



National Transportation Safety Board

Railroad Accident Brief

Southeastern Pennsylvania Transportation Authority Trolley Collision

Philadelphia, Pennsylvania

January 4, 2017

The Accident

On January 4, 2017, at 12:47 p.m. eastern standard time, Southeastern Pennsylvania Transportation Authority (SEPTA) trolley 9101 (struck trolley), traveling northwest on trolley route 10 with an estimated 47 passengers on board, stopped near the intersection of Lancaster Avenue and 38th Street, in Philadelphia, Pennsylvania, to offload passengers.¹ SEPTA trolley 9085 (striking trolley), with 6 passengers on board, was also traveling northwest on trolley route 10, and struck stopped SEPTA trolley 9101 in the rear at an estimated impact speed of 10 mph. First responders transported 40 passengers and both operators to local hospitals for treatment of minor injuries. The total estimated equipment damage to both trolleys was \$60,000. At the time of the accident, the sky was partly cloudy, visibility was 10 miles, and the temperature was 54°F. Figure 1 shows the accident scene.



Figure 1. Overhead view of the accident scene. (Photo courtesy of WPVI-TV.)

The National Transportation Safety Board (NTSB) recorder division received two digital video discs containing video footage from both the striking trolley and the struck trolley. In

¹ In this accident brief, all times are eastern standard time.

SEPTA Trolley Collision

addition, the SEPTA video recording system installed on each trolley recorded eight video cameras in color at a rate of 10 frames-per-second. No audio was recorded, however. Video footage reveals at 12:42:41 p.m., when the striking trolley (trolley 9085) exited the portal at 36th Street, between Market and Chestnut Streets, trolley 9101 was not in view.² The operator of the striking trolley said that when he stopped at the 36th Street portal transit stop, he could see trolley 9101 ahead of him, waiting at a red traffic signal at the intersection of 36th and Market Streets. He said that he decided to increase the space between the trolleys because he knew that the lead trolley would pick up all of the passengers. Forward-facing video footage from the striking trolley revealed that it passed through a facing point switch at 36th Street and Lancaster Avenue, without stopping, at 12:45:54 p.m.³ (See figure 2.)

