Issued: July 21, 2023 Railroad Investigation Report: RIR-23-09

Grade Crossing Collision Between MS Contracting LLC Dump Truck and Amtrak Passenger Train

Mendon, Missouri
June 27, 2022

1 Factual Information

1.1 Accident Description

On June 27, 2022, about 12:42 p.m. local time, eastbound National Railroad Passenger Corporation (Amtrak) train 4 (also known as the *Southwest Chief*), derailed both locomotives and all eight railcars in Mendon, Missouri, after colliding with an MS Contracting LLC dump truck that was fouling a highway-railroad grade crossing.[1] (See figure 1.) Three train passengers and the truck driver were killed, and 146 passengers and Amtrak crewmembers were transported to local hospitals with injuries. Amtrak and the BNSF Railway Company (BNSF) estimated damage to track and equipment to be about $4 million. Visibility conditions at the time of the collision were daylight and clear; the temperature was 81°F with no precipitation.

[1] (a) Visit www.ntsb.gov to find additional information in the public docket for this NTSB accident investigation (case number RRD22MR010). Use the CAROL Query to search safety recommendations and investigations. (b) All times in this document are local time. (c) *Amtrak* is a passenger railroad service that provides medium- and long-distance intercity passenger rail service in the contiguous United States and to nine cities in Canada. (d) *Fouling* refers to a person or object being in proximity to a track such that the person or object could be struck by a moving train.

Figure 1. Amtrak train 4 after the collision. (Courtesy of BNSF.)

The track near the collision was part of the BNSF Marceline Subdivision. It was Class 5 track as defined in federal regulations at Title 49 *Code of Federal Regulations* (*CFR*) 213.9, meaning that the maximum allowable operating speeds were 80 mph for freight trains and 90 mph for passenger trains. Train movements in the area were coordinated by a BNSF train dispatcher located at the BNSF Dispatch Center in Fort Worth, Texas.[2] The track along the Marceline Subdivision was signalized and equipped with a positive train control system that enforces signal indications.[3] The positive train control system was enabled and operating at the time of the collision.

[2] (a) See the timetable Chicago Div. No. 1 (updated January 11, 2021) for maximum authorized speeds in the Marceline Subdivision. (b) Amtrak trains regularly operate over track owned by other railroads.

[3] A *positive train control system* enforces speed limits and prevents a train from passing through a signal that requires it to stop.

The highway-railroad grade crossing involved in the collision (hereafter the crossing) was number 005284Y in the US Department of Transportation Crossing Inventory.[4] The crossing was at milepost 363.876 on the Marceline Subdivision where both tracks 1 and 2 (Amtrak train 4 was on track 2) of the rail line intersected County Road 113, a gravel road also known as Porche Prairie Avenue. (See figure 2.) The crossing was a *passive crossing*, meaning that it was not equipped with active warning or barrier systems such as flashing lights or gates.[5] Instead, it was equipped with crossbucks and stop signs for both north- and southbound highway traffic.

