Issued: December 16, 2022 Railroad Investigation Report: NTSB/RIR-22-15

Massachusetts Bay Transportation Authority Trolley Collision with Derailment

Brookline, Massachusetts
July 30, 2021

1. Factual Information

1.1 Accident Description

On July 30, 2021, about 6:03 p.m. local time, a westbound Massachusetts Bay Transportation Authority (MBTA) light rail vehicle consist (trolley) collided with the rear of another westbound MBTA trolley on the B Branch of the MBTA Green Line near the intersection of Commonwealth Avenue and Harry Agganis Street in Brookline, Massachusetts (see figure 1).[1] Each trolley consisted of two coupled railcars. Both of the struck trolley's railcars derailed, and the lead railcar of the striking trolley derailed. As a result of the accident, 24 passengers and 3 crewmembers were transported to local hospitals with minor injuries. Visibility conditions at the time of the accident were daylight with clear skies, no precipitation, and a temperature of 79°F. MBTA estimated equipment damage to be about $2 million.

[1] (a) Visit ntsb.gov to find additional information in the public docket for this NTSB accident investigation (case number RRD21FR013). Use the CAROL Query to search safety recommendations and investigations. (b) All times in this report are local time unless otherwise noted. (c) This report uses *trolley* to refer to the entire consist and *railcar* to denote the individual units within the consist. MBTA uses *train* and several other terms to describe its vehicles; any potential points of confusion are explained in context.

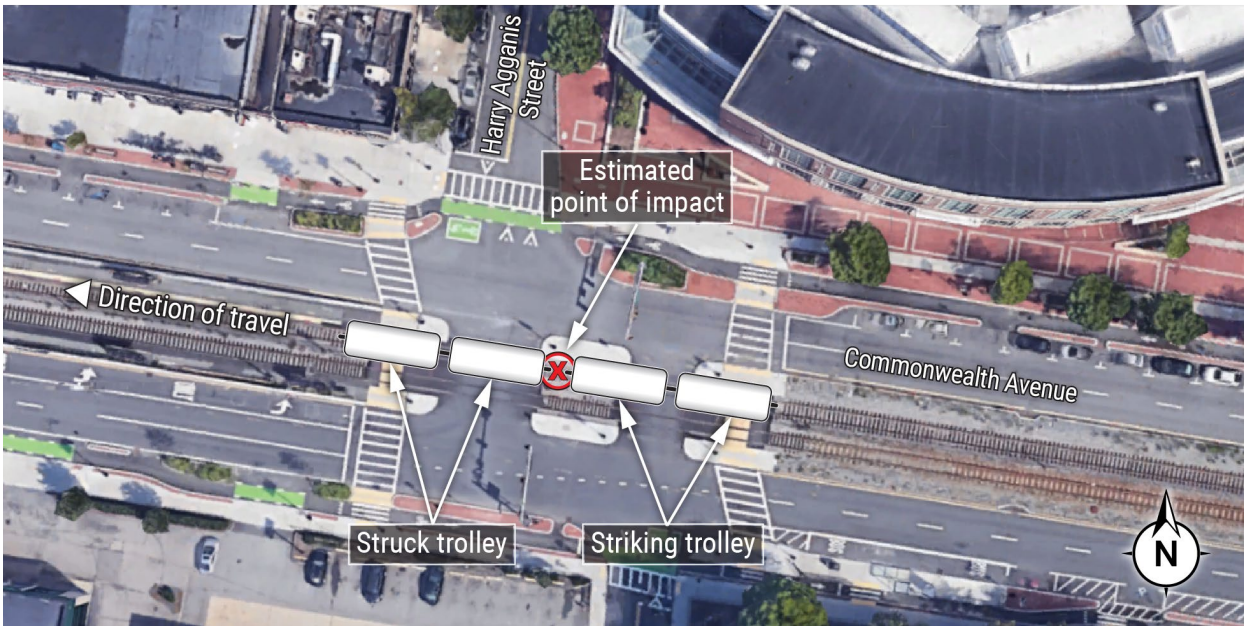

Figure 1. Overhead illustration of accident scene. (Source: Google Earth edit.)

The B Branch of the MBTA Green Line runs on a curb-separated guideway in the middle of Commonwealth Avenue.[2] In interviews with National Transportation Safety Board (NTSB) investigators, the striking trolley's operator reported that he saw the other westbound trolley while located east of the bridge over I-90, and that he slowed before crossing the bridge to increase separation between trolleys and avoid having two on the bridge at once.[3]

Soon after, based on NTSB's review of event recorder data, the operator stopped at St. Paul Street Station near St. Paul Street, which is about 2,000 feet west of the bridge over I-90, where he waited for a signal to proceed through the highway-railroad grade crossing at St. Paul Street.[4] The operator told investigators that "everything went black" after he observed the signal to proceed across St. Paul Street. He added that he did not know what happened but believed he had fallen asleep.

