in New Carrollton, Baltimore-Washington International Airport, Baltimore (Pennsylvania Station), and Aberdeen, Maryland, as well as Wilmington, Delaware. Train 188 arrived at Philadelphia's 30th Street Station at 9:06 p.m. where the engineer inspected the locomotive pantograph, as required by Amtrak. The pantograph transmits electrical current from the overhead catenary wire to the train. At 9:10 p.m., the train left the 30th Street Station on time on main track 1.


**Figure 2.** Train 188 intended route.

The engineer, who was alone in the cab, maintained the train speed near the required 30 mph for the next few miles. In postaccident interviews, the engineer said he was monitoring the radio when he heard an eastbound Southeastern Philadelphia Transportation Authority (SEPTA) train engineer and the train dispatcher discussing an incident in an area he was approaching. During the 6-minute conversation, the SEPTA engineer said his windshield was shattered near the Diamond Street Bridge—an area where people were known to throw rocks and other objects at passing trains. (See figure 3.) The SEPTA engineer said he had glass in his face and had used the emergency brake to stop his train on main track 1. He requested medical attention. (See appendix B for a transcript of radio communications.)

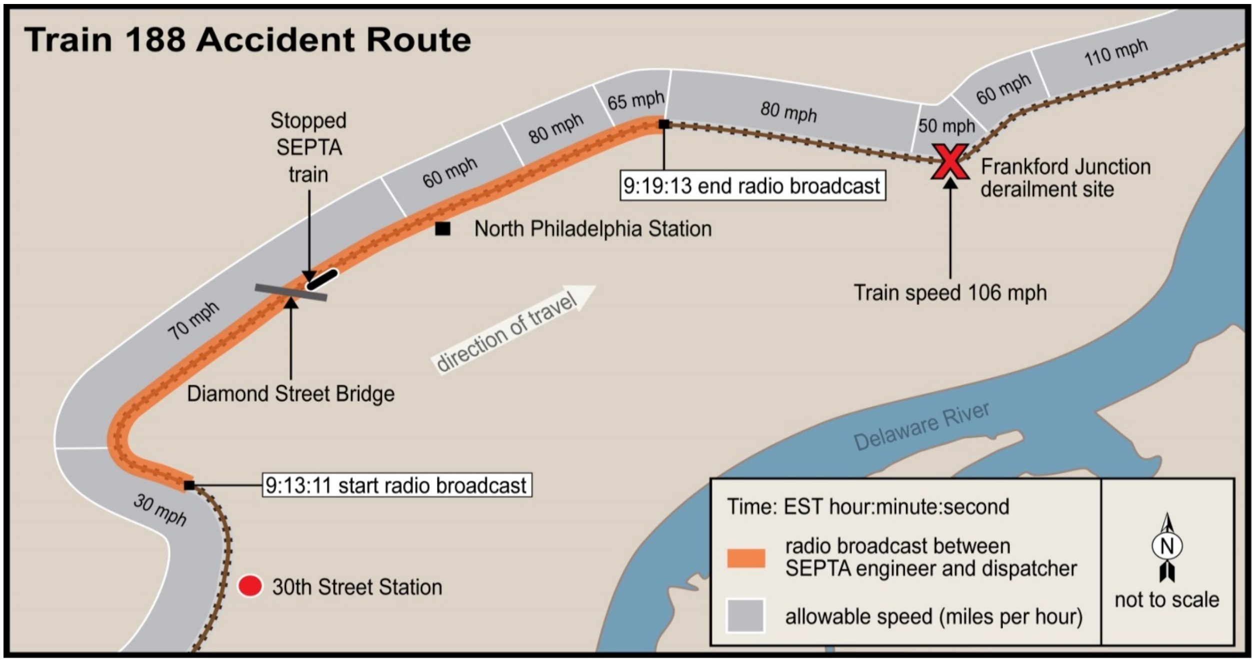


**Figure 3.** Train 188's route through Philadelphia.

In this area, four main tracks ran parallel to each other. In the direction train 188 was traveling, the tracks are numbered from right to left, main track 1 through main track 4.

As the Amtrak engineer approached the Diamond Street Bridge, he crossed from main track 1 to main track 2 in preparation for passing the SEPTA train. He accelerated to 67 mph in compliance with the authorized speed and sounded the horn as he approached the SEPTA train, which was stopped to his right at MP 86.[2] The Amtrak engineer broadcasted on the radio that he was about to pass the SEPTA train; he sounded the horn again as he passed in case the SEPTA crewmembers were on the ground inspecting the train for damage as required by operating rules. Despite speculation immediately following the accident that train 188 was also hit by a rock or bullet or other projectile, the engineer did not recall such an incident, nor did FBI testing show any evidence of ballistic material. (See section 1.10 for additional information.)

The Amtrak engineer continued to comply with authorized speeds, slowing to transit a right-hand curve that had a maximum speed of 65 mph. (See figure 3.) At MP 83.4—about the time the radio conversation between the SEPTA engineer and the dispatcher ended—the authorized speed increased to 80 mph; the Amtrak engineer moved the throttle to full power, and the train accelerated. The throttle stayed at full power for about 25 seconds, and the train reached about 95 mph. It had reached the 80 mph speed limit near MP 82.3, which was 1.2 miles from the point of derailment. At that point, the Amtrak engineer momentarily reduced the throttle, then returned to full throttle before reducing power about 20 seconds later. The train speed reached 106 mph as it entered the left-hand curve at Frankford Junction. The engineer began emergency braking at 9:20 p.m. Three seconds later, the train had slowed to 102 mph, and the

[2] Northeast Operating Rules Advisory Committee (NORAC) Operating Rules 19, Engine Whistle or Horn Signals, states that when approaching and passing standing trains the horn will be sounded in the following pattern: "long, long, short, long."

event recorder and forward-facing video stopped recording. The train derailed to the outside of the left-hand curve at MP 81.62.

## 1.3 Amtrak

The Rail Passenger Service Act (Public Law 91-518, October 30, 1970), created the National Railroad Passenger Corporation (Amtrak). The act directed that Amtrak 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 property from Conrail. Amtrak's Northeast Corridor is the busiest railroad in North America with about 2,200 commuter and freight trains operating on some portion of the Washington-Boston, Massachusetts, route each day. (See figure 4.) Annually, Amtrak carries more than 24 million passengers and 220 million commuters, either on its trains or on trains running on Amtrak property.

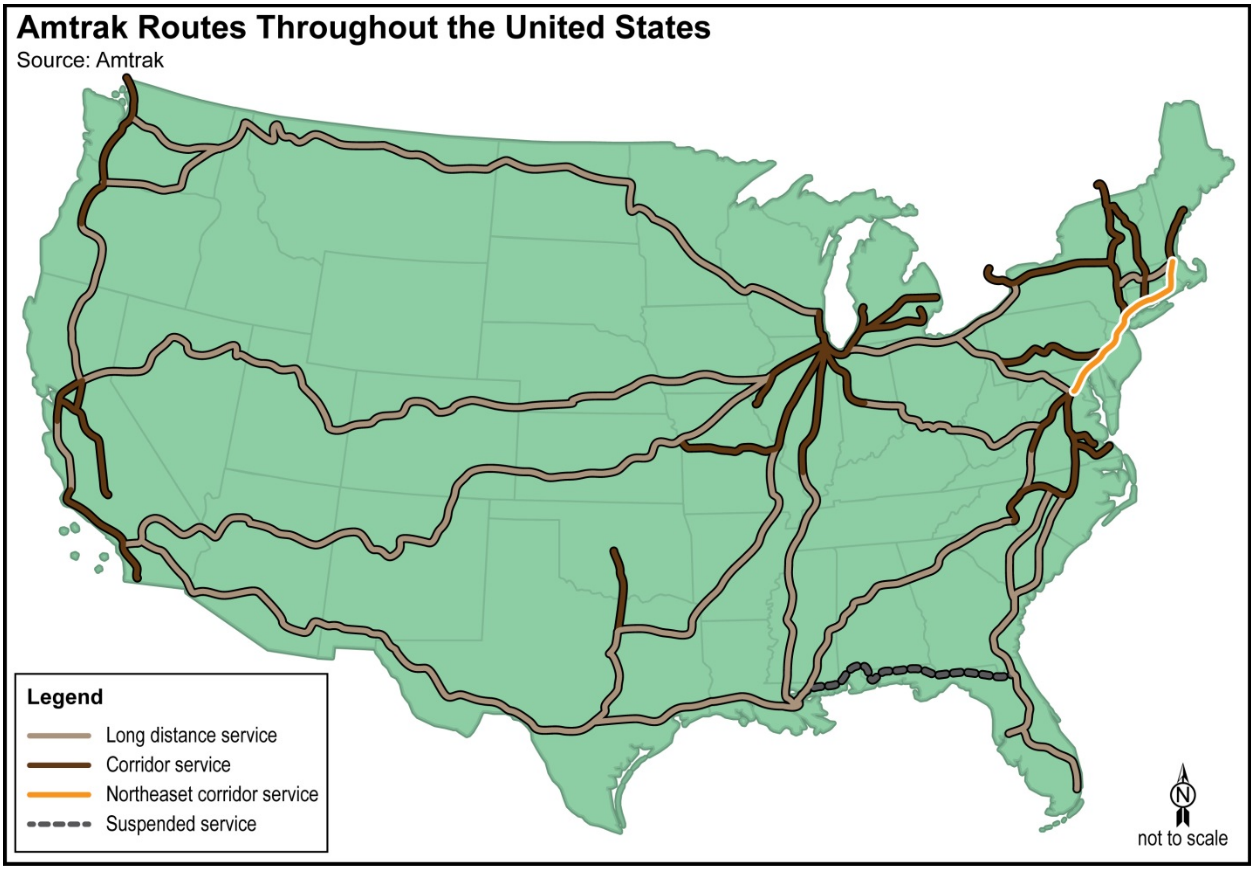


**Figure 4.** Amtrak routes throughout the United States.

In December 2015, Amtrak completed the implementation of positive train control (PTC) on tracks between New York and Washington, DC, completing installation on most Amtrak property in the Northeast Corridor.[3] PTC has been installed between Boston and New Haven,

[3] Since 2002, PTC has been installed and operating along the 95.6 miles of track Amtrak owns in Michigan and Indiana.

Connecticut, since 2000. The only exceptions were 7 miles of track located in or adjacent to terminals where trains move slower and automatic train control systems are in service. (For more information on PTC, see section 1.5.1.)

Most of the national network of track that Amtrak operates over is owned by other railroads. In fact, 72 percent of the miles traveled by Amtrak trains is on tracks owned by "host railroads." Host railroads are responsible for PTC installation on their property where passenger trains operate or where poison or toxic-by-inhalation hazardous materials are transported.[4] Amtrak has installed PTC on its locomotives that operate over host railroads.[5]

At the time of the accident, Amtrak trains operating through this territory were authorized by wayside and interlocking signals, as well as cab signals.[6] The signals that authorized the train movements were part of a traffic control system controlled from a dispatching center in Wilmington. All four main tracks were part of the traffic control system, and trains were authorized by signals to operate in both directions.

Employees were provided with operating procedures that were part of the Northeast Operating Rules Advisory Committee (NORAC) Operating Rules. Amtrak timetable 5 (effective November 11, 2012) also governed train movements included train speeds at specific locations.

## 1.4 Analysis of the Engineer's Actions

The Amtrak engineer told investigators he could not remember what happened immediately preceding the derailment.[7] Specifically, he could not explain why he increased the train's speed to 106 mph as he approached and entered the curve at Frankford Junction where the maximum authorized speed was 50 mph. His last memory until the time of the accident was at the end of the radio conversation (about 9:19 p.m.) between the disabled SEPTA train engineer and the dispatcher as he negotiated the right-hand curve preceding the derailment. Amtrak records showed the engineer was experienced, certified, and qualified, and he had no previous disciplinary action. He had worked on the Northeast Corridor since 2013 and had traveled through the curve at Frankford Junction hundreds of times.

The engineer maintained a regular work and rest schedule for several days leading up to the accident, and there was no evidence that he suffered from fatigue. There was no evidence of any medical condition that would have impeded his job performance, and postaccident tests showed no evidence that he was impaired during the accident trip by alcohol, other drugs, or any substance The train 188 conductor and assistant conductors described the engineer in positive terms, including saying that he was a "good engineer" who did "what he was supposed to do."

The engineer's cell phone and records from his cell phone provider showed it was not used during the trip. Specifically, there was no record of any calls, texts, instant messages, or

[4] See 49 *United States Code (USC)* 20157(a) and Title 49 *Code of Federal Regulations* (*CFR)* Part 171.

[5] The preceding information in this section was obtained from Amtrak's website, www.amtrak.com.

[6] For more information on cab signals see section 1.5.

[7] As further discussed in section 1.7, the engineer sustained a concussion in the accident, and medical records noted he had some amnesia.

data activity. Amtrak records indicated that the engineer's cell phone did not connect to the train's onboard wireless Internet system on the accident train. Furthermore, an examination of metadata downloaded from the cell phone was consistent with it's being powered off during the accident trip.[8]

There were no mechanical or operational issues reported for train 188 on the day of the accident.

NTSB investigators explored the reasons why a qualified, experienced, and apparently alert engineer would accelerate beyond the safe operating speed traveling through the curve at Frankford Junction. Specifically, investigators examined the factors that may have diverted the engineer's attention from train operations before the accident.

Train 188 left Philadelphia 30th Street Station a little after 9:10 p.m. According to the recorded radio transmissions, the 6-minute radio conversation between the SEPTA engineer and the train dispatcher took place between 9:13 p.m. and 9:19 p.m. The train derailed at 9:21 p.m., nearly 11 minutes after departing from the 30th Street Station. The Amtrak engineer was very focused on the incident that shattered the windshield of the SEPTA train and sent glass into the face of its engineer as he operated train 188 into the same area. During an interview 3 days after the accident, the Amtrak engineer accurately recalled the content of the radio transmissions. He said—

> The SEPTA engineer "sounded very upset, and it sounded like the dispatcher was trying to get clear information as to whether or not [the SEPTA engineer] needed medical help. And the SEPTA engineer was not being very clear and so they went back and forth.

During that same interview he also told investigators—

> I was a little bit concerned for my safety. There's been so many times where I've had reports of rocks that I haven't seen anything, that I felt it was unlikely that it would impact me. And I was really concerned for the SEPTA engineer. I had a coworker in Oakland that had glass impact his eye from hitting a tractor-trailer, and I know how terrible that is.

Locomotive engineers are expected to monitor radio transmissions while operating their trains because these communications can be pertinent to the safe operation of their trains.[9] Operationally relevant information might be discussed, including details about issues with the track or signals, deteriorating weather conditions, or issues with trains that might force engineers to make an unplanned stop. In this case, it was important for the Amtrak engineer and other train crews operating in the area to know someone may have thrown an object at a train, and the SEPTA train had made an emergency stop on main track 1. Because the Amtrak engineer was monitoring the radio, he was aware the train crew might be on the tracks inspecting the SEPTA train for damage or setting up protection (such as flags) for it, and he reported this as a concern

[8] For more information, see the NTSB's press release dated June 10, 2015, which addresses cell phone usage.

[9] NORAC Operating Rules 706, Radio Location and Monitoring: "The volume must be adjusted so that all transmissions can be heard."

during his interview on November 10, 2015. This prompted him to sound the train's horn and broadcast a radio advisory that his train was approaching and would be passing the SEPTA train.

As he listened to the 6-minute radio conversation between the SEPTA engineer and the dispatcher, the Amtrak engineer continued to operate his train at or below the maximum authorized track speed, and he remained cognizant of the signal indications affecting immediate train operations. The engineer's throttle manipulation that accelerated the train to 106 mph was initiated about 27 seconds after the last radio transmission between the SEPTA engineer and the train dispatcher at 9:19 p.m.[10] Clearly, this action was not appropriate at that time given that the maximum authorized speed was 80 mph and the speed-restricted curve at Frankford Junction was coming up. But if he had traveled another 2 miles, going through the Frankford Junction curve and an adjacent curve at appropriate speeds, he then would have been authorized to operate the train at 110 mph, a speed that he was accustomed to traveling at numerous points along the route.[11]

Investigators used event recorder data to derive the engineer's manipulation of the throttle.[12] The method by which the engineer manipulated the throttle to increase the train's speed to 106 mph was consistent with his description of how he normally made a significant increase in speed when it was appropriate to do so. He told investigators that he typically accelerated with full throttle and then backed off as he approached his target speed. Event recorder data indicated that he did execute this procedure with a slight throttle manipulation when the train reached about 95 mph. Therefore, NTSB concludes that the Amtrak engineer initially accelerated his train to a high rate of speed in a manner consistent with how he habitually manipulated the controls when accelerating to a target speed, suggesting that he was actively operating the train rather than incapacitated moments before the accident.