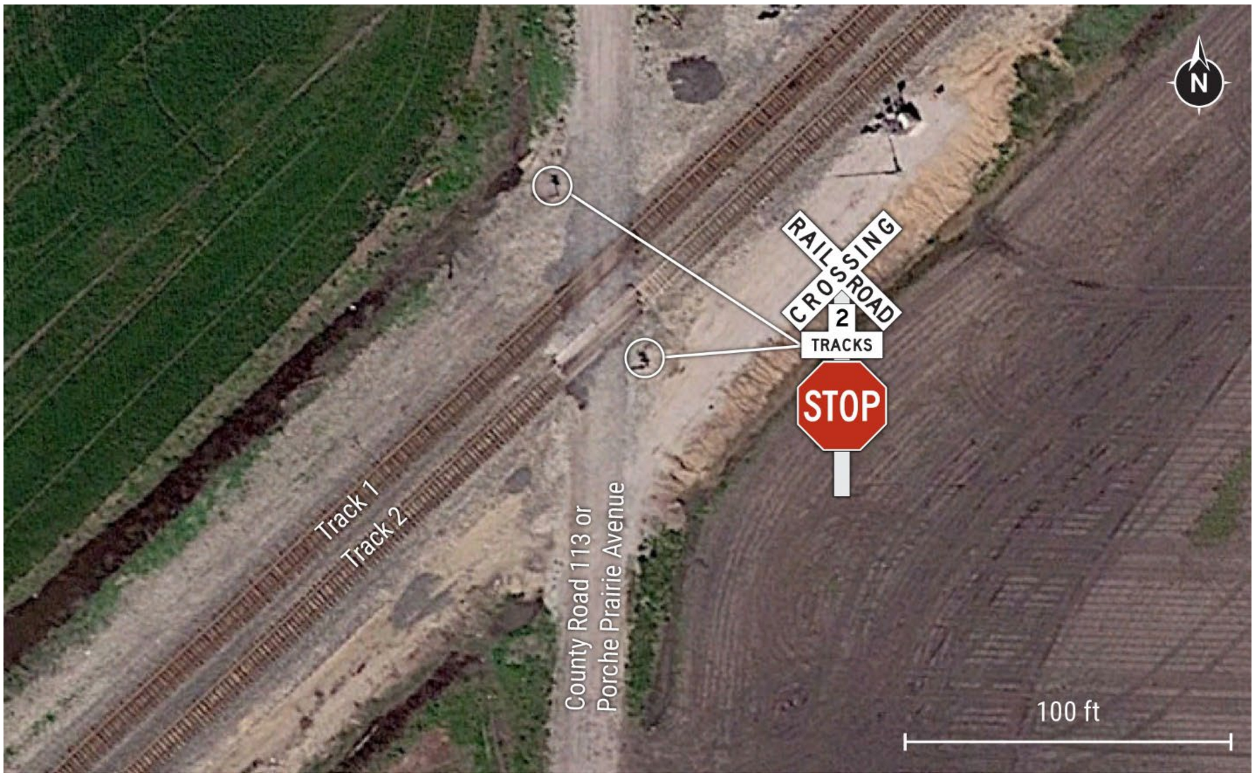

Figure 2. The crossing. (Source: Google Earth.)

According to Amtrak records and manifest information provided to the National Transportation Safety Board (NTSB), Amtrak train 4 was traveling from Los Angeles, California, to Chicago, Illinois, with 12 crewmembers and 271 passengers on board. The crew included an engineer in the lead locomotive and a conductor and assistant conductor in the passenger cars. The train consisted of two locomotives and eight

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[4] The US Department of Transportation Crossing Inventory is a database of intersections between railroad tracks and public highways, roads, streets, or private roadways.

[5] For regulations on active and passive protection devices at crossings, see section 1.7.1 or 49 *CFR* 213.347.

railcars; the railcars were a mix of Superliner I, Superliner II, and Viewliner II coach, sleeper, lounge, dining, and baggage cars.

The truck was a 2007 Kenworth W900B equipped with a manual transmission. It was owned and operated by MS Contracting, an intrastate motor carrier primarily in the business of moving equipment and construction aggregates such as sand, gravel, and crushed stone. The truck was loaded with aggregate at the time of the collision. The driver was the only occupant.

Locomotive event recorder data, along with the engineer's interview with the NTSB, show that the train engineer sounded the locomotive horn at 12:42:36 p.m. near the whistle board positioned 1,328 feet west of the crossing with County Road 113.[6] While the lead locomotive was near the whistle board, the engineer saw a truck approaching the crossing from the south on County Road 113. The train engineer sounded the horn four more times over the next 10 seconds as the train approached the crossing at 89 mph with the throttle in position T1.[7] Data from the lead locomotive's forward-facing onboard image recorder showed the truck traveling about 5–6 mph as it reached and traversed the crossing without stopping.[8] (See figure 3.)[9] When the Missouri State Highway Patrol (MSHP) recovered and examined the truck after the collision, the speedometer needle was stopped about 5 mph and the tachometer was displaying 1,100 rpm. At 12:42:44, the engineer initiated an emergency application of the train's air brakes. The train decelerated to 87 mph before striking the truck within the crossing at 12:42:46 p.m. and derailing.

[6] A *whistle board*, also called a *whistle post*, is a marker that shows where an engineer must sound a horn when approaching a crossing.

[7] Throttle position T1 is the lowest forward setting.

[8] The NTSB calculated the truck's speed based on the framerate of the forward-facing image recorder and an analysis program that superimposed calibration markers over the road.

[9] The aspect ratio of the image has been enhanced for clarity and to more accurately reflect the engineer's view.

Figure 3. Truck in the crossing shortly before collision. (Source: Amtrak.)