[2] A *curb-separated guideway* is a right-of-way for high-occupancy vehicles such as railcars that is separated from other vehicles by a curb.

[3] Trolleys on the Green Line are operated as single or double railcars. In single-car configurations, a single operator controls both trolley movement and the operation of the doors. In double-car configurations, a second operator in the second railcar operates the second railcar's doors; the lead railcar operator retains responsibility for trolley movement. This report refers to the lead railcar operator simply as the *operator*.

[4] St. Paul Street Station was the final station transited before the accident.

The NTSB's review of event recorder data from both trolleys showed that the striking trolley accelerated under full power for about 500 feet between the passenger stop at St. Paul Street Station and the point of impact near Harry Agganis Street, reaching a speed of about 33 mph when it struck the other westbound trolley, which was traveling about 10 mph. The impact accelerated the struck trolley to about 24 mph and caused it to derail. The struck trolley traveled about 240 feet westward before coming to rest east of the railroad-highway grade crossing at Crowninshield Road. Figure 2 shows the damage to the rear railcar of the struck trolley, railcar 3705. Figure 3 shows damage to the lead railcar of the striking trolley, railcar 3894.

Figure 2. Damage to the rear of railcar 3705 (rear railcar of struck trolley).

Figure 3. Damage to the front of railcar 3894 (lead railcar of striking trolley).

1.2 Before the Collision

On the day of the accident, the striking trolley's operator started his shift about 3:00 p.m. He completed one run (eastbound toward downtown Boston), exited the trolley for a short break, and was about an hour into his second run (westbound toward Boston College) when the accident occurred. The striking trolley's event recorder indicated at least three occurrences of speeding during the operator's shift. Reports from MBTA's speed monitoring systems did not capture these speeding events.[5]

[5] The total number of speeding incidents is unknown because event recorder data are not correlated with MBTA's local speed restrictions. The operator exceeded the maximum speed permitted on B Branch three times but may have violated MBTA's speed policies more frequently. MBTA's two speed monitoring systems are discussed in more detail in section 1.5.2. The system capable of identifying local speed violations covered about five percent of the Green Line's B Branch.

1.3 Trolleys

Each involved trolley consisted of a newer Type 8 railcar leading an older Type 7 railcar. Type 8 railcars are equipped with a single lever (a master controller) that controls both power and braking efforts. The master controller includes a failsafe (or deadman's switch) that requires the operator to rotate the controller handle 90 degrees and hold it in place. If released, the handle rotates back to its original position, and this activates the trolley's emergency brakes. (See figure 4 and figure 5.) Type 8 and Type 7 railcars do not have a forward collision avoidance feature to detect trolleys in the path of travel and automatically apply brakes.

Figure 4. Master controller with deadman's switch disengaged.

Figure 5. Master controller with deadman's switch engaged.

1.4 Striking Trolley Operator

The striking trolley operator was hired on September 22, 2014, and had worked on the Green Line since August 30, 2020. His most recent certification as a trolley operator occurred on January 21, 2021. He had eight documented disciplinary actions for six policy violations, including two actions for a previous accident involving a trolley hitting an automobile and two actions for speeding.

NTSB investigators reviewed the operator's work schedule and trip times for the month before the accident. In the 3 days before the accident, the operator's work schedule ran from 3:04 p.m. to 6:21 p.m. and from 7:09 p.m. to 11:28 p.m. each day.

1.5 Railroad Policies

1.5.1 Trolley Separation

MBTA operating rules at the time of the accident required operators to maintain 500 feet of separation between moving trolleys under most conditions.[6] Additional rules limit approach distances and speeds near stationary trolleys and trolleys at station platforms. St. Paul Street Station, where the striking trolley began its final acceleration before the collision, was about 500 feet from the point of impact.

1.5.2 Speed Limits and Monitoring

The MBTA Green Line has a maximum authorized speed of 25 mph, and speeds are limited by rule to 10 mph through intersections, pedestrian walkways, and within the limits of the station platforms.[7] The railroad monitors trolley speeds under its audit program. Since 2019, audits have included automated global positioning system (GPS) speed monitoring and a fixed speed sign system.[8] At the time of the accident, the fixed-sign system was active on about five percent of the B Branch. Other speed monitoring is conducted by MBTA staff standing trackside (and in view of trolley operators) with devices to measure the speed of approaching trolleys and determine compliance with MBTA speed policies. On the day of the collision, there were no MBTA officials monitoring trolley speeds near the accident site.