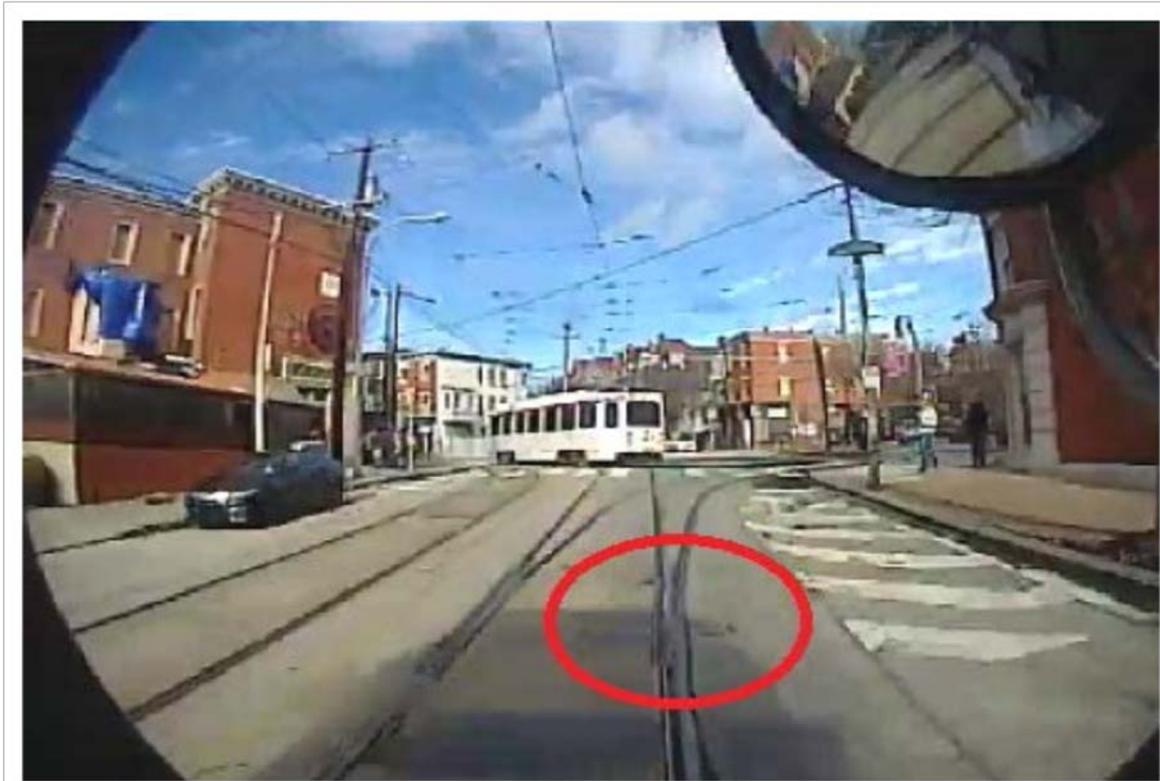


Figure 2. Forward-facing image of the facing point switch at 36th Street and Lancaster Avenue.

SEPTA operating rule RDR-65 requires trolley operators to bring the trolley to a complete stop before traversing a facing point switch to ensure proper switch point alignment. The facing point switch is circled in red in figure 3. According to the video, at 12:45:59 p.m., the striking trolley turned left onto Lancaster Avenue. After rounding the corner onto Lancaster Avenue, trolley 9101 was visible. By 12:46:19 p.m., the alternating, flashing red brake lights, and the steady, red tail lights of the struck trolley are visible in the video. At this time, trolley 9101 was at the intersection of Powelton Avenue and Lancaster Avenue and trolley 9085 was at the intersection of 37th Street and Lancaster Avenue.

² SEPTA uses a communication-based train control system inside a 2.5-mile tunnel section. This system provides speed enforcement, overspeed protection, and safe train separation between cars inside the tunnel. However, when a trolley exits the tunnel at either the 36th Street portal or the 40th Street portal, the trolley operator regains sole control of the vehicle's operation.

³ A *facing point switch* is a railroad switch that is set to allow a train to face points as it passes them.

SEPTA Trolley Collision

The striking trolley's operator said that he continued along the route and noticed that trolley 9101 was about 1 block ahead as he approached 37th Street. Video footage revealed that trolley 9085 stopped about 1 trolley-length behind trolley 9101 at the intersection of Powelton Avenue and Lancaster Avenue at 12:46:35. He said that the traffic light at Powelton Avenue turned green and he used the master controller to accelerate within the same city block as trolley 9101. Event recorder information from the striking trolley revealed that it had reached 23 mph within the same city block prior to impact. SEPTA Operating Rule RDR-61: Distance Spacing, prohibits trolleys from moving at speeds greater than 20 mph when there are other vehicles on the same city block. The rule states:

Under normal conditions outside of subway, light rail vehicles must operate at restricted speed not exceeding 20 mph when following another light rail vehicle within a city block. When closer than 200 feet (1/2 city block), light rail vehicles must operate at restricted speed not exceeding 5 mph. When conditions ahead require that a vehicle advance closer than the prescribed distance, operators must exercise extreme caution and operate at a speed that will enable them to stop their vehicle at least 2 car lengths behind the vehicle ahead.

The operator of the striking trolley told NTSB investigators that it was at this point that he began to feel groggy. He said that he blinked his eyes and saw trolley 9101, that was stopped behind a delivery truck, immediately in front of him. Although he slammed on his foot brake, trolley 9085 struck the rear of trolley 9101 at a speed of 10 mph. (See figure 3.)