The NTSB examined the possibility that as a result of diverting his attention to the extended radio communications between the SEPTA engineer and the dispatcher, the Amtrak engineer may have lost situational awareness. His loss of awareness, combined with the darkness, may have led him either to believe he had already passed the curve at Frankford Junction or to forget about the curve.

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[10] Research on distracted driving found that potentially unsafe mental distractions can persist for as long as 27 seconds after completing a highly distracting task. See: David L. Strayer, Joel M. Cooper, Jonna Turrill, James R. Coleman, and Rachel J. Hopman, *Measuring Cognitive Distraction in the Automobile III: A Comparison of Ten 2015 In-Vehicle Information Systems* (Washington, DC: American Automobile Association Foundation for Traffic Safety, 2015).

[11] There are many sections of track in the Northeast Corridor where the maximum authorized speed is 110 mph or greater.

[12] The throttle position was not recorded due to loose wires to the event recorder. Investigators derived the throttle movements from performance calculations of recorded speed and locomotive characteristics.

### 1.4.1 Loss of Situational Awareness

Situational awareness is defined as "the perception of the elements in the environment with a volume of time and space, comprehension of their meaning, and the projection of their status in the near future." Informally, it is "knowing what's going on."[13]

In this accident, the engineer may have lost awareness of which curve he had traveled through just before he accelerated his train to 106 mph. Immediately following Frankford Junction is a right-hand, 60 mph curve. Two miles before that curve there is a similar right curve near MP 83.5 with a maximum speed of 65 mph. The engineer would have had to operate his train similarly around both right curves. Moreover, each curve is followed by tangent (straight) track that allows the engineer to accelerate to significantly higher speeds. The right curve before the derailment location was followed by tangent track with a maximum operating speed of 80 mph, while the right curve immediately after the derailment location was followed by a 110 mph maximum speed. Given that the two curves were similar and the engineer's attention was diverted to the radio conversations about the emergency situation with the SEPTA train, he may have confused the right track curve preceding Frankford Junction with the right-hand curve following it. In that case, he would have believed it was appropriate to increase his speed to 110 mph after transiting the first curve.

Furthering the potential for error, the engineer was operating at night when there were fewer visible external cues to help him determine his location. According to the engineer's interview and the forward-facing video, neither the elevated bridge at Frankford Junction (which served as a cue to begin decelerating before the curve) nor the curve itself would have been visible when the engineer began accelerating. (See figure 1.) If the engineer did not see or focus enough attention on cues indicating that he needed to slow the train, he would be less likely to realize that accelerating the train to 106 mph was an error at that time and location.

The NTSB has investigated other railroad accidents in which the loss of situational awareness resulted when the engineer was engaged in other operational tasks. In its investigation of the 2002 collision of an Amtrak train and a Maryland Area Regional Commuter (MARC) train in Baltimore, the NTSB determined the engineer lost situational awareness because of excess focus on regulating train speed. Because of her excess focus on regulating the train's speed, she failed to see and comply with both the cab and wayside signals indicating she should stop.[14] Additionally, in the 2003 derailment of a Northeast Illinois Regional Commuter Railroad (Metra) train in Chicago, Illinois, the NTSB determined the engineer had lost situational awareness minutes before the derailment because of his preoccupation with paperwork relating to train operations. Because of his preoccupation, he failed to observe and comply with the signal indications.[15]

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[13] Mica R. Endsley, "Toward a Theory of Situation Awareness in Dynamic Systems," *Human Factors* 37, no. 1 (1995): 32-64. In many modes of transportation, this construct is often referred to as "situational awareness."

[14] National Transportation Safety Board, *Collision of Amtrak Train 9 and MARC Train 437, Baltimore, Maryland, June 17, 2002,* Railroad Accident Brief RAB-03/01 (Washington, DC: NTSB, 2003).

[15] National Transportation Safety Board, *Derailment of Northeast Illinois Regional Commuter Railroad Train 519 in Chicago, Illinois, October 12, 2003,* Railroad Accident Report RAR-05/03 (Washington, DC: NTSB, 2003).

While diverted attention and the loss of situational awareness can result in errors in identifying one's location, they can also result in errors in executing normal procedures and tasks. Despite the engineer's experience in the area, after operating around the 65 mph curve near MP 83.5, he failed to execute his next significant operating task: decelerating the train as it approached the curve at Frankford Junction, a maneuver he had performed many times. Omitting normal procedural steps is a form of prospective memory error (Dismukes, 2006). Prospective memory refers to remembering to perform an intended action at some future time or, more simply, remembering to remember.[16] It typically focuses on when to do something. Failures of prospective memory typically occur when we form an intention to do something later, become engaged with other tasks, and forget the thing we originally intended to do.[17] It is possible, then, that the Amtrak engineer failed to slow his train for the upcoming curve because his attention to the radio communications about the SEPTA train emergency caused him to forget about the impending operation.

The NTSB has investigated accidents where competing information interfered with a crewmember's retention of vital information, which affected the crewmember's future actions. For example, in the 1996 collision between MARC and Amtrak trains in Silver Spring, Maryland, the NTSB determined that the MARC train engineer apparently forgot the most recent signal he had passed and ran his train through the next signal because he was focused on other tasks and information.[18] The engineer was processing competing information that included the mental and physical tasks required to stop the train at an upcoming station; carrying on radio conversations with an engineer on another train; monitoring defect detector broadcasts and disrupted radio broadcasts; and listening to or talking with another crewmember in the cab. Processing these multiple pieces of information interfered with his retention of the signal information.

In addition to this accident, the NTSB has investigated other accidents where experienced crewmembers forgot to complete a normal procedural step they had successfully performed many times on previous trips. In the 2005 derailment of a Norfolk Southern Railway freight train in Graniteville, South Carolina, the train crew failed to restore a switch to the normal main track position, a task they had routinely performed before the accident.[19] In a number of aviation accidents, experienced crews forgot to perform routine duties such as setting flaps and slats to takeoff position; setting hydraulic boost pumps to high position before landing; and arming the spoilers before landing.[20] In many of these accidents, the crewmembers' routine duties were

[16] An example of prospective memory is remembering to take medicine at night before going to bed or remembering to deliver a message to a friend.

[17] Prospective memory depends on several cognitive processes, including planning, attention, and task management.

[18] National Transportation Safety Board, *Collision and Derailment of Maryland Rail Commuter MARC Train 286 and National Railroad Passenger Corporation AMTRAK Train 29, Silver Spring, Maryland, February 16, 1996*, Railroad Accident Report RAR-97/02 (Washington, DC: NTSB, 2002).

[19] National Transportation Safety Board, *Collision of Norfolk Southern Freight Train 192 with Standing Norfolk Southern Local Train P22 With Subsequent Hazardous Materials Release, Graniteville, South Carolina, January 6, 2005,* Railroad Accident Report RAR-05/04 (Washington, DC: NTSB, 2004).

[20] (1) National Transportation Safety Board, *Northwest Airlines, McDonnell Douglas DC-9-82, N312RC, Detroit Metropolitan Wayne Country Airport, Romulus, Michigan, August 16, 1987,* Aircraft Accident Report AAR-88/05 (Washington, DC: NTSB, 1988). (2) National Transportation Safety Board, *Runway Overrun During*

interrupted, and their attention was momentarily diverted. Studies have shown people are vulnerable to forgetting to resume interrupted tasks in a timely manner. When they do resume the interrupted task, they may struggle to mentally reconstruct the point at which they were interrupted, and they are vulnerable to increased errors.[21]

Therefore, the NTSB concludes that the Amtrak engineer accelerated the train to 106 mph without slowing the train for the curve at Frankford Junction, due to his loss of situational awareness, likely because his attention was diverted to the emergency situation with the SEPTA train.

### 1.4.2 Need for Improved Crew Training and Advanced Technologies

This accident, along with those discussed above, illustrates that a crewmember's prolonged focus on one area of train operations can take attention away from other critical operations, including those to be performed in the near future. To address this type of situation (and as a result of the 2003 Metra accident discussed in section 1.4.1), the NTSB recommended that Metra—

> Use locomotive engineer simulator training to go beyond basic skills and teach strategies for effectively managing multiple concurrent tasks and atypical situations (R-05-11)

The NTSB also recommended that the Federal Railroad Administration (FRA)—

> Develop guidelines for locomotive engineer simulator training programs that go beyond developing basic skills and teach strategies for effectively managing multiple concurrent tasks and atypical situations. (R-05-9).

The FRA contracted for a research study on this topic. Based on the results of that research, a training course was developed by the contractor that teaches strategies to locomotive crews for managing distractions and the importance of sustained attention on the locomotive operating task. The training material is available to the industry for purchase, but there is no requirement for railroads to incorporate this training material into their training programs.[22] Both recommendations are classified "Closed—Acceptable Action."

Many railroads, including Amtrak, have incorporated distraction management into their training programs. The engineer of train 188 received Amtrak's distraction management training. However, the Amtrak training could be expanded to more effectively address prolonged, atypical

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*Landing, American Airlines Flight 1420, McDonnell Douglas MD-82, N215AA, Little Rock, Arkansas, June 1, 1999,* Aviation Accident Report AAR-01/02 (Washington, DC: NTSB, 2001). (3) National Transportation Safety Board, *Runway Overrun Following Rejected Takeoff, Continental Airlines Flight 795, McDonnell-Douglas MD-82, N18835, LaGuardia Airport, Flushing, New York, March 2, 1994,* Aviation Accident Report AAR-95/01 (Washington, DC: NTSB, 1995).

[21] Rahul M. Dodhia and Robert K. Dismukes, "Interruptions create prospective memory tasks," *Applied Cognitive Psychology* 23, no. 1 (2009):73–89.

[22] The training material is a copyrighted product of Veolia (now known as Transdev).

situations that might divert attention for an extended amount of time, such as what occurred in this accident.

Further research on prospective memory has identified countermeasures to reduce vulnerability to forgetting to perform deferred tasks.[23] These strategies pertain to both the individual operator as well as the designers of systems and procedures. Some of the strategies relevant to this accident include the following:

- Educating individuals and managers about prospective memory vulnerability and pointing out countermeasures individuals can take
- Minimizing the juggling of multiple tasks concurrently if one of the tasks is vital
- Pausing to encode an explicit intention to resume an interrupted task after the interruption has ended
- Analyzing the specific operating environment to identify “hotspots” in which prospective memory and concurrent task demands are high and interruptions are frequent. To the extent possible, redesign procedures and systems to reduce demands, especially when the consequences of memory lapses are serious
- Designing display and alerting systems for the status of tasks not active where the need for prospective memory is high

Training strategies to combat prospective memory errors exist. There is a need for advanced training for locomotive engineers, particularly those alone in the cab who must engage in operations (such as monitoring radio communications) typically assigned to, or shared with, another crewmember. Amtrak’s training for locomotive engineers is comprehensive and incorporates state-of-the-art simulators that require engineers to operate on multiple territories and under varied conditions. The NTSB is also aware that many major railroads also have quality training programs for train operating crews. However, as noted earlier, those training programs do not generally include strategies for dealing with prolonged or emerging situations—such as the SEPTA incident—that may divert crewmember attention for an extended period of time and cause prospective memory errors. Therefore, the NTSB concludes that training focusing on prospective memory strategies for prolonged, atypical situations that could divert crewmember attention may help operating crews become aware of, and take measures to avoid, errors due to memory failure.

Therefore, the NTSB recommends that Amtrak incorporate strategies into its initial and recurrent training for operating crewmembers for recognizing and effectively managing multiple concurrent tasks in prolonged, atypical situations to sustain their attention on current and upcoming train operations. The NTSB also recommends that the American Public Transportation Association (APTA) and the Association of American Railroads (AAR) develop criteria for initial and recurrent training for operating crewmembers that reinforces strategies for recognizing

[23] R. Key Dismukes, “Remembrance of Things Future: Prospective Memory in Laboratory, Workplace, and Everyday Settings,” in *Reviews of Human Factors and Ergonomics* vol. 6, ed. Douglas H. Harris (Santa Monica, California: Human Factors and Ergonomics Society, 2010), 79–122.

and effectively managing multiple concurrent tasks and prolonged atypical situations to sustain their attention on current and upcoming train operations, and distribute those criteria to their members.

In this accident, the engineer likely would have benefitted from technology that showed him the location of his train in real time, which would have also helped him establish and maintain his situational awareness. The NTSB has advocated the use of memory aids, visual displays, alerting systems, and other strategies and technologies to reduce operator workload and prevent errors. This situational information would assist crews operating in high traffic areas, at night, or in adverse weather conditions. Although there will be less need for such situational information in PTC-compliant territory, and this technology will be available in some locomotives operating in PTC-compliant territories, there are many areas where PTC will not be implemented. Therefore, the NTSB recommends that the FRA require railroads to install devices and develop procedures that will help crewmembers identify their current location and display their upcoming route in territories where positive train control will not be implemented.

## 1.5 Signal and Train Control Information

All Amtrak main tracks on the Northeast Corridor are equipped with a cab signal system. All trains operating there are equipped with automatic train control (ATC) consisting of cab signals with automatic speed control and automatic train supervision capabilities. Automatic speed control prevents the locomotive from exceeding speed limits established by wayside signals, while automatic train supervision ensures the locomotive engineer recognizes and acknowledges track signal downgrades. The cab signal system in the area of the derailment consisted of four cab signal indications in the following table from the NORAC rulebook.

**Table 2.** Cab Signal Indications

| NORAC Rule | Name | Indication | Speed Enforced |
|---|---|---|---|
| 280 | Clear | Proceed not exceeding Normal Speed (Normal Speed is Maximum Authorized Speed by Timetable) | Limited only by speed governor on locomotive |
| 282 | Approach Medium | Proceed approaching the next signal at Medium Speed | 45 mph |
| 285 | Approach | Proceed prepared to stop at the next signal. Trains exceeding Medium Speed must begin reduction to Medium Speed. | 30 mph |
| 290 | Restricting | Proceed at Restricted Speed | 20 mph |

An audible warning is sounded in the cab when the cab signal changes from clear to any of the other named signals. The engineer must respond to the audible alarm and slow the train to the speed associated with the signal name. If the engineer fails to slow the train, the system applies the brakes and reduces the power. The cab signals indicate specific speeds associated with signal indications from wayside signals; however, even in the absence of wayside signals, the signal department can permanently configure the cab signal system by installing a signal change point to enforce a slower speed on a curve for an approaching train.

After an accident at Boston's Back Bay Station on December 12, 1990, Amtrak and the FRA reviewed all curves on the Northeast Corridor where trains might derail if the operator failed to comply with the lower speed specified for the curve.[24] Ten curves between Boston and Washington, DC, met that description. On each curve, a cab signal change point was added to drop the cab signal from clear to approach medium, which required the engineer to slow the train to 45 mph to negotiate the curve and enforced that speed if the engineer failed to do so.

There was cab signal protection for westbound trains at the accident location because the maximum approach speed for westbound trains was 110 mph, higher than the overturn speed of 98 mph.[25] Westbound train engineers approaching the curve at the accident site would have received a cab signal warning to reduce the train speed. If an engineer failed to do so, the system would have automatically slowed the train. However, that protection was not added to the accident curve in the eastbound direction because Amtrak assumed that those trains would not be traveling faster than the maximum approach speed of 80 mph. Because the overturn speed was 98 mph, even if an engineer failed to slow from that maximum approach speed, the train would still be below the overturn speed.

The NTSB concludes that cab signal protection to enforce the 50 mph speed restriction in the eastbound direction at Frankford Junction or a fully implemented PTC system would have prevented the accident. Following the accident, Amtrak modified the signal system so that eastbound trains traveling toward Frankford Junction received a cab signal change to ensure speed restriction enforcement until December 2015 when PTC was implemented on that section of track. (PTC enforces speed restrictions, so the signal change was no longer necessary.)[26]

### 1.5.1 Positive Train Control

PTC is defined in Title 49 *United States Code* (*USC*) section 20157(i)(3) as follows:

> [A] system designed to prevent train-to-train collisions, over-speed derailments, incursions into established work zone limits, and the movement of a train through a switch left in the wrong position.

PTC uses wireless communication to monitor train movements and automatically stop a train to ensure compliance with speed or signal restrictions thereby preventing collisions and derailments. In contrast, ATC systems rely primarily on hard-wired control points installed in the track and do not provide protection against all overspeed conditions. In other words, PTC is predictive and prevents a signal or overspeed violation; ATC is reactive and waits for a violation to occur before taking some control of the train.