1.6 Postaccident Observations, Inspections, and Testing

Investigators inspected the accident location and found no track defects or sight distance issues; the Green Line track along Commonwealth Avenue is straight for half a mile east of the accident site and free of visual obstructions. Investigators found minor accident damage to the track structure. Additional inspections of the striking trolley's railcars' running gear, wheels, couplers, and other mechanical components found all parts in working condition and within manufacturers' specifications. A brake test on the striking trolley's lead railcar found its brakes functional. Investigators also tested the

[6] See *Massachusetts Bay Transportation Authority Rules for Operations Employees* Section 6-14.

[7] See *Massachusetts Bay Transportation Authority Rules for Operations Employees* Section 6-8 for speed policies and the MBTA Green Line Track Chart, June 14, 2019, for local speed limits throughout the Green Line.

[8] MBTA uses all-traffic digital speed signs that communicate current trolley speeds to operators and to MBTA officials. The GPS-based system reports speeds to MBTA officials but does not analyze trolley locations to determine compliance with MBTA speed policies; it can detect violations of the maximum speed permitted by MBTA but not other violations of speed policies.

failsafe emergency brake system activated by the deadman's switch feature and found it functional.

1.7 Toxicological Testing

In accordance with Title 49 *Code of Federal Regulations* (*CFR*) 219.201, the striking trolley's operator underwent a postaccident alcohol breath test and a urine drug test.[9] The results were negative for all tested-for substances.

1.8 Postaccident Actions

MBTA is deploying a train protection system for the Green Line.[10] This system will include railcar-mounted and wayside equipment designed to mitigate the risk of trolley-to-trolley collisions by detecting obstacles, reduce signal violations through automation, and use signal and transponder data to enforce speed policies. It is scheduled for completion by June 2025.

2. Analysis

A westbound MBTA trolley collided with the rear of another westbound MBTA trolley on the B Branch of the MBTA Green Line near the intersection of Commonwealth Avenue and Harry Agganis Street in Brookline, Massachusetts, resulting in a derailment of both trolleys and injuries to passengers and crewmembers.

The striking trolley's operator observed the struck trolley more than 2,000 feet before the collision and adjusted his speed to create space, which indicates that, moments before the collision, he was actively engaged in operating his trolley. Weather conditions were clear, and NTSB investigators' observations of sight distance indicated that the struck trolley would have been visible from the striking trolley at least half a mile before the collision; visibility was therefore not a factor in this accident.

The striking trolley's operator reported a loss of situational awareness after leaving St. Paul Street Station. During this period, the striking trolley accelerated to about 33 mph, exceeding the maximum Green Line speed limit by about 8 mph and the maximum speed permitted through intersections by about 23 mph.

A review of event recorder data showed that the striking trolley's operator did not apply his brakes before impact; the master controller was in the full-power position. The

[9] Tested-for substances including amphetamines, barbiturates, benzodiazepines, cocaine, alcohol and cannabis metabolites, methadone, methaqualone, MDA-analogues, opiates, 6-acetylmorphine, oxycodone, opiates, phencyclidine, and propoxyphene.

[10] MBTA refers to the proposed deployment as the Green Line Train Protection System. MBTA refers to trolleys and railcars variously as *cars, streetcars, trains*, and *vehicles*.

failure to brake indicates that the striking trolley's operator was not engaged in his duties and therefore did not take any actions to avoid the imminent danger of collision. The operator told NTSB he blacked out upon departing the St. Paul Street Station, possibly falling asleep. The lack of any action by the operator to avoid the collision after departing the station suggests that he momentarily became unaware of his situation. Based on a review of work schedules and an interview with the operator, investigators determined that the striking trolley's operator's workload and work schedule were not contributors to fatigue on the day of the accident. Postaccident alcohol breath test and urine drug test results were negative for all tested-for substances. The investigation did not determine the cause of the operator's loss of situational awareness.

In this accident, the striking trolley was over-speeding by about 23 mph. MBTA's current operations and control system does not have an engineering feature that would automatically intervene and apply brakes to prevent trolleys from violating speed or separation policies. Had such a system been in place at the time of the accident, this collision would have been prevented. MBTA is deploying a train protection system designed to prevent trolley-to-trolley collisions by enforcing speed policies and detecting collision threats. MBTA plans to have the system completed by June 2025. Finally, MBTA terminated the striking trolley's operator.

3. Probable Cause

The National Transportation Safety Board determines that the probable cause of the July 30, 2021, Massachusetts Bay Transportation Authority trolley collision and derailment was the operator's acceleration to 33 mph as he departed the St. Paul Street Station, exceeding maximum authorized speed due to his loss of situational awareness and colliding with the moving trolley.

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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" (Title 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 (Title 49 *United States Code* section 1154(b)).

For more detailed background information on this report, visit the NTSB investigations website and search for NTSB accident ID RRD21FR013. Recent publications are available in their entirety on the NTSB website. Other information about available publications also may be obtained from the website or by contacting–

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