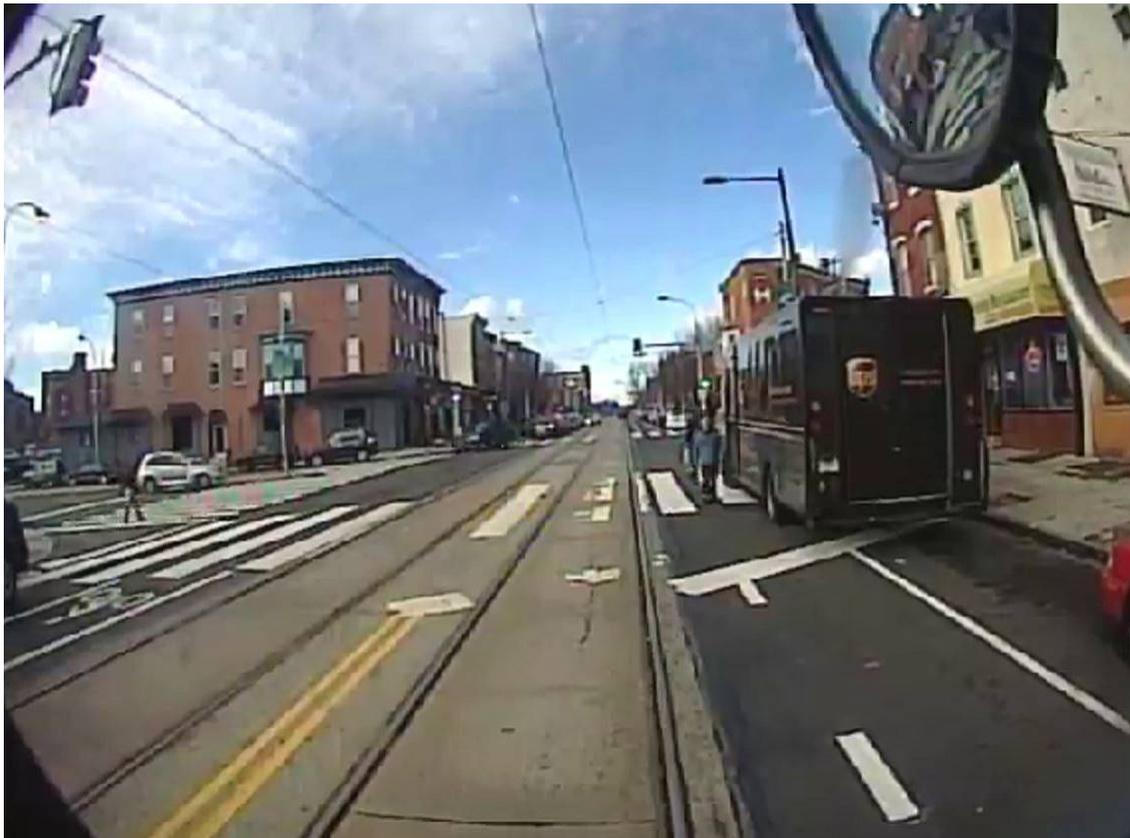


Figure 3. The view from the struck trolley's forward-facing camera, 2 seconds before impact.

Emergency Response

At 12:47:42 p.m., the operator of the struck trolley reported the accident to the SEPTA Control Center. Video recordings from the struck trolley revealed that a Philadelphia Fire Department vehicle, with emergency lights activated, appeared less than 5 minutes later. A Philadelphia Police Department car also arrived on scene.

The following events occurred from 12:52:41 p.m. until 1:17:19 p.m.:

- Multiple emergency services personnel and vehicles arrived on scene
- Emergency services personnel entered and removed passengers from trolleys 9101 and 9085
- SEPTA's transportation manager arrived on scene
- Police and firefighters spoke with the operator of the struck trolley

Forty people, including the two operators, were transported to local area hospitals in Philadelphia for treatment.