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[24] National Transportation Safety Board, *Derailment and Collision of Amtrak Passenger Train 66 With MBTA Commuter Train 906 at Back Bay Station, Boston, Massachusetts, December 12, 1990,* Railroad Accident Report RAR-92/01 (Washington, DC, NTSB, 1992).

[25] Overturn speed refers to the speed at which a train would likely derail on a curve.

[26] For more information, see section 2.3.

Because ATC does not control a train's speed in all circumstances, Amtrak installed the Advanced Civil Speed Enforcement System (ACSES), which FRA has said meets the conceptual requirements of PTC, on portions of the Northeast Corridor in 2000. (See figure 5.)

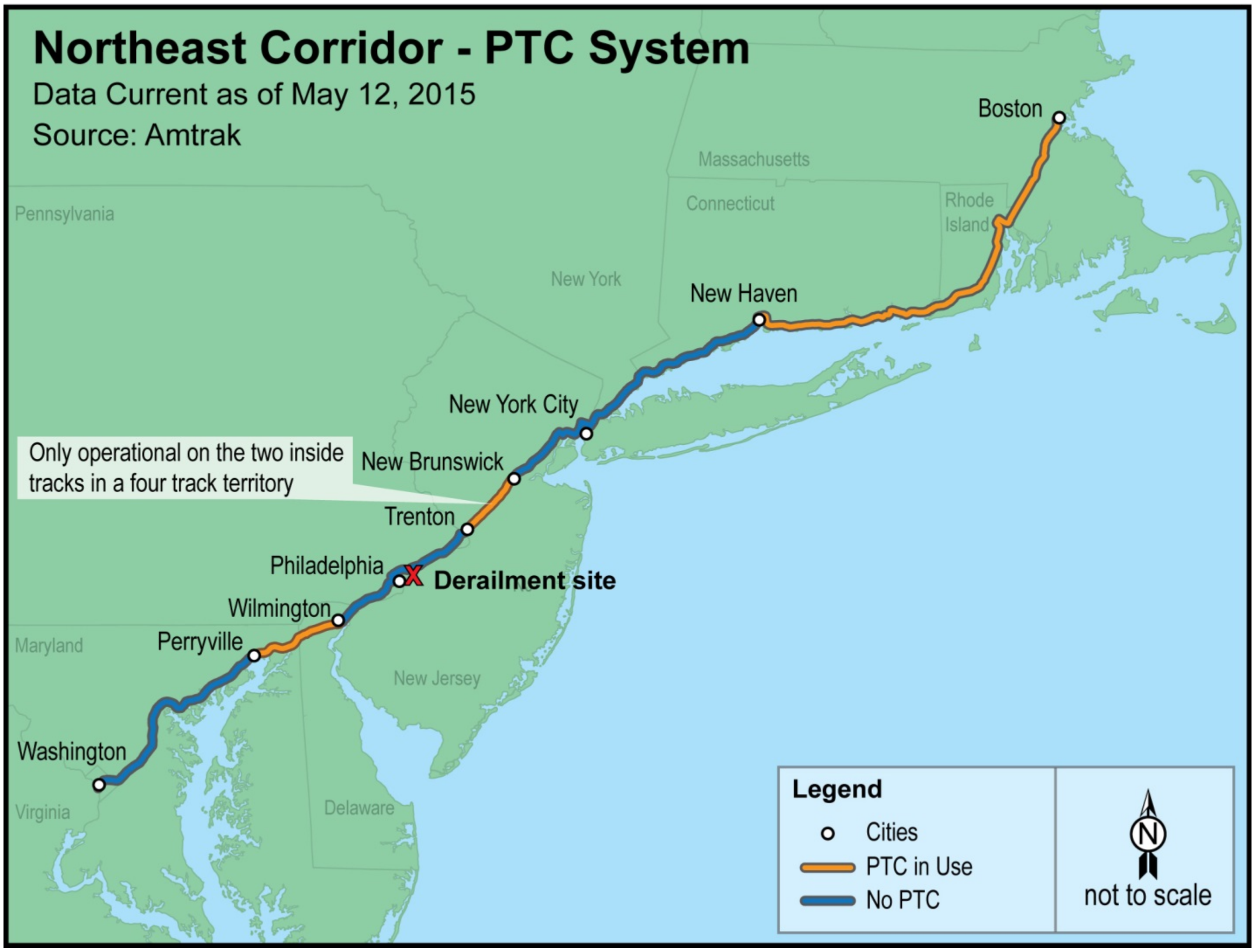


**Figure 5.** PTC (ACSES) was installed on the Northeast Corridor in 2000.

The ACSES system was designed to enforce speeds that were not enforced by ATC, such as some permanent speed restrictions on curves and bridges and maximum authorized speeds as prescribed in the operating timetable. The system was also designed to enforce a positive stop at interlocking signals and temporary speed restrictions via a data radio communication system.

In 2010, the FRA issued regulations for PTC systems in accordance with the Rail Safety Improvement Act of 2008, which required PTC to be implemented nationwide by December 31, 2015.[27] (This deadline was later extended to December 2018.) ACSES was the first PTC system to be certified by the FRA. Amtrak had installed ACSES on all Amtrak-owned track on the Northeast Corridor required to be PTC-equipped by the end of 2015.[28] PTC is now fully operational from Washington, DC, to Boston. Thus, all curves with a speed change such as

[27] Public Law 110-432, div. A, October 16, 2008. 49 *USC* 20157.

[28] Some Northeast Corridor track owned by Metro North and Long Island Railroad is not PTC-equipped. Amtrak also installed a PTC system on a portion of its track in Michigan.

the approach to the accident curve are now protected by PTC, preventing a recurrence of this type of accident in the Northeast Corridor. Amtrak routes beyond the Northeast Corridor are operated on tracks owned by other railroads, so PTC implementation on those routes depends upon those railroads installing the necessary equipment.

The NTSB has advocated the implementation of PTC systems to prevent collisions and overspeed events for over 40 years and has placed it on its Most Wanted List of Transportation Safety Improvements for 22 of the 26 years that the list has been in existence. The NTSB has investigated many deadly accidents that could have been prevented by PTC, but progress in implementing PTC has been slow. Following a PTC-preventable accident in Goodwell, Oklahoma, in June 2012, the NTSB noted the value of frequent implementation updates from each railroad so the FRA and the public could follow progress. Toward that end, the NTSB issued Safety Recommendation R-13-27 asking that all railroads subject to the PTC provisions of the Rail Safety Improvement Act of 2008 provide regular implementation updates to the FRA:

> Provide positive train control implementation update reports to the Federal Railroad Administration every 6 months until positive train control implementation is complete. The update reports should consist of two sections: components and training. The components section should include a description of the positive train control component to be implemented, the number of components, the number of components completed on the report date, the number of components that remain to be completed, the overall completion percentage, and the estimated completion date. Components are defined as locomotives, wayside units, switches, base station radios, wayside radios, locomotive radios, and any new and novel technologies that are part of a positive train control system. The training section shall include the number of safety-related employees and equivalent railroad carrier contractors and subcontractors that need to be trained, by class and craft; minimum training standards for those employees and contractors, meaning the knowledge of and ability to comply with federal railroad safety laws and regulations and carrier rules and procedures to implement positive train control; the percentage of employees who have completed training; the percentage of employees who remain to be trained; and the estimated date that training will be completed.

The NTSB also issued Safety Recommendation R-13-23 to the FRA:

> Publish the positive train control implementation update reports submitted by all railroads subject to the positive train control provisions of the Rail Safety Improvement Act of 2008 and make the reports available on your website within 30 days of report receipt.

Several railroads responded that they would file such progress reports. However, the FRA declined to make the progress reports public. On January 2, 2014, the FRA responded that the annual reports required by the Rail Safety Improvement Act of 2008 “provide only a snapshot in time” and that “alone, and without the additional context, the data contained in a railroad’s [implementation plan] has little value and does not account for the fluidity, complexity, and depth of PTC system implementation. To publish this information would likely mislead and confuse the public." On February 24, 2014, the NTSB classified Safety Recommendation R-13-23 "Open—Unacceptable Response." On March 11, 2015, the FRA announced it had made the railroads' revised plans and implementation schedules publicly available online.

The Positive Train Control Enforcement and Implementation Act of 2015 (Public Law 114-73, section 1302, October 29, 2015) extended the deadline for PTC implementation until December 31, 2018, and contains provisions for railroads to request an additional 24-month extension. The act also prohibits the FRA from imposing monetary fines on railroads that do not meet the extended deadline until 2021. The act also requires each railroad to file a revised implementation plan and annual progress reports detailing the extent to which they are meeting the schedule set forth in those plans with the US Department of Transportation (DOT). The DOT is required to make the annual progress reports available to the public within 60 days of receiving them, and in a letter dated May 5, 2016, the FRA committed to doing this.

The NTSB is concerned that the extension legislation will allow many tracks to remain unprotected by PTC for an additional 3 to 5 years and believes frequent progress reports are even more important now. Although most of the progress report elements listed in Safety Recommendation R-13-27 were included in the 2015 extension legislation, the act requires the FRA to make progress reports available annually rather than every 6 months as NTSB recommended. In its September 2015 report *Additional Oversight Needed as Most Railroads Do Not Expect to Meet 2015 Implementation Deadline*, the Government Accountability Office (GAO) recognized the usefulness of more frequent and detailed reports.[29] The GAO recommended that the FRA be required to improve its oversight of railroads' PTC implementation by holding them accountable for continuing to make progress. The GAO also noted that the FRA is receiving private, monthly updates from railroads on their progress.

On February 3, 2016, the FRA announced that it plans to begin publishing quarterly progress reports on PTC implementation later this year. The NTSB is encouraged by this announcement and looks forward to seeing it fulfilled. Accordingly, Safety Recommendation R-13-23 is now classified "Closed–Acceptable Alternate Action."

### 1.5.2 Two-Person Crews

In April 2014, the FRA announced its intention to issue a proposed rule establishing minimum crew size standards for main line freight and passenger rail operations. As stated by the FRA in its 2014 press release, "We believe that safety is enhanced with the use of a multiple person crew—safety dictates that you never allow a single point of failure." On March 15, 2016, the FRA published a notice of proposed rulemaking (NPRM) to establish minimum requirements for the size of train crews depending on the type of operation.[30] The NPRM proposes a minimum requirement of two crewmembers "for all railroad operations, with exceptions for those operations that FRA believes do not pose significant safety risks to railroad employees, the general public, and the environment by using fewer than two-person crews." The proposed rule

[29] Government Accountability Office, *Additional Oversight Needed as Most Railroads Do Not Expect To Meet 2015 Implementation Deadline*, GAO/15-739 (Washington DC: GAO, 2015).

[30] *Federal Register* 81, no. 50 (March 15, 2016): 13918.

"would also establish minimum requirements for the roles and responsibilities of the second train crewmember on a moving train, and promote safe and effective teamwork."

The engineer on train 188 was alone in the control cab, as is customary for most Amtrak operations on the Northeast Corridor, and therefore he was solely responsible for ensuring compliance with signals and speed restrictions. The Brotherhood of Locomotive Engineers and Trainmen (BLET) has advocated for a two-person crew requirement and asserts that a second qualified employee in the cab would have prevented this accident, but they do not explain the basis for this assertion. (See BLET Revised Final Submission in the public docket for this accident.)

Increased crew size is one of the options for enforcing speed limits at specific locations in the Fixing America's Surface Transportation (FAST) Act (Public Law 114-94, December 4, 2015). Section 11406 of the FAST Act requires railroads providing intercity rail passenger transportation or commuter rail passenger transportation to develop action plans for warning and enforcing speed limits at locations not governed by PTC where there is a speed reduction of more than 20 mph approaching a curve, bridge, or tunnel. Appropriate actions listed in the act include the following:

- modification to ATC systems or other signal systems
- increased crew size
- installation of signage notifying crews of the maximum authorized speed
- installation of alerters
- increased crew communication
- other practices

The NTSB agrees that relying on a single person to make correct decisions can result in a single point failure. This single-point failure will be substantially addressed by full PTC implementation since that system will provide an independent automated means of compliance with speed and signal restrictions in case of human error. In areas where PTC is not implemented, other ways of addressing this single point failure may be necessary. It is unclear if a two-person crew would satisfactorily address this issue because there is insufficient data to demonstrate that accidents are avoided by having a second qualified person in the cab. In fact, the NTSB has investigated numerous accidents in which both qualified individuals in a two-person crew made mistakes and failed to avoid an accident. (See appendix C.)

The NTSB attempted to use the FRA accident database, which comes from accident reports submitted by railroads, to determine whether trains with one-person crews have a higher rate of accidents than trains with multi-person crews; however, investigators found the data were not useful in making such a comparison. The FRA acknowledged in its recent NPRM that it "cannot provide reliable or conclusive statistical data to suggest whether one-person crew operations are generally safer or less safe than multiple-person crew operations."[31] The

[31] *Federal Register* 81, no. 50 (March 15, 2016): 13918.

accident/incident report form (FRA form 6180.54) includes fields indicating how many crewmembers were on the train at the time of the accident.[32] The form, however, provides insufficient information about the accident circumstances to determine if the accidents could have been prevented by a second crewmember. More important, it does not provide information about how many crewmembers were in the controlling cab.

Therefore, the NTSB concludes that the FRA accident database is inadequate for comparing relevant accident rates based on crew size because the information about accident circumstances and number of crewmembers in the controlling cab is insufficient. Accordingly, the NTSB recommends that the FRA modify form 6180.54 (Rail Equipment Accident/Incident Report) to include the number of crewmembers in the controlling cab of the train at the time of an accident (R-16-33). The NTSB further recommends that after form 6180.54 is modified as specified in Safety Recommendation R-16-33, the FRA use the data regarding number of crewmembers in the controlling cab of the train at the time of an accident to evaluate the safety adequacy of current crew size regulations.

To the extent that two-person crews are relied upon as a means of ensuring speed and signal compliance, it is important to continuously emphasize the need for crew resource management (CRM) training to ensure that crews make the best use of both crewmembers and minimize the risks inherent in relying on two-person crews. Since 1973, the NTSB has been concerned about the quality of interaction among crewmembers in the cab of a locomotive. Following a June 25, 1973, accident in which a Southern Pacific freight train rear-ended another freight train in the rail yard in Indio, California, the NTSB recommended that the Southern Pacific Transportation Company—

> Train all new employees including brakemen in their responsibilities and duties so that they understand their responsibility to monitor the performance of other employees and to take positive action when the situation warrants. (R-74-11)[33]

Another example occurred on March 25, 1998, when southbound Norfolk Southern Corporation train 255L5 struck the side of eastbound Conrail train TV 220 at a railroad crossing at grade in Butler, Indiana.[34] The Norfolk Southern conductor was killed; the engineer and student engineer sustained minor injuries. The investigation showed that the crewmembers had received the proper signals and alerts to stop the train before reaching the other train; however, they did not work together to comply with those signals and alerts.

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[32] FRA Rail Equipment Accident/Incident Report Form 6180.54 can be found at http://safetydata.fra.dot.gov/OfficeofSafety/publicsite/Forms.aspx.

[33] In that accident, the engineer and brakeman of the striking train were killed. The engineer became incapacitated, but the brakeman had received adequate cues that action was required on his part to prevent the accident. National Transportation Safety Board, *Rear End Collision of Two Southern Pacific Transportation Company Freight Trains, Indio, California, June 25, 1973*, Railroad Accident Report RAR-74/01 (Washington, DC: NTSB, 1974). Safety Recommendation R-74-11 is classified “Closed—Acceptable Action.”

[34] National Transportation Safety Board, *Collision of Norfolk Southern Corporation Train 255L5 with Consolidated Rail Corporation Train TV 220, in Butler, Indiana, March 25, 1998*, Railroad Accident Report RAR-99/02 (Washington, DC: NTSB, 1999).

As a result of that accident, the NTSB issued safety recommendations to the Norfolk Southern Corporation (R-99-22), the FRA (R-99-13), all Class 1 railroads including Amtrak (R-99-25), the American Short Line and Regional Railroad Association (R-99-26), the BLET (R-99 27), and the United Transportation Union (now the International Association of Sheet Metal, Air, Rail, and Transportation Workers [SMART]) (R-99-28), recommending that they—

> In cooperation with [each other] …, develop, for all train crewmembers, train crew resource management training that addresses, at a minimum: crewmember proficiency, situational awareness, effective communication and teamwork, strategies for appropriately challenging and questioning authority.
>
> These recommendations have been classified "Closed—Acceptable Action."