Operator of Struck Trolley

The operator of the struck trolley was qualified and was fully rested prior to going on duty at 6:54 a.m. on the day of the accident. He said the ground was wet in the early morning when he started his shift, and then dry after the sun came out.⁴

Operator of Striking Trolley

The operator of the striking trolley was working an additional shift for overtime on the day of the accident. The regular days off for the operator of the striking trolley were Tuesday and Wednesday; however, he called the dispatcher-in-charge the previous day to see if extra work was available.⁵ After taking some cold medicine in tea around 9:00 a.m. that morning, he arrived at work at 11:30 a.m., checked in with the dispatcher, and confirmed with the transitioning operator that the trolley was in good condition before leaving the trolley depot at 11:54 a.m. A review of the trolley's forward-facing video showed that the striking trolley operator was compliant with wayside signals in the tunnel.

SEPTA records reflected that the operator of the striking trolley was fully qualified. He had a Class B commercial driver's license, which was due to expire on January 2, 2018. Vehicles included on the license were bus and "other rail". He began working as a trolley operator for SEPTA in 2014, and had an authority date of January 27, 2014, on his "Operator Qualification Record" for the Suburban/Light Rail Training section. SEPTA records documented the training

⁴ According to the Record of Decision for Federal Transit Administration (FTA)/SEPTA Postaccident Drug and Alcohol Testing form, the criteria for postaccident testing were not met. In addition, Federal Railroad Administration (FRA) toxicology testing was not performed on the operator of the struck trolley.

⁵ The area of responsibility for dispatchers at SEPTA differs some from the traditional "dispatcher" role. At SEPTA, dispatchers assign routes and check employees in to work.

SEPTA Trolley Collision

history of the operator of the striking trolley. His primary routes included route 10 on the weekends and the route 15 on weekdays.

Human Performance Factors

The operator of the striking trolley reported feeling ill, with cold symptoms and a persistent cough, on the day prior to the accident. But, he said that after using a nighttime over-the-counter (OTC) cough and cold medication containing the sedating antihistamine diphenhydramine before going to sleep, he “felt a whole lot better” upon waking on the morning of the accident.⁶ At around 9:00 a.m., prior to reporting for duty on the morning of the accident, he reported taking another dose of the same sedating medication. Although the day of the accident was one of his normal days off, the operator of the striking trolley had volunteered to work to earn overtime pay.

The SEPTA dispatcher said that he interacted with the operator of the striking trolley briefly on the morning of the accident when he verified the operator’s attendance, indicating that “I didn’t have a conversation with him, just checked him off.”

A review of recordings from the striking trolley’s inward-facing video recorder revealed performance decrements on the part of the operator of the striking trolley that could be contributory with fatigue:

- While operating the trolley prior to the collision, the operator failed to open a door for a passenger, even though the passenger had pulled the stop request cord to indicate she needed to get off the trolley. The passenger had to speak to the operator to get his attention so that he would open the door.
- The operator of the striking trolley was traveling north on 36th Street when he was stopped by a red traffic light at the intersection of 36th Street and Lancaster Avenue, behind trolley 9101. When the light turned green, he proceeded through the light, following trolley 9101 west onto Lancaster Avenue, failing to maintain the required separation between the two trolleys.
- The operator of the striking trolley failed to stop and confirm the correct position of the facing point switch at 36th Street and Lancaster Avenue.
- Inward-facing video of the striking trolley revealed that about 1 minute prior to the accident, the operator of the striking trolley was propping his head up with his hands while stopped at the Powelton Avenue traffic light. When the light turned green, he moved the trolley forward, but continued to rest his head on his hands. The operator of the striking trolley remained in this position until a few seconds before the collision with trolley 9101, at which point he sat up with his back fully against his seatback—a movement consistent with a bracing position, looked out the front window, and activated the trolley brake.