More recently, as a result of the collision of two freight trains near Two Harbors, Minnesota, the NTSB issued Safety Recommendation R-13-7 asking the FRA to "require railroads to implement initial and recurrent crew resource management training for train crews."[35] The recommendation was reiterated as a result of the 2013 collision of two freight trains in Chaffee, Missouri.[36] Because the FRA has not yet mandated CRM training, Safety Recommendation R-13-7 is classified "Open—Unacceptable Response."

## 1.6 Train Information

Amtrak train 188 consisted of one locomotive, six passenger cars, and one café car. The train weighed about 955,000 pounds and was about 663 feet long. The train makeup and orientation are shown in the following table.

**Table 3.** Amtrak Train 188.

| Sequence | Car Type | Car Number | Number of Seats |
|---|---|---|---|
| 1 | Locomotive | 601 | 3[a] |
| 2 | Business (Car 1) | 81528 | 62 |
| 3 | Passenger (Car 2) | 82776 | 72 |
| 4 | Passenger (Car 3) | 82644 | 72 |
| 5 | Café (Car 4) | 43346 | 48 |
| 6 | Passenger (Car 5) | 82761 | 72 |
| 7 | Passenger (Car 6) | 82797 | 72 |
| 8 | Passenger (Car 7) | 82981 | 72 |

[a]Each cab is equipped with a jump seat to allow for three crewmembers.

[35] National Transportation Safety Board, *Head-on Collision Between Two Canadian National Freight Trains Near Two Harbors, Minnesota, September 30, 2010*, Railroad Accident Report RAR-13/01 (Washington, DC: NTSB, 2013).

[36] National Transportation Safety Board, *Collison of Union Pacific Railroad Freight Train with BNSF Railroad Freight Train Near Chaffee, Missouri, May 25, 2013*, Railroad Accident Report RAR-14/02 (Washington, DC: NTSB, 2014).

### 1.6.1 Postaccident Testing

**Passenger Cars**

The damaged passenger cars were transported to an Amtrak facility and reassembled with their recovered air brake components. The first car was too damaged to be reassembled, but most of the air brake components from the car were recovered and sent to an AAR-certified air brake shop for testing. All components passed the tests.

Most of the air brake components on the remaining cars were tested. Because the second car was deemed unsafe to enter due to structural damage, the conductor's emergency brake valves were not tested. Finally, the five rear cars were connected sequentially, and the brake system was tested.

Investigators determined that the individual braking components that were recovered functioned as designed. When the five cars were tested configured as a train, the braking system functioned as designed.

**Locomotive**

The friction brakes, propulsion system, event recorder, alerter, ATC, and ACSES were tested on locomotive 601. Other than the event recorder, discussed below, all the systems functioned as intended.

During a preliminary review of the accident event recorder data from the locomotive, investigators noted that some throttle data were not recorded.[37] Investigators determined a disconnected feedback wire caused the failure. Engineers at Siemens USA, the locomotive's manufacturer, demonstrated to investigators that the signals on the train lines were generated, processed, and communicated correctly, meaning the actual train lines were functional, just not reporting to the event recorder. Amtrak reviewed event recorder data from its Siemens locomotive fleet, and locomotive 601 was the only locomotive with this problem. The event recorder has no effect on the operation or control of the locomotive.

Investigators reconnected the loose wire and validated the proper functionality of the event recorder.

## 1.7 Personnel Information

The locomotive engineer, 31, was hired by Amtrak on June 26, 2006. He had been an engineer since 2010. He was experienced, certified, and qualified to perform his duties. As mentioned earlier, he had maintained a regular work and rest schedule for several days leading up to the accident, and there was no evidence that he suffered from fatigue. He had no identified medical conditions, and postaccident toxicology tests showed no evidence that he was impaired by alcohol, other drugs, or any substance. The engineer had no previous disciplinary action.

[37] For more information see the Mechanical Group Chairman Factual Report and the Locomotive Event Recorder Factual Report in the public docket for this accident.

During his emergency medical treatment after the accident, it was noted that he had some retrograde and anterograde amnesia and was diagnosed with an acute head injury, a left knee laceration, a forehead laceration, and a right knee sprain.[38] Postaccident evaluations by specialists indicated that he had a posttraumatic headache and a concussion resulting from the accident.

The conductor, 32, had been hired by Amtrak on August 14, 2009. The first assistant conductor, 38, was hired on October 14, 2011. The second assistant conductor, 34, was hired on May 7, 2014.

Toxicological tests for all four of the operating crewmembers were negative for all drugs tested pursuant to 49 *CFR* Part 219, Subpart C, Post-Accident Toxicological Testing.[39] In addition, the engineer was tested for more than 1,300 substances with negative results except for lidocaine, a local anesthetic administered during postaccident medical treatment.

Amtrak records indicated that the crewmembers had taken and successfully completed numerous railroad training courses. The courses covered various aspects of railroad operations. Some also included management oversight to ensure employees could properly apply and were in compliance with railroad rules, regulations, and instructions. Amtrak records also contained no disciplinary action for the crewmembers during the preceding year.

## 1.8 Survival Factors

### 1.8.1 The Derailment Sequence

A review of the locomotive forward-facing video showed that the locomotive traveled past—and did not strike—the first catenary support structure, N121. (See figure 6.) After the first passenger car derailed, it struck catenary support structure N121. This support structure completely separated from the remainder of the catenary structure, and the first passenger car was severely damaged, likely from the impact. The second catenary support structure, N122, was struck with enough force to separate it from the rest of the catenary structure and flatten it to the ground. Components of the first passenger car were found beginning at the second support structure N122. As a result of multiple impacts with catenary support structures and subsequent overturning, the structure of the first car was catastrophically compromised. Four of the eight passengers who died were recovered in or near this car.

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[38] Amnesia is the inability to recall events. Anterograde amnesia is the inability to recall events preceding a traumatic event, often a blow to the head; retrograde amnesia is the inability to recall events just after the injury.

[39] The service employee who was working in the café car was not subject to the drug testing requirements.

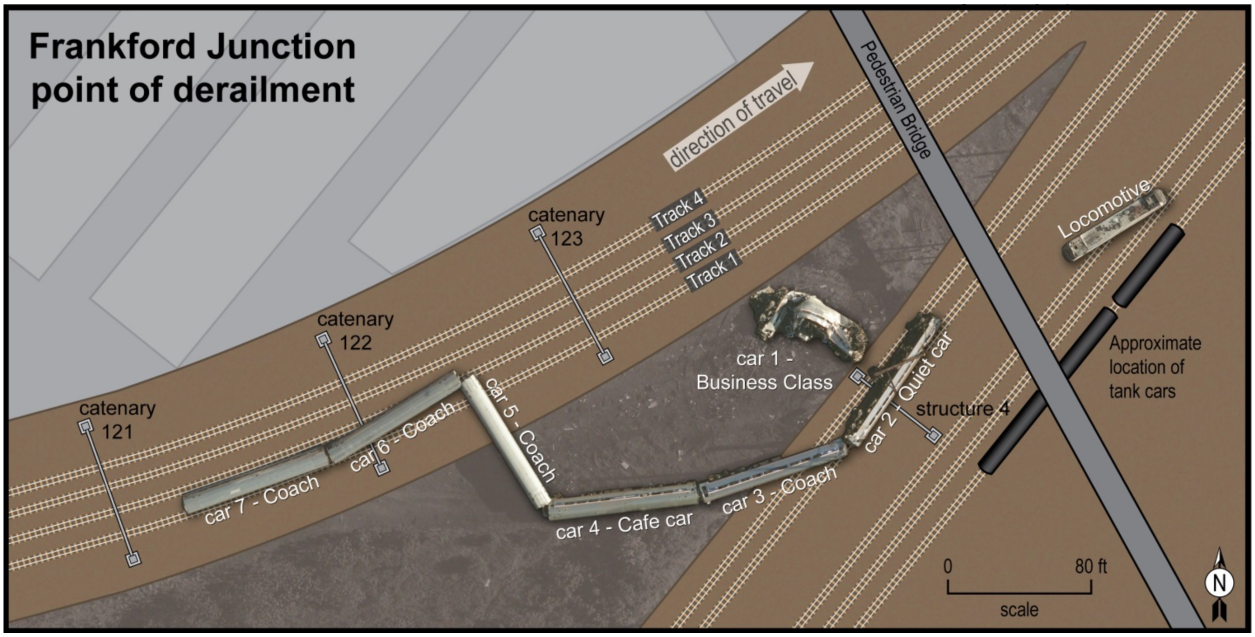


**Figure 6.** Accident site showing derailed cars, catenary structures locations.

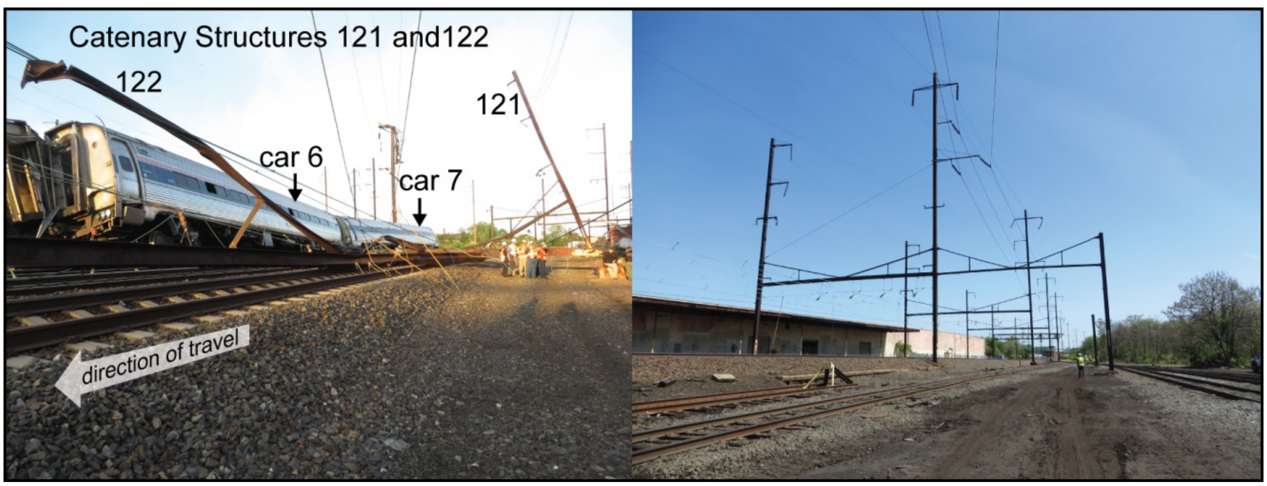


**Figure 7.** Damaged catenary supports (left); example of undamaged catenary supports (right).

### 1.8.2 Damage to Passenger Car Windows and Injuries

Exterior window zip strips were found on and to the right of the tracks (in the direction of travel) starting between the point of derailment and catenary support structure N121.[40] Blue material from exterior decals on a passenger car was found on the outer rail of track 1. This evidence shows that at least one passenger car, and likely more, was on its side at this point in the derailment sequence. The second, third, and fourth passenger cars rolled onto their sides and were dragged on the ground and extensively damaged on their right sides. On the second car,

[40] Zip strips are removable inserts around the rail car's window openings that can be pulled out so that the windows can be removed during emergencies or maintenance.

six right-side windows were completely separated from their openings, and three right-side windows were partially dislodged and missing exterior zip strips. On the third car, all nine of the right-side windows were separated from their openings, and there was extensive scraping on the blue decal surrounding the windows. On the fourth car, three right-side windows were completely separated from their openings, and four windows were partially dislodged. The remaining cars in the consist had varying degrees of scraping damage on their right sides (car body and windows).

**Figure 8.** Photograph showing damaged right side of car 3.


**Figure 9.** Close-up of damaged windows on right side of car 4.

Four of the passengers who died were recovered under or near the third passenger car. Two of these four passengers were partially ejected from window openings and trapped under the third car. Another passenger was found under car 3, and the last was found adjacent to car 3. These two were most likely ejected from the train through window openings after the windows had separated. As previously mentioned, six windows were completely separated from car 2, and all nine of the right-side windows were separated from their openings from car 3. The NTSB concludes that if the passenger car windows had remained intact and secured in the cars, some passengers who died would not have been ejected and would likely have survived the accident.

The NTSB has been concerned about passengers being ejected through window openings for more than 40 years. In 1972, the NTSB noted that window ejections accounted for a large portion of passenger fatalities. Because of this, the NTSB issued Safety Recommendation R-72-32 to the FRA—

> In establishing near-future safety standards for railroad and rail rapid-transit passenger cars, give priority to the problem of ejection of passengers through large side windows. Regulations should be promulgated on realistic performance tests. This source of fatalities, even though small in number, is of such a large proportion among passenger fatalities as to warrant action prior to the issuance of the Mechanical Standards.[41]

The problem remains serious. The Philadelphia accident was the second passenger rail accident in less than 2 years that resulted in the deaths of passengers as a result of ejection through damaged or displaced passenger car windows. Similar window separations were seen in the December 1, 2013, crash of a Metro-North passenger train near Bronx, New York.[42] That train, which derailed at 82 mph, consisted of seven passenger cars and a locomotive. Four passengers were killed, and 57 passengers and 4 crewmembers were injured. In that case, the NTSB found that a contributing factor to the severity of the accident was the loss of windows that resulted in the fatal ejection of four passengers from the train. As a result of that accident, the NTSB issued the following recommendation to the FRA on December 2, 2014:

> Develop a performance standard to ensure that windows (e.g., glazing, gaskets, and any retention hardware) are retained in the window opening structure during an accident and incorporate the standard into 49 *Code of Federal Regulations* (*CFR)* 238.221 and 49 *CFR* 238.421 to require that passenger railcars meet this standard. (R-14-74)

The FRA responded on March 25, 2015, that it was developing a research program to test all safety aspects of window systems, including window retention and passenger containment during potential accident scenarios, as well as emergency egress, rescue access, and impact

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[41] National Transportation Safety Board, *Derailment of Amtrak Train Number 1 While Operating on the Illinois Central Railroad Near Salem, Illinois, June 10, 1971*, Railroad Accident Report RAR-72/5 (Washington, DC: NTSB, 1972). Safety Recommendation R-72-32 was classified "Closed—Acceptable Action" on July 29, 1985, based on the FRA's promulgation of 49 *CFR* Part 223, *Safety Glazing Standards - Locomotives, Passenger Cars and Cabooses*.

[42] National Transportation Safety Board, *Metro-North Railroad Derailment, Bronx, New York, December 1, 2013*, Railroad Accident Brief RAB-14/12 (Washington, DC: NTSB, 2014).

resistance requirements. The FRA's letter also stated that it would have to obtain more information to provide a basis before determining a research approach on this issue due to the competing expectations for railcar window performance. The letter further stated that the FRA expected this research to provide performance data on window retention and passenger containment; evaluate existing and potential designs and design methodologies for window systems; and investigate practical testing metrics and methodologies to assess and quantify containment capabilities. Once this research is complete, FRA can assess the influence of design methodologies that enhance containment capabilities while preserving the ability of window systems to provide required emergency egress and rescue access without compromising other safety purposes. The expected completion date for the research is October 2016. The FRA said it will then be able to determine proposed regulatory changes that are reasonable and practical. Safety Recommendation R-14-74 is currently classified "Open—Acceptable Response."

The NTSB recognizes that developing a performance standard and incorporating it into the federal regulations will require research and time. Nonetheless, the Philadelphia accident has again demonstrated the necessity for this standard to protect occupants during accidents; therefore, the NTSB reiterates recommendation R-14-74. [**Recommendation Reiteration**]

### 1.8.3 Occupant Protection in Derailment Scenarios

Among the 46 people who were seriously injured in this accident, the majority sustained torso or chest injuries. Twenty-four of those who were seriously injured sustained 68 chest injuries at Abbreviated Injury Scale (AIS) level 2 or higher.[43] (The number of injuries exceeds the number of people because one individual can sustain multiple chest injuries.) This included flail chests (in which a series of ribs are fractured in multiple places resulting in impairment of respiratory function), pulmonary contusions, people with multiple rib fractures, and a fractured sternum. There were fewer head and neck injuries: four people sustained fractured cervical vertebrae each coded with an AIS score of 2; there was one head injury with an AIS score of 3, and one person had a cervical fracture with a spinal cord injury with an AIS score of 5.

The NTSB considered the possible causes for this number of serious torso injuries. In a collision that results in the railcars remaining upright and in line, the occupants would likely strike the seat back in front of them and remain close to their seating area.[44] This is known as "compartmentalization." Compartmentalization, although not required, has been one strategy to protect occupants in railroad accidents by restricting their movement and preventing them from being thrown from their seats in the car. In the preamble to its final rule promulgating the Passenger Equipment Safety Standards currently codified at 49 *CFR* Part 238, the FRA noted that based on previous research, interior passenger protection requirements for Tier I and II passenger cars rely on compartmentalization as a passenger protection strategy.[45] As currently

[43] The Abbreviated Injury Scale (AIS) uses a 1–6 scale to score injuries for the likelihood that the injury is life-threatening. On this scale, 1 is a minor injury (contusion, superficial laceration), and 6 is fatal. AIS 2005 Update 2008. Association for the Advancement of Automotive Medicine. Barrington, IL 2008.

[44] This assumes that the seat back is high enough to restrict forward motion. For further details about seat testing and compartmentalization, see Commuter Rail Seat Testing and Analysis DOT/FRA/ORD-01-06.

[45] *Federal Register* 64, no. 91 (May 12, 1999): 25540.

implemented, compartmentalization is focused on preventing occupants from being thrown forward and away from their immediate seating area.

In this accident, the occupants experienced complex forward and lateral motions and forces. At least one passenger car, and likely more, overturned early in the accident sequence between the point of derailment and catenary support structure N121. This overturning would have resulted in occupants being thrown across the width of the rail car and striking the sides of the seats and sidewalls causing many passenger injuries. Therefore, the NTSB concludes that passengers were seriously injured by being thrown from their seats when the passenger cars overturned.

As noted above, 49 *CFR* Part 238 contains the current safety requirements for passenger railroad equipment. Those regulations include standards intended to minimize the effects of collision crash forces by trying to ensure that occupant space is preserved (structural crashworthiness) and that interior fittings such as seats remain secure (interior crashworthiness). To study these standards, the FRA has sponsored full-scale collision testing with conventional and crash energy management equipment.[46] This research for passenger car crashworthiness has focused on in-line collision scenarios and the occupant response to the initial collision impact. Although this scenario is representative of some accidents, it is not representative of the full spectrum of accidents, such as derailments. The effects of derailments and passenger car overturns on occupants and the associated injury mechanisms have not been extensively studied.

Passenger equipment safety regulations did not even exist prior to 1999, and the NTSB acknowledges the progress in passenger car design that has been made in the past two decades. These safety standards, however, should not remain static and permanent because they may not provide protection to occupants in otherwise survivable derailments with passenger car overturns. According to postaccident interviews, in this accident many occupants were injured because they were thrown laterally and not compartmentalized. Others were injured because they were struck by luggage, seats, or other people.

The NTSB notes that in the case of highway vehicles, occupant protection standards have evolved to reflect current knowledge of crash dynamics. For example, the NTSB has recognized that in the case of school buses, compartmentalization is an incomplete solution, and seat belts are beneficial in preventing injury, especially in lateral impacts and rollovers.[47]

The railcars involved in this accident were manufactured in the 1970s and, therefore, were not subject to the current passenger equipment safety regulations. But even if they had been built to meet the current standards, they would not have been required to provide protection from

[46] (1) Federal Railroad Administration, *Passenger Rail Two-Car Impact Test Volume II: Summary of Occupant Protection Program*, DOT/FRA/ORD-01/22.II (Washington, DC: DOT, FRA, 2002). (2) Federal Railroad Administration, *Passenger Rail Train-to-Train Impact Test Volume II: Summary of Occupant Protection Program*, DOT/FRA/ORD-03/17II (Washington, DC: DOT, FRA, 2003). (3) Federal Railroad Administration, *Occupant Protection Experiments in Support of A Full-Scale Train-to-Train Crash Energy Management Equipment Collision Test*, DOT/FRA/ORD-09/14 (Washington, DC: DOT, FRA, 2009).

[47] National Transportation Safety Board, *School Bus and Truck Collision at Intersection Near Chesterfield, New Jersey, February 16, 2012*, Highway Accident Report HAR-13/01 (Washington, DC: NTSB, 2013).

lateral forces caused by derailments and overturns. The injuries in this accident illustrate the need for railcar safety design standards to address such forces.

Therefore, the NTSB concludes that although the passenger equipment safety standards in 49 *CFR* Part 238 provide some level of protection for occupants, the current requirements are not adequate to ensure that occupants are protected in some types of accidents. The NTSB believes that railroad occupant safety research and regulations should better reflect a greater spectrum of accident types and must employ a systematic approach that considers the causes of injury during derailments in which occupants may be thrown or struck by loose objects. Therefore, the NTSB recommends that the FRA conduct research to evaluate the causes of passenger injuries in passenger railcar derailments and overturns and evaluate potential methods for mitigating those injuries, such as installing seat belts in railcars and securing potential projectiles (R-16-35). The NTSB further recommends that when the research specified in Safety Recommendation R-16-35 identifies safety improvements, use the findings to develop occupant protection standards for passenger railcars that will mitigate passenger injuries likely to occur during derailments and overturns.

## 1.9 Emergency Medical Response

### 1.9.1 Incident Management

According to the Federal Emergency Management Agency,

> the National Incident Management System is a systematic, proactive approach to guide departments and agencies at all levels of government, nongovernmental organizations, and the private sector to work together seamlessly and manage incidents involving all threats and hazards—regardless of cause, size, location, or complexity—in order to reduce loss of life, property and harm to the environment.[48]

This management system is a high-level framework that officials can use to develop and customize their community-level emergency response plan that takes into account local resources and practices.

In this accident, the first 911 call reporting the derailment was placed by a passenger and received at 9:25 p.m. The first fire department companies dispatched at 9:28 p.m. to the accident scene included two engines, two pipelines, two ladders, two battalion chiefs, a medic unit, a rescue squad, and an emergency medical services (EMS) supervisor. The first arriving company reported on scene at 9:31 p.m. The first incident commander was a battalion chief who arrived on scene at 9:32 p.m. A staging area was established. The incident commander requested five additional medic units at 9:33 p.m. The medic units and two EMS supervisors were dispatched. The incident commander reported to the fire communications center that there were people on the tracks, cars were overturned, and Amtrak should be notified to shut down the corridor. While en route at 9:35 p.m., a deputy fire chief ordered the incident classified as a mass casualty

[48] Source: www.fema.gov/national-incident-management-system (accessed March 28, 2016).

incident (MCI). A second alarm was ordered, and the mass casualty unit was dispatched. Additional ambulances and EMS supervisors were dispatched and responded to the accident site. Two EMS collection points were established. The first time stamp in a patient's hospital chart occurred at 9:57 p.m.

A Philadelphia Police Department (PPD) chief inspector and the director of the Philadelphia Office of Emergency Management (OEM) were liaisons from their departments to the incident commander. Because the accident was classified as an MCI, the chief inspector confirmed that all available emergency patrol wagons were sent to the scene in the event that additional transport vehicles were needed. According to the chief inspector, the PPD policy is to coordinate patient transportation with the Philadelphia Fire Department's (PFD) EMS. The chief inspector reported that after the accident many people on the train tried to leave the site immediately. He said that if officers encountered a seriously injured person, the officers transported the patient to a hospital.

### 1.9.2 Transportation of the Injured

Of the 253 people on train 188, 186 (one of whom later died) were transported to area hospitals for medical care. Interviews with occupants, hospital staff, and PFD personnel and a review of the medical and EMS records revealed the majority of the injured were transported to hospitals in police vehicles or SEPTA buses. According to the PFD, only 24 people were transported by ambulance. Only 3 of the 43 people with serious injuries had an ambulance transport chart showing they were transported to the hospital by ambulance. In addition, the injured were unevenly distributed across nearby trauma centers and hospitals; the trauma center at Temple University Hospital received at least 43 patients. (See figure 10 and compare with figure 11.)[49] As explained later in this section, overutilizing some hospitals while leaving others underutilized is not ideal for treatment of accident victims or other patients.

[49] Figure 10 compares the number of patients who went to each facility with serious injuries, minor injuries, and none. The category "none" denotes patients who went to the hospital but were released after a determination that they had no injuries.

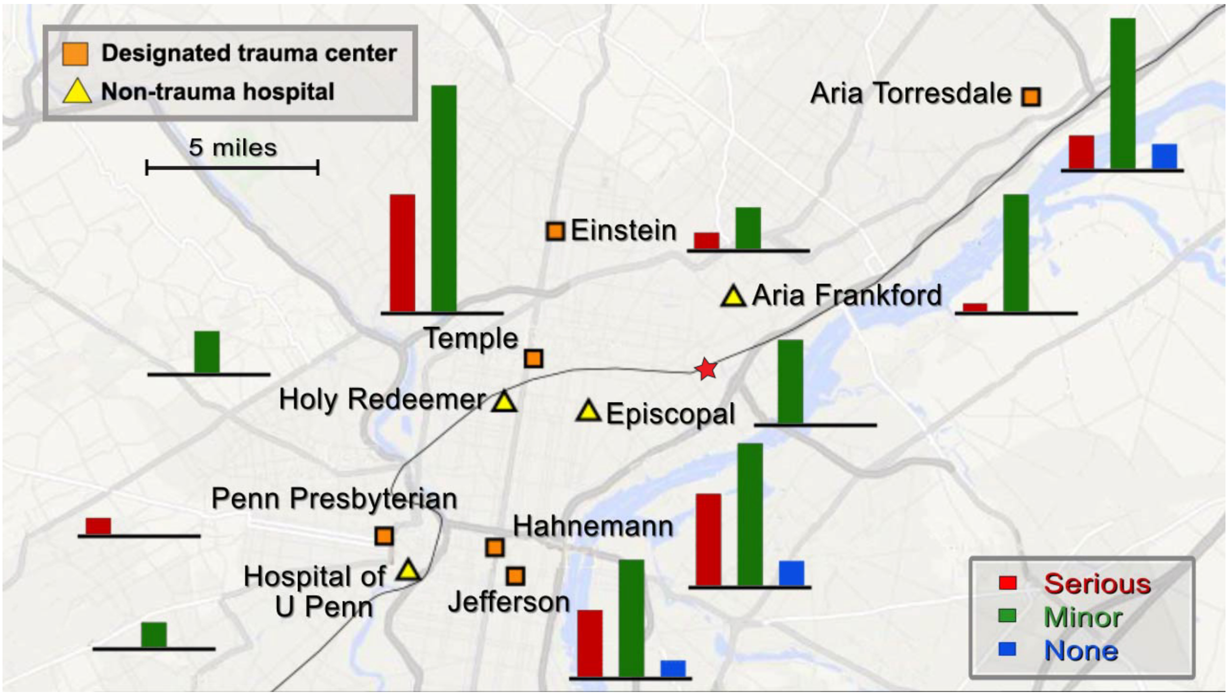


**Figure 10.** Map of hospitals near derailment and accident patients treated as of 1:30 a.m. the night of the accident.

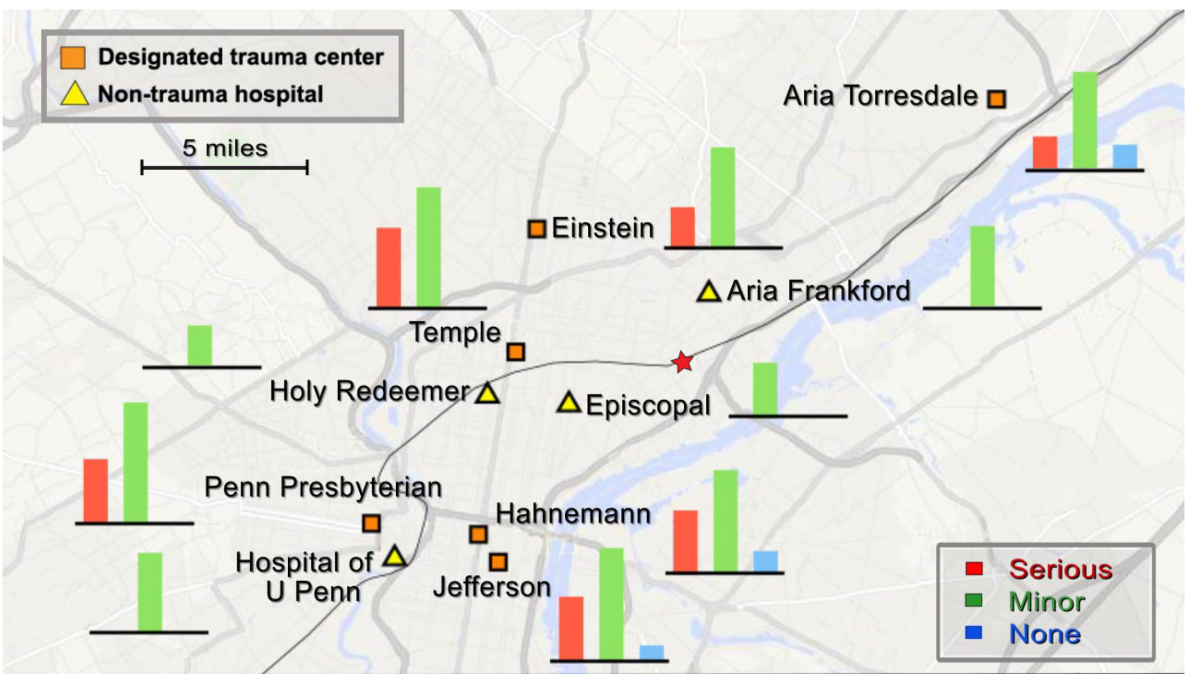


**Figure 11.** Map of hospitals near derailment and more even distribution of accident patients.

An MCI is defined as a situation in which the number of injured people surpasses the immediately available medical resources. In the area surrounding the accident site, there are five

Level I adult trauma centers (Einstein Medical Center, Hahnemann University Hospital, Thomas Jefferson University Hospital, Penn Presbyterian Medical Center, and Temple University Hospital) within 8 miles and a Level II adult trauma center (Aria Health Torresdale) about 12 miles away. Temple University Hospital and Aria Health Frankford (not a trauma hospital) are the closest medical facilities; both are within 3 miles of the accident site.[50]

In an MCI, the goals for EMS are to triage, treat, and transport the injured as expeditiously as possible within the incident command system. EMS personnel are trained to perform an initial, quick triage of patients in an MCI. According to the PFD's operational procedure, EMS uses the Simple Triage and Rapid Transport method in which patients are evaluated and classified as follows:

- An injured person who is walking and talking is classified as priority 3 or green.
- A person who cannot walk but is breathing normally, is not in shock, and is following commands is classified as priority 2 or yellow.
- A person who cannot walk and has signs of respiratory distress or shock or cannot follow commands is classified as priority 1 or red.[51]

After evaluating the injured, EMS must then get them to the appropriate level of medical care as expeditiously as possible. Traditionally, red patients are transported first, followed by yellow, and then green. Generally, patients classified as red and yellow will require expert care in a Level I or II trauma center.[52] In order for a hospital to respond appropriately to an influx of seriously injured patients, each needing this level of resources, the staff must be drawn from outside the hospital or from the care of other patients.

At the beginning of an MCI, hospitals are notified of the event by a 911 center or other local authority, and each hospital reports how many critical (red and yellow) and minor (green) patients they can reasonably handle.[53]

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[50] Level I trauma centers provide multidisciplinary treatment and specialized resources for at least 600 major trauma patients a year, perform trauma research, and train surgeons. Level II trauma centers provide similar medical services to at least 350 major trauma patients a year, but they do not perform research and training. Level III trauma centers may care for moderately injured trauma patients. Level III and IV trauma centers have the capacity to stabilize and transfer seriously injured patients to a higher level of trauma care.

[51] This is the method detailed in the Philadelphia Fire Department OPS-35 for an MCI response.

[52] On arrival at a Level I or II trauma center, each patient classified as red or yellow generally merits activation of the trauma team, which typically consists of at least a trauma surgeon, an anesthesiologist, an emergency physician, a radiology technician, a respiratory technician, and multiple nurses. Additional personnel may include lab or blood bank personnel and various trainees (doctors, nurses, technicians, and students). In addition, the operating room must be prepared and various specialists (such as neurosurgeons and orthopedic surgeons) are notified to prepare for urgent consultation.

[53] A number of issues affect each hospital's response, such as the number of operating rooms that can be opened; the number of intensive care, ward, and emergency department beds that are available; and the number of staff that are available. Hospitals may activate their internal disaster response to ensure there are enough appropriate staff to respond to the expected influx of patients. This often means holding staff over at the end of a shift, calling the next shift in early, and calling in "on call" staff and physicians. However, while staff can be held over or called

Within a hospital, the response to an MCI affects patients other than those injured in the MCI. Existing patients being treated in emergency departments may be transferred to inpatient beds before their evaluations are complete. Scheduled procedures or surgeries may be delayed or postponed to ensure sufficient staff, procedural beds, and intensive care beds are available to care for the acutely injured MCI victims. In addition, some outpatients with an urgent medical problem unrelated to the MCI who might normally go to a particular hospital may choose to delay their visit or to go elsewhere. Thus, when hospital resources become overwhelmed, some patients are inevitably forced to wait for care.