⁶ *Diphenhydramine* is an antihistamine drug with useful sedative and anti-itching properties. It is a constituent in many OTC cough and decongestant remedies. Robert M. Youngson, *Collins Internet-linked Dictionary of Medicine*, 2nd ed., (Glasgow, Scotland: Collins, 2005). According to [Drugs.com](http://www.drugs.com), this is an ingredient in many over-the-counter medications such as Benadryl, Sudafed, and Theraflu.

Medical Review and Toxicology

The 62-year-old operator of the striking trolley reported that he had head congestion and had not been sleeping well for about 5 days before the accident. He also reported feeling unwell the day prior to the accident. He self-treated with an OTC nighttime cold medication containing the sedating antihistamine diphenhydramine the evening before and again in the morning about 4 hours before the accident. He reported he was otherwise in good health and took no other medications. Postaccident alcohol breath testing and urine drug testing were negative for alcohol and other tested-for substances.⁷ Federal Transit Administration (FTA)-required postaccident urine toxicology protocol does not test for diphenhydramine.

The OTC sedating nighttime cold medication packet has warnings including “marked drowsiness may occur” and “be careful when driving a motor vehicle or operating machinery.”⁸ Diphenhydramine is a sedating impairing medication and peak drug levels (the highest levels of the sedating medication present in the blood after taking a dose of medicine) generally occur about 2.5 hours following ingestion. The drug is eliminated from the body at various rates, but can take as long as 14 hours to eliminate half the dose of the drug in elderly adults.⁹ Compared to other antihistamines, diphenhydramine causes marked sedation; this is the rationale for its use as a sleep aid. Altered mood and impaired cognitive and psychomotor performance may also be observed. In fact, in a driving simulator study, a single 50 mg dose of diphenhydramine resulted in significant reported drowsiness and impaired driving ability more than a blood alcohol concentration of 0.100 gm/dl.¹⁰ In the United States, drivers with blood alcohol concentrations of 0.08 gm/dl or greater are considered legally intoxicated.

Prior to the accident, the operator of the striking trolley demonstrated degraded operating performance consistent with fatigue. Therefore, it is likely that the driver’s degraded performance was the result of a combination of fatigue from the effects of his recent illness, not sleeping well the 5 nights prior to the accident, and the sedating effects of diphenhydramine. This combination of factors negatively affected his medical fitness for duty. The video recording from his trolley revealed the operator failed to apply the trolley brakes in time to avoid the collision.

The trolley operator had received training on restrictions for over-the-counter medications during initial training on January 27, 2014, almost 3 years before the accident, but refresher information was not provided. Since the accident, the SEPTA medical department has distributed and posted an advisory notice for OTC medications.

⁷ LabCorp laboratory conducted FTA-mandated postaccident urine drug testing. Urine was tested for amphetamines, cocaine metabolites, opiates, phencyclidine, and marijuana metabolites. The cutoff levels are defined in Title 49 *Code of Federal Regulations (CFR)* 40.87. <https://www.transportation.gov/odapc/part40/40-87>. Accessed April 24, 2018.

⁸ CVS Health Severe Cough & Cold Drink Packets. <http://www.cvs.com/shop/health-medicine/cough-cold-flu/cough-cold-medicine/cvs-health-severe-cough-cold-drink-packets-prodid-1011693#!#Directions>. Accessed July 25, 2017.

⁹ R.C. Baselt, “Diphenhydramine” in *Disposition of Toxic Drugs and Chemicals in Man*, 10th ed. (Seal Beach, California: Biomedical Publications, 2014), 684-687.

¹⁰ (a) Blood alcohol content is measured this way in the United States, Canada, and Australia. (b) J.M. Weiler, J.R. Bloomfield, G.G. Woodworth, A.R. Grant, T.A. Layton, T.L. Brown, D.R. McKenzie, T.W. Baker, and G.S. Watson, “Effects of fexofenadine, diphenhydramine, and alcohol on driving performance, a randomized, placebo-controlled trial in the Iowa Driving Simulator,” *Annals of Internal Medicine* 132, no. 5 (March 2000): 354-363.