It is difficult to directly measure risks to other patients during an MCI. However, research shows that 30-day outcomes are worse for patients with chest pain and possible coronary syndromes who arrive at an emergency department simultaneously with a patient requiring a trauma team activation, compared to those arriving during periods without a trauma activation.[54] In addition, emergency department overcrowding (essentially, more patients in the emergency department than beds, with prolonged waiting times for patients in the waiting room) is associated with treatment delays for severe pain and pneumonia and worse cardiovascular outcomes for patients with chest pain.[55] Emergency department overcrowding is more likely when the number of injured patients arriving from an MCI surpasses the hospital's triage, registration, and treatment capacity. Therefore, the NTSB concludes that matching patient arrival to hospital capacity in an MCI is crucial to ensuring optimal care can be provided for all patients.

During the transport phase of the EMS response to an MCI, a transport coordinator (the exact title may vary) is designated to coordinate transport for all patients to ensure the patient load does not overwhelm any one hospital's ability to care for the injured. Depending on the size of the MCI and local resources, the transport coordinator may be located on scene or in a dispatch center. Typically, in addition to information regarding the status of individual patients, there is two-way communication between the transport coordinator and the hospitals during the transport phase, as some patients may arrive on foot or be transported by family, friends, or bystanders. Hospitals can better prepare for individual patients if they know something about the type and degree of the patient's injuries before the patient arrives. This information begins with the transport coordinator and is expanded upon by communication from the transporting EMS providers during the ride to the hospital.

In the United States, patients with significant traumatic injury are usually evaluated, treated, and transported to a trauma center by EMS. However, sometimes the injured are

in to increase personnel, some resources are static. For example, only so many computed tomography (CT) scanners, ventilators, and ultrasound machines are available. Information about the initial hospital capacity reports during the response to this accident is not permanently retained and was no longer available when the NTSB requested it.

[54] Fishman PE, Shofer FS, Robey JL, Zogby KE, Reilly PM, Branas CC, Pines JM, Hollander JE, "The impact of trauma activations on the care of emergency department patients with potential acute coronary syndromes," *Annals of Emergency Medicine* 48, no. 4 (2006):347–53.

[55] (1) Pines JM, Pollack CV Jr, Diercks DB, Chang AM, Shofer FS, Hollander JE, "The association between emergency department crowding and adverse cardiovascular outcomes in patients with chest pain," *Academic Emergency Medicine* 16, no. 7 (2009):617–25. (2) Pines JM, Localio AR, Hollander JE, Baxt WG, Lee H, Phillips C, Metlay JP "The impact of emergency department crowding measures on time to antibiotics for patients with community-acquired pneumonia," *Annals of Emergency Medicine* 50, no. 5 (2007):510–6. (3) Pines JM, Hollander JE, "Emergency department crowding is associated with poor care for patients with severe pain," *Annals of Emergency Medicine* 51, no. 1 (2008):1–5.

transported to the hospital by family, friends, bystanders, or police—generally without medical care being provided. According to several studies, arriving at a trauma center by personal or police vehicle does not increase, and may decrease, mortality for patients with blunt or penetrating trauma.[56]

For more than 25 years, it has been routine in Philadelphia for police officers to transport injured patients from the scene to the hospital without waiting for an ambulance to arrive. Most often, these are victims of gunshots and stab wounds, and they are transported without medical care on the way. Research in Philadelphia has demonstrated that the mode of hospital arrival does not negatively influence the victim's chance of survival.[57]

In this accident, the majority of patients were transported by police vehicles or SEPTA buses without medical care on the way to the hospital. While some patients may have been triaged by EMS, most were not. As is the PPD's routine practice, the police officer driving the vehicle chose the destination. In at least one case, this meant a critically injured person was transported to a nontrauma hospital (Aria Health Frankford) and then had to be transferred to a higher level of care. Other patients may have experienced significant discomfort as they were transported by police vehicle or SEPTA bus with multiple broken bones. However, this investigation did not identify any negative health outcomes as a result of the means of transportation.

Consistent with the PPD's routine practice, police dispatch notified the hospital of the number of patients en route without providing vital signs, injury descriptions, or other medical details that would have been communicated if the patients were being transported by EMS. Nor did the police department communicate with EMS personnel regarding the destinations of the patients they transported. This resulted in at least 43 people arriving at Temple University Hospital and no patients arriving at Penn Presbyterian Medical Center directly from the scene, although the distance was similar and both are Level I trauma centers. (Two patients with serious injuries were subsequently transferred to Penn Presbyterian Medical Center from other facilities.) Passenger interviews described at least one police vehicle arriving at Temple University Hospital only to be waved off to another hospital before any of the injured got out of the car. The NTSB concludes that as a result of victims being transported to hospitals without coordination, some hospitals were overutilized while others were significantly underutilized during the response to the derailment.

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[56] (1) Cornwell EE 3rd, Belzberg H, Hennigan K, Maxson C, Montoya G, Rosenbluth A, Velmahos GC, Berne TC, Demetriades D, "Emergency medical services (EMS) vs non-EMS transport of critically injured patients: a prospective evaluation," *Archives of Surgery* 135, vol. 3 (2000):315–9. (2) Demetriades D, Chan L, Cornwell E, Belzberg H, Berne TV, Asensio J, Chan D, Eckstein M, Alo K, "Paramedic vs private transportation of trauma patients. Effect on outcome," *Archives of Surgery* 131, no. 2 (1996):133–8. (3) Branas CC, Sing RF, Davidson SJ, "Urban trauma transport of assaulted patients using nonmedical personnel," *Academic Emergency Medicine* 2, no. 6 (1995):486–93. (4) Aurora Century 16 Theater Shooting After Action Report for the City of Aurora, Colorado. 2014 https://www.auroragov.org/CityHall/StatsReportsandSurveys/025372, accessed February 9, 2016.

[57] (1) Band RA, Pryor JP, Gaieski DF, Dickinson ET, Cummings D, Carr BG, "Injury-adjusted mortality of patients transported by police following penetrating trauma," *Academic Emergency Medicine* 18, no. 1 (2011):32–7. (2) Branas CC, Sing RF, Davidson SJ, "Urban trauma transport of assaulted patients using nonmedical personnel," *Academic Emergency Medicine* 2, no. 6 (1995):486–93.

This derailment was not the first time a majority of patients were transported by police vehicles during an MCI. According to the after-action report following the shooting of 70 people in a movie theater in Aurora, Colorado, police officers and a paramedic independently chose to utilize police vehicles to transport injured survivors when ambulances were unable to get close to patients because of traffic and pedestrian congestion. Of the 60 people who reached the hospital, 27 were transported in police vehicles, 20 by ambulance, and the remainder by private vehicle or on foot. The use of police vehicles in that situation was unplanned, but the swift transport was credited with saving at least two lives. All injured survivors were transported from the scene within 52 minutes.[58]

EMS transport in MCIs typically requires staging ambulances and removes all of the involved ambulances from use by the rest of the community for the duration of the MCI. This may mean the response times for 911 calls for unrelated medical assistance become delayed. While most communities have a complex web of nearby agencies they can call upon for mutual aid, adding to the pool of available EMS transportation, using these resources may increase the size of the population with temporarily diminished access to EMS resources. On the other hand, using police vehicles to transport the injured increases transport resources and likely means the scene will be cleared of injured persons more quickly. For example, following the derailment of train 188, records show the first person was registered at the hospital at 9:57 p.m., the same time on-scene triage stations became operational. Therefore, the NTSB concludes that transportation of injured victims by police or other municipal vehicles early in an MCI may be a reasonable use of resources.

However, successful use of police transport in an MCI requires integration of police into patient transport coordination and the incident command system. This did not occur during the response to the derailment of train 188. One reason is the divide between the PPD and the PFD/EMS personnel. Each department has its own command structure and policies (described below), which do not align with one another. In addition, PPD and PFD personnel are dispatched through separate dispatch centers (known locally as the police radio and the Fire Communications Center) that do not routinely communicate with each other.

Prior to this accident, in the PFD policy on MCI response, the only mention of police was to coordinate with the police to: establish a perimeter, identify a staging area for transport vehicles, and allow patients triaged as green to be transported using nontraditional means such as a SEPTA or school bus, private ambulances, or police wagons. However, these green patients were to be accompanied by at least one certified EMT or paramedic.[59] Following the accident, the PFD updated its policy (September 2015) to state,

> Police vehicles will only be used for patient transportation with the permission of the EMS Branch Director or Patient Transportation Group Supervisor [the transport coordinator]. Only patients who have been properly assessed and triaged as Priority 3 [green] will be transported by police. The Transportation Group Supervisor in consultation with the Medical Communications Coordinator will

[58] Aurora Century 16 Theater Shooting After Action Report for the City of Aurora, Colorado. 2014 https://www.auroragov.org/CityHall/StatsReportsandSurveys/025372 Accessed February 9, 2016.

[59] PFD Operational Procedure: Multiple Patient/Mass Casualty Incidents (OPS-35-11. June 2011).

> ensure that those patients are transported to appropriate facilities for minor treatment and not sent to Trauma Centers or hospitals in close proximity to the event. To facilitate communication with police vehicles a police supervisor will be requested and should be assigned to the Transportation Group to allow for direct communications with police units.[60]

The Philadelphia OEM included similar language in its draft updated citywide mass casualty plan. Meanwhile, the PPD directive 3.14 states, "Police personnel assigned to radio patrol cars will, whenever possible, without detriment to the person, handle hospital cases to ensure availability of emergency patrol wagons for other assignments." Hospital cases are injured or medically ill individuals. The directive further specifies that hospital cases with "a serious penetrating wound or a blunt trauma to the body will be transported to the nearest accredited trauma center."[61] However, it later specifies that "persons suffering from blunt trauma or a violent injury to the body (e.g., closed trauma to the head or chest as may result from a motor vehicle accident or a fall)" should be transported by fire department paramedics. There is no PPD policy regarding transportation of injured victims in an MCI or describing the command-level participation with PFD regarding patient transport. Of note, Philadelphia OEM has not finalized its after-action report following this accident.

It is noteworthy that the current PFD policy specifies police will not transport patients in an MCI without being asked to do so by an assigned incident supervisor from the PFD, but the PPD has no corresponding policy. In addition, the PPD routinely transports injured patients from the scene before EMS arrives. However, the current PFD policy and updated draft OEM policy quoted above, which were developed following this accident, may not optimize the use of PPD resources. Specifically, they require police officers to change their routine and delay transporting hospital cases in the event of an MCI, thus restricting their ability to provide more rapid transport to many patients than they would otherwise have received.

While the response to the MCI resulting from the derailment of train 188 used the structure of the National Incident Management System, the individual agency response plans had not been customized to address daily operations that allow police officers to independently transport injured patients to hospitals. As a result, transport of the injured was not coordinated after the derailment. As noted above, the Philadelphia OEM has developed an updated citywide mass casualty plan, but, as of the date of this report, it remains a draft, just as it was on the day of the accident. The previous plan, from May 2011, includes several systems that are no longer in use in Philadelphia, including the facilities and resources emergency database. The 2011 plan, which remains in effect, states that responsibility for patient transport belongs to the PFD and that "patient transport from the incident scene to hospital will be provided by ambulances, helicopters, buses, and other available resources." The NTSB concludes that current Philadelphia Police Department, Philadelphia Fire Department, and Philadelphia Office of Emergency Management policies regarding transport of patients in an MCI were not, and still are not, integrated.

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[60] PFD Operational Procedure: Multiple Patient/Mass Casualty Incidents (OPS-35-15. September 2015).

[61] PFD. Directive 3.14. Hospital Cases. Updated 12-17-01.

Therefore, the NTSB recommends that the PPD, the PFD, and the OEM collaborate and develop a plan that effectively integrates rapid police transport of patients into the emergency medical response plans for large mass casualty incidents, including a means of coordinating hospital destinations regardless of the method of transport (R-16-39). Having an MCI response plan that integrates police, fire, and EMS activities is only the first step. It takes practice for the plan to function in the real world. Therefore, the NTSB recommends to the PPD, the PFD, and the OEM that, once the plan specified in Safety Recommendation R-16-39 is developed, they practice the plan periodically, including at least one full-scale drill every 3 years, to ensure that it functions as intended. Because all three of these agencies report to the mayor, the NTSB further recommends that the mayor of the city of Philadelphia facilitate the collaboration among the PPD, the PFD, and the OEM to develop a plan that effectively integrates police transport of patients into the emergency medical response plans for large mass casualty incidents and to practice the plan periodically, including at least one full-scale drill every 3 years. While the principles of MCI response apply to all such events, the management of each event differs in scope, potential risks to first responders, hospital availability (based on geography and capacity), and transport options. Although complicated by the lack of transport coordination, this accident and the response to the movie theater shooting in Aurora, Colorado, demonstrate the utility of using police vehicles to provide patient transport during an MCI, essentially becoming a force multiplier for EMS. This is a concept other municipalities may want to consider incorporating into their mass casualty plans. Therefore, the NTSB recommends that the National Association of State EMS Officials, the National Volunteer Fire Council, the National Emergency Management Association, the National Association of EMS Physicians, the International Association of Chiefs of Police, and the International Association of Fire Chiefs educate their members regarding the details of this accident, including the lessons learned from the emergency medical response, and the potential utility of integrating police transport of victims into mass casualty incident response plans.

### 1.9.3 Amtrak's Passenger Accountability System

On April 18, 2002, an Amtrak auto train derailed on CSXT track near Crescent City, Florida.[62] At the time of the accident and for several months following the accident Amtrak erroneously reported the number of people on board as 468. In fact, the train was carrying 446 people, but this was not apparent from the paper, on-board record system Amtrak was using at that time. The NTSB noted the importance of a complete and accurate accounting of all people on the train to ensure that emergency responders locate, evacuate, and treat all of the victims and ensure that emergency responders are not exposed to needless risk searching for people who were not on board. As a result, the NTSB issued Safety Recommendation R-03-10 to Amtrak:

> Develop and implement an accurate passenger and crew accountability system for all Amtrak long-distance, overnight, and reserved trains that will immediately provide an accurate count of the people on board the train in case of emergency.

In 2012, Amtrak implemented its electronic ticketing (eTicketing) for mobile devices on all trains. Amtrak acknowledged that because of passenger autonomy and the fluidity of rail

[62] National Transportation Safety Board, *Derailment of Amtrak Auto Train P052-18 on the CSXT Railroad, near Crescent City, Florida, April 18, 2002,* Railroad Accident Report RAR-03/02 (Washington, DC: NTSB, 2003).

travel, no passenger accountability system could be perfect. The NTSB concluded that the eTicketing system is the best one possible, given current logistics and technology, and classified Safety Recommendation R-03-10 “Closed—Acceptable Alternate Action.”

The NTSB is pleased that the eTicketing system worked well in this accident. Accountability for passengers was significantly improved when compared to the difficulties encountered after the Crescent City accident.

## 1.10 Factors Not Contributing to This Accident

The locomotive and the passenger cars passed postaccident mechanical inspections. A review of preaccident testing and maintenance records did not reveal any defects. Although it was night, the weather at the time of the accident was clear with good visibility. The engineer did not recall or report the locomotive being struck by an object prior to the derailment, and FBI testing showed no evidence of ballistic material. Postaccident toxicological tests for crewmembers were negative for alcohol and other drugs. Postaccident testing and examination of the engineer did not identify any medical conditions that would have interfered with train operation. There was no evidence of cell phone use by the engineer during the accident trip. Further, the on-duty/off-duty schedule provided adequate time for the employees to obtain rest.

Investigators examined the records for track inspections and maintenance. The undamaged track was examined during the on-scene investigation. The track was inspected and maintained within regulatory standards, and no track anomalies were discovered after the derailment.

The NTSB concludes that none of the following was a factor in this accident: the mechanical condition of the train; a foreign object striking the locomotive; the condition of the track; the weather; medical conditions of the Amtrak engineer; alcohol, other drugs, or any other type of impairment; cell phone use; and fatigue.

# 2 Postaccident Actions

## 2.1 NTSB Recommendations

The engineer's inability to report what happened in the moments before the accident presented a challenge to investigators. Inward-facing audio and image recorders in the cab would have provided important information in this case—and many others—to assist investigators in understanding what happened. Such cameras are installed on some trains and have assisted the NTSB in recent investigations. As a result, on July 8, 2015, the NTSB issued the following recommendations to Amtrak:

R-15-28

> Install, in all controlling locomotive cabs and cab car operating compartments, crash- and fire-protected inward-and outward-facing audio and image recorders capable of providing recordings to verify that train crew actions are in accordance with rules and procedures that are essential to safety as well as train operating conditions. The devices should have a minimum 12-hour continuous recording capability with recordings that are easily accessible for review, with appropriate limitations on public release, for the investigation of accidents or for use by management in carrying out efficiency testing and systemwide performance monitoring programs

R-15-29

> Semi-annually, issue a public report detailing Amtrak's progress in installing crash- and fire-protected inward- and outward-facing audio and image recorders. The report should include the number of locomotives and cab car operating compartments that have been equipped with the recorders, as well as the number of locomotives and cab car operating compartments in Amtrak's fleet that still lack those devices

R-15-30

> Regularly review and use in-cab audio and image recordings in conjunction with other performance data to verify crewmember actions are in accordance with rules and procedures that are essential to safety.

In a letter dated March 10, 2016, Amtrak reported that it had installed inward-facing video cameras meeting the specifications in the recommendation on its current fleet of 57 ACS-64 locomotives and that it continues to install them throughout the fleet. Amtrak stated it was planning to install crash-hardened units incorporating event recorders on its fleet and would release another installation progress report in October 2016. Amtrak also stated it had developed a policy for the use of data obtained by inward- and outward-facing audio and image recorders. On the basis of this response, recommendations R-15-28 through -30 are classified "Open—Acceptable Response."

As a result of this accident, on July 8, 2015, the NTSB also reiterated the following previously issued recommendations to the FRA asking it to require inward-facing cameras:

<u>R-10-1</u>

> Require the installation, in all controlling locomotive cabs and cab car operating compartments, of crash- and fire-protected inward- and outward-facing audio and image recorders capable of providing recordings to verify that train crew actions are in accordance with rules and procedures that are essential to safety as well as train operating conditions. The devices should have a minimum 12-hour continuous recording capability with recordings that are easily accessible for review, with appropriate limitations on public release, for the investigation of accidents or for use by management in carrying out efficiency testing and systemwide performance monitoring programs.

<u>R-10-2</u>

> Require that railroads regularly review and use in-cab audio and image recordings (with appropriate limitations on public release), in conjunction with other performance data, to verify that train crew actions are in accordance with rules and procedures that are essential to safety.

Safety Recommendations R-10-1 and -2 are classified “Open—Acceptable Response” based on the FRA’s stated intention to issue an NPRM to mandate installation of video cameras. The NTSB noted in its reply to the FRA that in order to satisfy the recommendation both video and audio would need to be required.

The NTSB notes that the recently passed FAST Act requires installation of image recorders on all passenger trains. Specifically, section 11411 states the following about the installation of audio and image recording devices:

> (a) **IN GENERAL**: Not later than 2 years after the date of enactment of the Passenger Rail Reform and Investment Act of 2015, the Secretary of Transportation shall promulgate regulations to require each railroad carrier that provides regularly scheduled intercity rail passenger or commuter rail passenger transportation to the public to install inward- and outward-facing image recording devices in all controlling locomotive cabs and cab car operating compartments in such passenger trains.
>
> (b) **DEVICE STANDARDS**: Each inward- and outward-facing image recording device shall
>
> (1) have a minimum 12-hour continuous recording capability;
>
> (2) have crash and fire protections for any in-cab image recordings that are stored only within a controlling locomotive cab or cab car operating compartment; and

(3) have recordings accessible for review during an accident or incident investigation.

(c) **REVIEW**: The Secretary shall establish a process to review and approve or disapprove an inward- or outward-facing image recording device for compliance with the standards described in subsection (b).

(d) **USES**: A railroad carrier subject to the requirements of subsection (a) that has installed an inward- or outward-facing image recording device approved under subsection (c) may use recordings from that inward- or outward-facing image recording device for the following purposes:

(1) Verifying that train crew actions are in accordance with applicable safety laws and the railroad carrier's operating rules and procedures, including a system-wide program for such verification.

(2) Assisting in an investigation into the causation of a reportable accident or incident.

(3) Documenting a criminal act or monitoring unauthorized occupancy of the controlling locomotive cab or car operating compartment.

(4) Other purposes that the Secretary considers appropriate.

(e) **DISCRETION**:

(1) **IN GENERAL**: The secretary may:

(A) require in-cab audio recording devices for the purposes described in subsection (d); and

(B) define in appropriate technical detail the essential features of the devices required under subparagraph (A).

(2) **EXEMPTIONS**: The Secretary may exempt any railroad carrier subject to the requirements of subsection (a) or any part of the carrier's operations from the requirements under subsection (a) if the Secretary determines that the carrier has implemented an alternative technology or practice that provides an equivalent or greater safety benefit or that is better suited to the risks of the operation.

## 2.2 FRA Emergency Order

On May 21, 2015, the FRA issued Emergency Order No. 31, Notice No. 1, requiring Amtrak to take the following actions to control passenger train speed at certain locations on main line track in the Northeast Corridor: (1) immediately implement code changes to its ATC system to enforce the passenger train speed limit ahead of the curve at Frankford Junction; (2) identify each main track curve on the Northeast Corridor where there is a significant reduction (more than 20 mph) from the maximum authorized approach speed to those curves for passenger trains, and develop and comply with an FRA-approved action plan to modify its existing ATC system or other signal systems to enable enforcement of passenger train speed limits at the identified curves (unless PTC was already operational for that portion of track); and (3) install additional wayside passenger train speed limit signage at appropriate locations on its Northeast Corridor right-of-way.[63]

## 2.3 Amtrak

**Inward-facing cameras.** In May 2016 Amtrak reported that it has installed inward-facing video cameras on its current fleet of ACS-64 locomotives and that 65 of its 70 locomotives on the Northeast Corridor are operating with these cameras. Amtrak states it is expecting the remaining ACS-64 locomotives to be equipped with such cameras in 2016. Amtrak plans to complete installation of inward-facing video cameras on its entire fleet by the end of 2018.

**Speed restrictions.** Prior to issuance of FRA Emergency Order 31, Amtrak had already made the necessary ATC code changes to enforce the eastbound speed restriction at Frankford Junction. Amtrak also complied with FRA Emergency Order 31 by identifying curves with significant speed reductions, implementing speed enforcement at those curves in accordance with a curve mitigation plan, and installing additional speed limit signage.

**Positive Train Control.** As discussed in section 1.5.1, in December 2015 Amtrak completed the installation and implementation of PTC on all Amtrak-owned property along its Northeast Corridor that is required to be PTC-equipped.[64] Amtrak also activated the PTC system on the 104-mile Harrisburg line. Amtrak also reports it is working on installation of PTC on other lines, including the 60-mile Springfield line, the 105-mile Hudson line between Poughkeepsie and the Schenectady area (leased by Amtrak), and the 135-mile Dearborn-Kalamazoo segment of the Michigan line owned by Michigan, as well as the Chicago Union Station and New Orleans terminal areas.

[63] *Federal Register* 80, no. 102 (May 28, 2015): 30534.

[64] As noted previously, some Northeast Corridor track owned by Metro North and Long Island Railroad is not PTC-equipped. Amtrak also installed a PTC system on a portion of its track in Michigan.

# 3. Conclusions

## 3.1 Findings

1. None of the following was a factor in this accident: the mechanical condition of the train; a foreign object striking the locomotive; the condition of the track; the weather; medical conditions of the Amtrak engineer; alcohol, other drugs, or any other type of impairment; cell phone use; and fatigue.

2. The Amtrak engineer initially accelerated his train to a high rate of speed in a manner consistent with how he habitually manipulated the controls when accelerating to a target speed, suggesting that he was actively operating the train rather than incapacitated moments before the accident.

3. The Amtrak engineer accelerated the train to 106 mph without slowing the train for the curve at Frankford Junction, due to his loss of situational awareness, likely because his attention was diverted to the emergency situation with the SEPTA train.

4. Training focusing on prospective memory strategies for prolonged, atypical situations that could divert crewmember attention may help operating crews become aware of, and take measures to avoid, errors due to memory failure.

5. Cab signal protection to enforce the 50 mph speed restriction in the eastbound direction at Frankford Junction or a fully implemented positive train control system would have prevented the accident.

6. The Federal Railroad Administration accident database is inadequate for comparing relevant accident rates based on crew size because the information about accident circumstances and number of crewmembers in the controlling cab is insufficient.

7. If the passenger car windows had remained intact and secured in the cars, some passengers would not have been ejected and would likely have survived the accident.

8. Passengers were seriously injured by being thrown from their seats when the passenger cars overturned.

9. Although the passenger equipment safety standards in Title 49 *Code of Federal Regulations* Part 238 provide some level of protection for occupants, the current requirements are not adequate to ensure that occupants are protected in some types of accidents.

10. Matching patient arrival to hospital capacity in a mass casualty incident is crucial to ensuring optimal care can be provided for all patients.

11. As a result of victims being transported to hospitals without coordination, some hospitals were overutilized while others were significantly underutilized during the response to the derailment.

12. Transportation of injured victims by police or other municipal vehicles early in a mass casualty incident may be a reasonable use of resources.

13. Current Philadelphia Police Department, Philadelphia Fire Department, and Philadelphia Office of Emergency Management policies regarding transport of patients in a mass casualty incident were not, and still are not, integrated.

## 3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of the accident was the engineer's acceleration to 106 mph as he entered a curve with a 50 mph speed restriction, due to his loss of situational awareness likely because his attention was diverted to an emergency situation with another train. Contributing to the accident was the lack of a positive train control system. Contributing to the severity of the injuries were the inadequate requirements for occupant protection in the event of a train overturning.

# 4 Recommendations

## 4.1 New Recommendations

Based on its investigation, the National Transportation Safety Board issues the following new safety recommendations:

**To the Federal Railroad Administration:**

> Require railroads to install devices and develop procedures that will help crewmembers identify their current location and display their upcoming route in territories where positive train control will not be implemented. (R-16-32)
>
> Modify form 6180.54 (Rail Equipment Accident/Incident Report) to include the number of crewmembers in the controlling cab of the train at the time of an accident. (R-16-33)
>
> After form 6180.54 is modified as specified in Safety Recommendation R-16-33, use the data regarding number of crewmembers in the controlling cab of the train at the time of an accident to evaluate the safety adequacy of current crew size regulations. (R-16-34)
>
> Conduct research to evaluate the causes of passenger injuries in passenger railcar derailments and overturns and evaluate potential methods for mitigating those injuries, such as installing seat belts in railcars and securing potential projectiles. (R-16-35)
>
> When the research specified in Safety Recommendation R-16-35 identifies safety improvements, use the findings to develop occupant protection standards for passenger railcars that will mitigate passenger injuries likely to occur during derailments and overturns. (R-16-36)

**To Amtrak:**

> Incorporate strategies into your initial and recurrent training for operating crewmembers for recognizing and effectively managing multiple concurrent tasks in prolonged, atypical situations to sustain their attention on current and upcoming train operations. (R-16-37)

**To the American Public Transportation Association and the Association of American Railroads:**

> Develop criteria for initial and recurrent training for operating crewmembers that reinforces strategies for recognizing and effectively managing multiple concurrent tasks and prolonged atypical situations to sustain their attention on current and

upcoming train operations, and distribute those criteria to your members. (R-16-38)

**To the Philadelphia Police Department, the Philadelphia Fire Department, and the Philadelphia Office of Emergency Management:**

Collaborate and develop a plan that effectively integrates rapid police transport of patients into the emergency medical response plans for large mass casualty incidents, including a means of coordinating hospital destinations regardless of the method of transport. (R-16-39)

Once the plan specified in Safety Recommendation R-16-39 is developed, practice the plan periodically, including at least one full-scale drill every 3 years, to ensure that it functions as intended. (R-16-40)

**To the mayor of the city of Philadelphia:**

Facilitate the collaboration among the Philadelphia Police Department, the Philadelphia Fire Department, and the Office of Emergency Management to develop a plan that effectively integrates police transport of patients into the emergency medical response plans for large mass casualty incidents and to practice the plan periodically, including at least one full-scale drill every 3 years. (R-16-41)

**To the National Association of State EMS Officials, the National Volunteer Fire Council, the National Emergency Management Association, the National Association of EMS Physicians, the International Association of Chiefs of Police, and the International Association of Fire Chiefs:**

Educate your members regarding the details of this accident, including the lessons learned from the emergency medical response, and the potential utility of integrating police transport of victims into mass casualty incident response plans. (R-16-42)

## 4.2 Previously Issued Recommendations Arising from this Accident

On July 8, 2015, the NTSB issued the following recommendations to Amtrak:

Install, in all controlling locomotive cabs and cab car operating compartments, crash- and fire-protected inward- and outward-facing audio and image recorders capable of providing recordings to verify that train crew actions are in accordance with rules and procedures that are essential to safety as well as train operating conditions. The devices should have a minimum 12-hour continuous recording capability with recordings that are easily accessible for review, with appropriate limitations on public release, for the investigation of accidents or for use by management in carrying out efficiency testing and systemwide performance monitoring programs. (R-15-28)

> Semi-annually, issue a public report detailing Amtrak's progress in installing crash- and fire-protected inward- and outward-facing audio and image recorders. The report should include the number of locomotives and cab car operating compartments that have been equipped with the recorders, as well as the number of locomotives and cab car operating compartments in Amtrak's fleet that still lack those devices. (R-15-29)

> Regularly review and use in-cab audio and image recordings in conjunction with other performance data to verify crewmember actions are in accordance with rules and procedures that are essential to safety. (R-15-30)

On July 8, 2015, the NTSB also reiterated the following previously issued recommendations to the FRA asking it to require inward-facing cameras:

R-10-1

> Require the installation, in all controlling locomotive cabs and cab car operating compartments, of crash- and fire-protected inward- and outward-facing audio and image recorders capable of providing recordings to verify that train crew actions are in accordance with rules and procedures that are essential to safety as well as train operating conditions. The devices should have a minimum 12-hour continuous recording capability with recordings that are easily accessible for review, with appropriate limitations on public release, for the investigation of accidents or for use by management in carrying out efficiency testing and system wide performance monitoring programs.

R-10-2

> Require that railroads regularly review and use in-cab audio and image recordings (with appropriate limitations on public release), in conjunction with other performance data, to verify that train crew actions are in accordance with rules and procedures that are essential to safety.

## 4.3 Previously Issued Recommendation Reiterated in this Report

**To the Federal Railroad Administration:**

R-14-74

> Develop a performance standard to ensure that windows (e.g., glazing, gaskets, and any retention hardware) are retained in the window opening structure during an accident and incorporate the standard into 49 *Code of Federal Regulations* (*CFR*) 238.221 and 49 *CFR* 238.421 to require that passenger railcars meet this standard.

## 4.4 Previously-Issued Recommendations Classified in this Report

Safety recommendations R-15-28 through -30 are classified “Open—Acceptable Response” in section 2.1 of this report.

Safety Recommendation R-13-23 is classified “Closed—Acceptable Alternate Action” in section 1.5.1 of this report.

## BY THE NATIONAL TRANSPORTATION SAFETY BOARD

**CHRISTOPHER A. HART**
Chairman

**ROBERT L. SUMWALT**
Member

**T. BELLA DINH-ZARR**
Vice Chairman

**EARL F. WEENER**
Member

**Adopted: May 17, 2016**

Chairman Hart, Vice Chairman Dinh-Zarr, and Member Sumwalt filed the following statements.

# Board Member Statements

**Chairman Christopher A. Hart filed the following concurring statement on May 20, 2016.**

I concur with the findings, probable cause, and recommendations in this report, and I would like to comment on what this accident demonstrated not only about the importance of Positive Train Control (PTC), but also the importance of how PTC is implemented.

<u>PTC</u>. This accident demonstrated once again that PTC can save lives. Our investigators explored all of the usual suspects regarding the engineer's condition – fatigue, impairment from alcohol or other drugs, and cellphone use – and found none of them. However, we have investigated many accidents in which an operator's thought processes were interrupted, and even when a checklist was being used, the thought processes missed a step or two because of the interruption.

This accident is reminiscent of a bus accident we investigated in which the bus driver was distracted by looking into her rear view mirror to determine if it was safe to change lanes – which is certainly important in order to change lanes safely – only to crash into vehicles that had stopped in front of her. In Amtrak 188, it was not only appropriate but required for the engineer to pay attention to the disabled train, to determine, among other things, if he needed to slow down and/or sound his horn while passing that train. By process of elimination, we concluded that the distraction of the engineer diverting his attention to the disabled train interrupted his thought processes and caused him to lose situational awareness.