SEPTA Trolley Collision

SEPTA Rail Operations Division Authority Standard Rules-4 “Fitness for Duty” states the following:

Employees must not perform any service while affected by any condition that could impair their ability to perform their duties properly. Such conditions include fatigue, use and effect of OTC medications, personal situations that impact alertness or one’s ability to concentrate, etc. Employees must notify the Authority Medical Department of any condition not already on record that could impair their ability to perform their duties.

The SEPTA *Drug Free Workplace Manual* provides employees with information about prescription and OTC medications, but does not specifically discuss the generic name of the medications used by the trolley operator. Further, the manual instructs employees to pay attention to labels indicating drowsiness or restrictions regarding driving and/or working around machinery, and to adjust their dosage and work schedule accordingly.

Collision Avoidance Systems

The communication-based train control (CBTC) system used inside of the tunnel to control the speed of the trolleys is not feasible in a roadway where the traffic flow of trolleys and vehicles intermingle. CBTC and positive train control systems require track and wayside components that cannot be mounted in the roadway. The gross vehicle weight of a commercial vehicle can be up to 80,000 pounds, while the weight of a trolley is about 58,000 pounds without passengers. Members of the NTSB investigative team researched the applicability of modern collision avoidance systems, such as those presently being used in the highway vehicle operating environment—particularly those used by commercial carriers—to the trolley and streetcar operating environment. Currently, none of the collision avoidance systems technologies reviewed by the NTSB are being used in the trolley or streetcar operating environment. However, the NTSB believes that highway collision avoidance systems may also be applied to trolleys.

There are several advanced collision avoidance technologies currently available in the marketplace that employ on-board sensor technologies such as cameras, radar, or lidar, to monitor the vehicles’ surroundings.¹¹ Cameras, radar, and lidar that are installed on a vehicle can gather information directly by sensing their surroundings. These are called “vehicle-resident” systems because they are installed on one vehicle and do not communicate with other vehicles. These vehicle-resident collision avoidance technologies can use that information to warn the driver of impending danger so the driver can take appropriate action to avoid or mitigate an accident.

Automatic emergency braking (AEB) includes a range of systems that are designed to address rear-end accidents in which drivers do not apply the brakes or fail to apply sufficient braking power to avoid or mitigate a collision. AEB systems use vehicle-resident sensors—such

¹¹ A *lidar device* detects objects and determines their position, velocity, or other characteristics by analysis of pulsed laser light reflected from their surfaces.

SEPTA Trolley Collision

as radar, cameras, or lidar—to detect an imminent collision, warn the driver, and engage the brakes, should the driver take insufficient action.¹²

The technology in these collision avoidance systems have proven to be effective and are currently being installed in some new motor vehicles.¹³ NTSB believes if the applicable avoidance technologies are also applied to trolley systems, the occurrences of rear-end collisions, such as this one, will be significantly reduced.

Previous NTSB Reports

NTSB has a long history of investigating rear-end-collisions amongst highway vehicles. Since 1995, NTSB has encouraged technological countermeasures to mitigate such accidents. In 2001, NTSB released a Special Investigation Report on this subject and made several safety recommendations to federal agencies and vehicle manufacturers.¹⁴

Continued technological advancements in collision avoidance systems and delays in the implementation of previous NTSB safety recommendations prompted another Special Investigation Report in May 2015.¹⁵ In this report, the NTSB “examined the prevalence of rear-end crashes, their cost in lives lost, and the extent to which collision avoidance systems could have prevented or mitigated such crashes.”¹⁶ As a result of this special investigation report, the NTSB issued the following recommendation to the National Highway Traffic Safety Administration (NHTSA):

Complete, as soon as possible, the development and application of performance standards and protocols for the assessment of forward collision avoidance systems in commercial vehicles. (H-15-5)

Although NHTSA has advised the NTSB that it is researching the development of collision avoidance systems and supporting technologies, the NTSB has responded that it believes that NHTSA has not done enough to address this issue. Hence, the NTSB has reiterated Safety Recommendation H-15-5 in August 2015, March 2017, and October 2017.¹⁷ This safety recommendation is currently classified *Open—Unacceptable Response*.