The engineer was distracted, but the distraction was about something that he had a duty to take care of – passing the disabled train safely. This demonstrates once again that even when a person is competent (as he was, with extensive experience on the route and an unblemished record), not fatigued, not impaired, and not using his cell phone, he or she is still fallible, even on his or her best day.

PTC is crucial, and we have recommended it, or something like it, for more than 45 years, because it is a backup, a safety net, for inevitable human fallibility.

<u>Implementation of PTC</u>. Having said that, we have also investigated accidents that demonstrated that introducing automation into a complex human-centric situation can present many challenges. Those challenges can be exacerbated when, as here, the automation is partial instead of complete. In this instance, the curve where the derailment occurred had automatic speed protection in one direction, but there was no speed protection for trains going in the direction of Amtrak 188.

Amtrak explained this speed protection disparity by noting that the permitted speed limit approaching the curve in the other direction exceeded the derailment speed, whereas the permitted speed limit approaching the curve in this direction was less than the derailment speed. Experience has shown, however, that partial automation can be more dangerous than no automation at all.

In this case, assuming that the Amtrak 188 engineer knew about the existence of speed protection on curves on this route, query whether he also knew that this particular curve did not have speed protection; and if not, query whether the presence of speed protection on some of the curves had the unintended consequence of making him less vigilant about his speed on any curves.

This accident demonstrated that PTC is very important and can save lives, but it must be introduced carefully in order to avoid unintended consequences.

Member Weener joined in this statement.

**Vice Chairman T. Bella Dinh-Zarr filed the following statement concurring in part and dissenting in part on May 24, 2016.**

While I concur with the findings, recommendations, and overall report, I disagree with the probable cause. The report states that the NTSB "determines that the probable cause of the accident was the engineer's acceleration to 106 mph as he entered a curve with a 50 mph speed restriction, due to his loss of situational awareness because his attention was likely diverted to an emergency situation with another train." The lack of Positive Train Control (PTC) is listed later as a contributing factor to the probable cause. I strongly believe that PTC should be included in the main probable cause statement, along with the engineer's overspeeding.

Time and time again, in the accidents we investigate, the biggest safety challenge we find is human error, which is an area where technology can be very helpful. PTC is a safety system that uses technology to prevent overspeed derailments, among other accidents. We know that PTC is a backup system – the engineer is still in control, but we also know that PTC is a known, accepted, and implementable safety intervention that should have been in place. The NTSB has been recommending automated and positive train control systems since 1970. Since 2004 alone, the NTSB has investigated 30 PTC-preventable freight and passenger rail accidents in which 69 people died and more than 1,200 were injured – Chatsworth, Two Harbors, Red Oak, Mineral Springs, Hoboken, Westville, Chaffee, and the Bronx to name a few. In each of these accidents, the NTSB concluded that PTC would have provided critical redundancy that would have prevented the accident. But at the same time, in these accidents, we found that the lack of PTC was merely a contributing cause – rather than the main probable cause and instead placed the probable cause on the engineer's actions.

In this accident in Philadelphia last year, eight people died and many dozens have life-changing injuries because the government and industry failed to act for decades on a well-known safety hazard. So, why does our probable cause focus on one human's mistake and what he may have been distracted by?

I believe after more than 40 years of recommending this proven technology and after placing this issue on our NTSB Most Wanted List for 23 of the past 26 years, it is time to take a less myopic view of the probable cause in these accidents. I understand that we try to be linear and formulaic in the way that we draft probable causes – we identify the root cause and move to the broader proximate cause. However, in doing so in every situation, we are limiting our ability to highlight the importance of prevention. We are limiting ourselves by our own institutional inertia.

We look at many different frameworks in our work and I would like to point you to Haddon's Matrix, the most widely accepted framework in injury prevention. Haddon's Matrix divides prevention into Pre-Crash, Crash, and Post-Crash. Clearly, PTC is a form of Pre-Crash prevention, which is the most effective and desirable. In addition, PTC is a well-established prevention system that we have recommended and that should have been in place on that track.

Our mission is to determine the probable cause in order to prevent accidents like this one from happening again. We always try to prevent human error, but humans will make errors and we should focus on how to mitigate the damage – in this case, preventing accidents through PTC.

While the prospective memory training described in the findings may have helped avoid errors due to memory failure, this engineer still may have lost situational awareness, but PTC would have prevented this accident entirely. This focus on PTC in the probable cause is not about casting blame, but rather, it is about prevention and how we, as an agency, can make the greatest difference in public safety and public policy. The lack of PTC should have been included in the primary probable cause of this accident.

**Member Robert L. Sumwalt III filed the following concurring statement on May 20, 2016.**

In the Board Meeting, there was an interesting discussion about whether the lack of Positive Train Control (PTC) should have been included in the causal statement of the Probable Cause, or whether it should be listed as a contributing factor. The majority, including me, decided in a 3 to 1 vote that the lack of PTC should be cited as a contributing factor.

In order for something to be listed as a causal factor, in my opinion, it must be an event, failure, or circumstance that initiated the accident sequence. To say the lack of PTC initiated the tragic Amtrak 188 accident sequence would be equivalent to saying that the cause of a tightrope walker's fatal plunge was the lack of a safety net below him. When it comes to railroad safety, that's precisely what PTC is –a safety net to trap errors, not by a tightrope walker in this case, but by a locomotive engineer.

That said, it's important to note that I do not believe only human errors committed by front line employees should be listed in the causal statement, or that issues such as organizational factors or lack of regulatory oversight should be relegated to contributing factors. To the contrary, there have been several accidents where I have pushed to have these factors listed in the causal statement. For example, last year the Board deliberated a commercial spaceship accident where the copilot actuated a lever prematurely, resulting in the inflight breakup of the vehicle. The Probable Cause proposed by staff listed the copilot's error in the causal statement, followed by a contributing factor of the spaceship manufacturer's failure to consider and protect against the possibility that a single human error could be catastrophic. I argued that if the spaceship manufacturer had designed a system that would not have allowed the copilot's error to occur, this accident would not have happened. Therefore, I felt the manufacturer's failure should be moved from a contributing factor to the causal statement. My colleagues agreed.

There is a subtle, but important, distinction between the commercial spaceship and Amtrak 188 cases. In the spaceship crash, the organization's failure to properly design the spaceship set the stage for the copilot's error. In short, it enabled the error. In the case of Amtrak 188, the lack of PTC did not enable the locomotive engineer's error. While its presence might have prevented his error from becoming catastrophic, the lack of PTC did not set the stage for his error of entering the Frankford Junction curve at excessive speed.

The Board unanimously adopted a finding that states, in part, "a fully implemented positive train control system would have prevented the accident." However, one must not confuse prevention with causation.

In the Board Meeting, it was suggested that by elevating PTC into the main body of the causal statement, it would help send the message that the NTSB strongly believes in the importance of PTC. While I agree a well-crafted Probable Cause statement can be useful in sending a powerful message, it must be underpinned by logic and supported by evidence. A Probable Cause statement that lacks either element potentially undermines the credibility of NTSB investigations.

In closing, I appreciate the enlightened debate we had in the Board Meeting. It is through such debates that we learn different perspectives and, in the end, produce a better product for the traveling public.

Chairman Hart joined in this statement.

**Member Earl F. Weener filed the following concurring statement on May 24, 2016.**

I concur with the findings and recommendations in this report generally. However, I think that an insufficient emphasis was placed on several circumstances that, if not contributing factors, created an environment with great potential for an accident and greatly diminished NTSB's ability to determine the actual cause of this accident with certainty.

When the NTSB investigates an accident, the result is a finding of probable cause. In some accidents, the probable cause is clear and certain. In some accidents, the nature of the evidence recovered during the investigation limits the determination to the literal meaning of the word probable. So it is with the derailment of Amtrak 188. We were able to determine that no track or train malfunction caused the accident. That left investigators with the actions of the engineer having caused the excessive speed as the train entered the curve at the accident site. Because no inward-facing camera had been installed in this locomotive, however, it is impossible to say with certainty what happened inside that locomotive or what, in fact, caused the engineer to lose awareness to the extent that he failed to reduce the train's speed in time for the curve.

It is very disturbing that so much rests on the ability of an engineer, working alone for extended periods of time, to determine his or her location based not on clear visual markers, but on memory. The engineer must do this in many instances without the assistance of GPS driven, two-dimensional map display and guidance. While memory training may prove to be of some benefit when studied in the future, the reality is that intervening events are likely. In this accident, for example, the engineer explained to NTSB investigators that the rock throwing incident on the SEPTA train was a fairly common occurrence. Until each train can be equipped with an active navigational display, an engineer could be required to use a checklist to keep track of his or her location as stops or landmarks are passed. The use of checklists has been extremely successful in aviation to reduce the type of diverted attention or prospective memory error that may have been the root of this accident.

Investigators looked at what evidence they did have and theorized that the engineer must have lost track of where he was on his route and that this must have been due to his attention being focused on the emergency situation on the SEPTA train. While this is a reasonable possibility, acceptance of that theory requires the dismissal of a portion of the engineer's statement in which he stated that he did know where he was shortly before approaching the curve. This is troubling given that much of our probable cause is based on that same engineer's statement. Again, without a recording of his actions inside the locomotive, the engineer's statement is the best evidence of his experience. The reality is that exactly what happened that night will never be known.

What is obvious, however, is that something did cause the engineer to fail to properly control the speed of the train. There is no doubt that an alert, well trained, healthy operator is the most important safeguard in any mode of transportation, but humans are inherently fallible. Even with the best training, medical screening, and hours of service prohibitions, anything from an undiagnosed medical condition to a poor night's sleep to some external stress can result in a temporary, partial or complete loss of awareness or even consciousness. Such occurrences are eventualities, not mere possibilities. This is why I understand the vice chairman's vigorous support of the inclusion of positive train control as a part of a probable cause. Although I agree with the Board's vote and believe that the primary probable cause of the derailment was the engineer's failure to reduce the train's speed as appropriate, the reality is that such a failure is foreseeable.

Every mode of transportation is working toward technological solutions for human errors. In rail, a solution already exists. It cannot be overstated that positive train control would have prevented this derailment. While the lack of positive train control did not initiate the accident, it certainly could have stopped it. The NTSB has seen far too many instances where available, effective technology would have saved lives. Ultimately, that is the sad truth here. The only good to come out of a tragedy of this nature is that we learn from it and, finally, act to keep something like this from happening again.

Chairman Hart and Vice Chairman Dinh-Zarr joined in this statement.

# Appendix A: Investigation

The National Transportation Safety Board (NTSB) was notified on May 12, 2015, of the derailment of Amtrak train 188 in Philadelphia, Pennsylvania, and launched an investigative team. Groups were established to gather evidence on human performance, railroad operations, track and engineering, signals and train control, survival factors and crashworthiness, mechanical/equipment, event/data recorders, video recorders, and portable electronic devices. Board Member Robert Sumwalt was the spokesperson on scene.

The NTSB Transportation Disaster Assistance division was on scene to provide assistance to the victims and victims' families.

Parties to the investigation included the Federal Railroad Administration; Amtrak; the Brotherhood of Locomotive Engineers and Trainmen; the International Association of Sheet Metal, Air, Rail and Transportation Workers; the Brotherhood of Maintenance of Way Employes Division of the International Brotherhood of Teamsters; Philadelphia Police Department; Philadelphia Fire Department; and Philadelphia Office of Emergency Management.

# Appendix B: Transcript of Radio Transmissions

| SOURCE | TIME | DURATION (seconds) | TRANSMISSION |
|---|---|---|---|
| **Train 769** | 21:13:11 | 9 | Something happened to the window. It looks like a rock. Train 769 Amtrak CTEC. Over. |
| **Dispatcher** | 21:13:32 | 3 | Track CETC 6 to 769 |
| **Train 769** | 21:13:36 | 35 | 769, coming out of Mantua, right at, uh, almost at the Diamond Street under grade bridge. Something hit our windshield. I don't know if somebody threw something, or somebody – but our windshield is shattered. I saw somebody by the side of the rail, but they had a light on. They had on a light on dark clothes. I couldn't see what they looked like, but the windshield from this train is shattered. Over. |
| **Dispatcher** | 21:14:14 | 13 | All right. Somebody either threw something or – all right. Um. Diamond Street under bridge, under bridge. Bridge. Uh, and you're all right? Over. |
| **Train 769** | 21:14:28 | 31 (0–10 seconds noise) | So far, everything – I mean – I just got glass in my face. I saw a trespasser by the freight tracks. I blew the horn. It had a light; they put the light out, and that's when it happened. It's about – I dumped the train about six cat poles from where it happened. Over. |
| **Dispatcher** | 21:14:35 | 2 | You said you got glass on your face. Over. |
| **Dispatcher** | 21:15:01 | 5 | All right. Roger. So you dumped the train? And you're all intact and on the rail, correct? Over. |
| **Train 769** | 21:15:07 | 14 | We're on the rail, and, like I said, the windshield is shattered. Something hit it. I don't know what it was. I've seen people throw rocks here before. I don't know if it was a rock, but this windshield is shattered. |
| **Dispatcher** | 21:15:22 | 8 | All right. Roger. And, um – do you have like an exact milepost where that dump at Diamond Street Bridge is? Over. |
| **Dispatcher** | 21:15:36 | 3 | Where you stopped right now, 769? Over. |
| **Train 769** | 21:15:54 | 6 | On the cat 4-pole where I'm stopped. |
| **Train 188** | 21:16:07 | 6 | Amtrak 188 as SEPTA 769, hot rail, hot rail. Number 2 rail coming. Over. |
| **Dispatcher** | 21:16:17 | 4 | CETC 6, 769, what's your exact location there? |
| **Train 769** | 21:16:37 | 10 | I'm over on top of 22nd and Diamond. Right. Over. Diamond Street, around 22nd. milepost 86. It's milepost 86. |
| **Dispatcher** | 21:16:47 | 7 | All right, Milepost 86. All right. So, the front windshield is completely shattered. Um, you're all right? Correct? Over. |
| **Train 769** | 21:16:57 | 12 | Kind of dinged… because there's glass all in my face. |
| **Dispatcher** | 21:17:00 | 3 | Do you need any medical attention or anything? Over. |

| SOURCE | TIME | DURATION (seconds) | TRANSMISSION |
|---|---|---|---|
| **Dispatcher** | 21:17:11 | 5 | All right, I understand that, 769. Do you need medical attention or anything? Over. |
| **Train 769** | 21:17:23 | 14 | [Indiscernible response] |
| **Dispatcher** | 21:17:44 | 3 | Amtrak CETC 6, SEPTA 769. Over. |
| **Train 769** | 21:17:48 | 12 | 769 answering. Over. Ah, yes, it's a good idea. Please, please, I just want to make sure. |
| **Dispatcher** | 21:17:50 | 2 | Yeah, do you need medical attention? |
| **Dispatcher** | 21:18:01 | 3 | All right, you do want medical attention. Okay, all right. Roger. |
| **Undetermined** | 21:19:08 | 5 | First person: [Indiscernible]<br>Second person: [Laughs] Yeah, we got rocked. |
| **Accident** | 21:20:38 | -- | **--** |

# Appendix C: Sample of Recent NTSB Accident Investigations with Two-Person Crews Involving Noncompliance with Signals or Instructions

| Location | Date | Fatal | NTSB Report |
|---|---|---|---|
| Amarillo, Texas | 9/25/2013 | 0 | RAR-15-02 |
| Chafee, Missouri | 5/25/2013 | 0 | RAR 14/02 |
| Barton County, Missouri | 7/21/2012 | 0 | RAB 14-05 |
| Westville, Indiana | 1/06/2012 | 0 | RAB 13/03 |
| Goodwell, Oklahoma | 6/24/2012 | 3 | RAR 13-02 |
| Two Harbors, Minnesota | 9/30/2010 | 0 | RAR 13-01 |
| Mineral Springs, North Carolina | 5/24/2011 | 2 | RAB 13-01 |
| Red Oak, Iowa | 4/17/2011 | 2 | RAR 12-02 |
| Chicago, Illinois | 11/30/2007 | 0 | RAR 09-01 |
| Betram, California | 11/10/2007 | 2 | RAB 08-04 |
| Lincoln, Alabama | 1/18/2006 | 2 | RAB 07-01 |
| Anding, Mississippi | 7/10/2005 | 4 | RAR 07-01 |
| Carrizozo, New Mexico | 2/21/2004 | 2 | RAB 06-05 |
| Texarkana, Arkansas | 10/15/2005 | 0 | RAB 06-04 |
| Macdona, Texas | 6/28/2004 | 3 | RAR 06-03 |
| Gunter, Texas | 5/19/2004 | 1 | RAR 06-02 |
| Kelso, Washington | 11/15/2003 | 0 | RAB-05-03 |