¹² National Highway Traffic Safety Administration, “Manufacturers make progress on voluntary commitment to include automatic emergency braking on all new vehicles,” news release, December 21, 2017. <https://www.nhtsa.gov/press-releases/nhtsa-iihs-announcement-aeb>, accessed May 24, 2018.

¹³ National Highway Traffic Safety Administration, “Automatic emergency braking.”

¹⁴ National Transportation Safety Board, *Vehicle- and Infrastructure-based Technology for the Prevention of Rear-End Collisions*, SIR-01/01 (Washington, DC: National Transportation Safety Board, 2001).

¹⁵ National Transportation Safety Board, *The Use of Forward Collision Avoidance Systems to Prevent and Mitigate Rear-End Crashes*, SIR-15/01 (Washington, DC: National Transportation Safety Board, 2015).

¹⁶ NTSB Safety Recommendation Letter to Passenger Vehicle, Truck-Tractor, Motorcoach, and Single-Unit Truck Manufacturers for NTSB Safety Recommendations H-15-8 and H-15-9, June 8, 2015.

¹⁷ (a) National Transportation Safety Board, *Multivehicle Work Zone Crash on Interstate 95, Cranbury, New Jersey, June 7, 2014*, HAR-15/02 (Washington, DC: National Transportation Safety Board, 2015); (b) National Transportation Safety Board, *Motorcoach Collision With Crash Attenuator in Gore Area, US Highway 101, San Jose, California, January 19, 2016*, HAR-17/01 (Washington, DC: National Transportation Safety Board, 2017); (c) National Transportation Safety Board, *Motorcoach Collision With Combination Vehicle After Traffic Break on Interstate 10, Palm Springs, California*, HAR-17/04 (Washington, DC: National Transportation Safety Board, 2017).

SEPTA Trolley Collision

This technology is also applicable to the trolley-streetcar operating environment. Therefore, the NTSB recommends the American Public Transportation Association develop performance standards for the use of forward collision avoidance systems technology for light-rail vehicles operating on an urban street environment.

NTSB Postaccident Actions

On January 8, 2017, NTSB investigators completed sight distance observations and four brake performance tests on the striking trolley at the accident location. NTSB investigators observed that the track brake did not function when using the emergency brake push-button during brake performance tests.¹⁸ Although this defect was discovered during the postaccident testing of the braking systems, this flaw did not contribute to the accident because the operator used the brake pedal to apply the emergency brake, as indicated on video from inside the trolley.

After postaccident brake performance testing, NTSB investigators released the striking trolley to the Elmwood maintenance facility to troubleshoot the inoperative track brake. They removed the inspection panel under the operator console and found a broken electrical switch no longer attached to the emergency brake push-button. NTSB investigators contacted the manufacturer of the emergency brake push-button electrical switch, WABTEC Corporation (WABTEC), concerning this issue. WABTEC published a service bulletin that explained the proper installation and adjustment of the electrical switch and distributed it to its customers who use that design in rail transit vehicles.

In response to the SEPTA push-button electrical switch failure, the NTSB issued a safety alert to warn rail transit agencies, the Federal Transit Administration, (FTA) and the state safety oversight agencies (SSOA) of the potential failures for similar vehicles of a comparable design.¹⁹ This safety alert helps rail transit operators:

- identify vehicles that may use comparable designs
- prevent or reduce the severity of accidents that may result from an emergency brake push-button electrical switch failure

In addition, the NTSB issued the following early safety recommendation to the FTA on May 17, 2017.

Utilize your authority under Title 49 *Code of Federal Regulations* 670.25, and issue a general directive that would require all state safety oversight agencies to direct rail transit agencies to periodically test the performance of all of their rail transit vehicle braking systems to detect potential latent system failures. (R-17-04)²⁰

On August 8, 2017, the executive director of the FTA told the NTSB that the FTA plans to develop and issue a general directive that will be published in the *Federal Register*. Safety Recommendation R-17-04 is currently classified *Open—Acceptable Response*.

¹⁸ For more information, see the *Mechanical Factual Report* in NTSB Docket DCA17FR003.

¹⁹ National Transportation Safety Board, *Rail Transit Vehicle Emergency Brake Push-button Electrical Switch Failure*, SA-063, April 2017.

²⁰ National Transportation Safety Board, *Rail Transit Vehicle Safe Braking*, RSR 17/01 (Washington, DC: National Transportation Safety Board, 2017).

SEPTA Postaccident Actions

Since the accident, SEPTA has implemented or began the process of implementing the following:

- Included a review of SEPTA Rail Division Rule 61 – Following Light Rail Vehicles in future recertification classes to ensure that all trolley operators are familiar with the spacing requirements associated for following trolleys in street operation.
- Created an engineering modification for the trolley emergency brake push-button to correct the switch failure discovered during testing. Installing the modification in both the single-end and double-end fleets.
- Issued a notice to all employees discussing best practices and reiterating SEPTA’s requirements for being mindful of taking OTC medications and the potential effects of their use on safety-sensitive employees.
- Modified the reporting windows at operator reporting locations so that district dispatchers and/or clerk receivers can observe operators without a glass divider in place.
- Trained all clerk receivers in drug and alcohol recognition so that they may assist district dispatchers in observing operators as they report for duty.
- Worked with third party vendors on the development of a collision avoidance warning system for the current street-running trolley fleet. Investigating the technology for future trolley procurements.
- Posted advisory notices that discuss the hazards associated with OTC medication, specifically identifying diphenhydramine, the sedating medication used by the operator of the striking trolley.²¹

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the operator of the striking trolley to slow and stop his trolley before colliding with the stopped trolley because of his impairment from fatigue and the sedating effects of the repeated doses of over-the-counter antihistamine diphenhydramine. Contributing to the operator’s fatigue was his illness, which negatively affected his medical fitness for duty.

²¹ “Notice Medical Department Advisory for Over the Counter Medications” can be found in the *Medical Factual Report* – Attachment 2 in the accident docket, DCA17FR003.

Safety Recommendation

The National Transportation Safety Board makes the following safety recommendation:

To the American Public Transportation Association:

Develop performance standards for the use of forward collision avoidance systems technology for light-rail vehicles operating on an urban street environment. (R-18-023)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

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Adopted: September 11, 2018

For more details about this accident, visit www.nts.gov/investigations/dms.html and search for NTSB accident ID DCA17FR003.

The NTSB has authority to investigate and establish the facts, circumstances, and cause or probable cause of a railroad accident in which there is a fatality or substantial property damage, or that involves a passenger train. (49 U.S. Code § 1131 - *General authority*)

The NTSB does not assign fault or blame for an accident or incident; rather, as specified by NTSB regulation, “accident/incident investigations are fact-finding proceedings with no formal issues and no adverse parties . . . and are not conducted for the purpose of determining the rights or liabilities of any person.” 49 *Code of Federal Regulations*, Section 831.4. Assignment of fault or legal liability is not relevant to the NTSB’s statutory mission to improve transportation safety by investigating accidents and incidents and issuing safety recommendations. In addition, statutory language prohibits the admission into evidence or use of any part of an NTSB report related to an accident in a civil action for damages resulting from a matter mentioned in the report. 49 *United States Code*, Section 1154(b).