Based on the MSHP accident report provided to the NTSB, a witness called 911 and dispatchers notified emergency responders of the crash at 12:45 p.m. Emergency responders arrived on scene at 1:02 p.m. Two passengers from the train's lounge car and the truck driver were pronounced dead at the scene by the Chariton County coroner; a third passenger was pronounced dead at University of Missouri Hospital in Columbia, Missouri. The NTSB's investigation did not definitively identify which railcar the third deceased passenger was in before the collision and derailment. An additional 146 passengers and Amtrak crewmembers were transported to local hospitals for treatment.

The NTSB performed on-scene examinations of derailed equipment on June 28-29, 2022. The NTSB found collision damage to the lead locomotive's left-front bulkhead. (See figure 4.) Distance measurements showed that the train continued moving east after the collision, and the front of the lead locomotive came to rest 1,286 feet east of the crossing. Both locomotives and all eight railcars derailed; seven railcars overturned and came to rest on their right sides.

Figure 4. Damage to the front-left bulkhead of the lead locomotive.

The NTSB's postcollision examination of the truck's wreckage on June 30, 2022, and later review of locomotive image recorder data identified the left-rear sidewall panel of the truck as the point of impact. The collision spun the truck counterclockwise and separated the cab and dump bed from the chassis.

1.2 Before the Collision

1.2.1 Train 4 Movements

The NTSB interviewed the engineer, conductor, and assistant conductor of train 4. Based on these interviews, train 4 departed Kansas City, Missouri, about 9:00 a.m., about 1.5 hours behind schedule.[10] The crew did not report any unusual events or problems with the train or track before the collision.

1.2.2 Truck Movements

On July 19, 2022, MSHP interviewed a truck driver from MS Contracting who was working on the same contract and witnessed the collision from his own truck south of the crossing (hereafter the *witness driver*). Based on this interview, the truck involved in the

[10] Although train 4 originated in Los Angeles, it took on a new crew in Kansas City; this was the crew aboard the train at the time of the collision and derailment.

collision made two previous trips through the crossing on the day of the accident while delivering construction aggregate from a quarry in Huntsville, Missouri, to sites near the Garden of Eden levee system on the Missouri River. On their third trip from the quarry, both drivers stopped for lunch in Brunswick, Missouri, before continuing to the crossing.

1.3 Grade Crossing

1.3.1 Grade Crossing Horizontal Geometry

The crossing where the collision occurred was a passive skew intersection equipped with crossbucks and stop signs.[11] County Road 113 intersected the rail line's two tracks at a 45° angle and ran north to south; the rail line ran northeast to southwest.

The American Association of State Highway and Transportation Officials (AASHTO) notes that skew intersections can result in a driver having to turn their head farther to see approaching train traffic.[12] AASHTO recommends that crossings have an angle of intersection as close as practicable to 90° and no less than 75°.[13]

While conducting sight distance observations on July 1, 2022, the NTSB evaluated the effect of the crossing angle on visibility by positioning an exemplar truck near the crossing and observing approaching eastbound rail traffic. The NTSB found that an observer in the driver's seat had to lean forward and look over their left shoulder to see down the track without the B-pillar obstructing their view.[14] From this position, the observer could see an eastbound freight train near the whistle board. (See figure 5.)

[11] As defined by American Association of State Highway and Transportation Officials (AASHTO) in *A Policy on Geometric Design of Highway and Streets*, 2018, 7th Edition, a *skew* angle is any angle less than 90°.

[12] See AASHTO, *A Policy on Geometric Design of Highways and Streets*, 7th Edition, 2018. Washington, DC: AASHTO.

[13] The crossing involved in the collision predates the records available to the NTSB. It is unclear what, if any, AASHTO or other standards applied at the time of its construction.

[14] The *B-pillar* is the car or truck frame at the rear edge of a front-side window.

Figure 5. An NTSB investigator (left) leans forward to see an eastbound BNSF train (right).

1.3.2 Grade Crossing Vertical Geometry

The NTSB measured the slope of the road grade near the crossing on June 30, 2022. The road grade near the crossing was uphill for approaching highway traffic. Measured 30 feet from the nearside rail, the grade dropped 39 inches (10.8%). The NTSB noted potholes and humps on the gravel road surface on the approach to the crossing. AASHTO recommends that the highway surface near a crossing not slope down more than 3 inches as measured 30 feet from the nearside rail (a 0.83% grade).[15] Based on MSHP measurements of the crossing taken the day of the collision, the road grade flattened about 152 feet south of the nearside rail.

The MSHP interview of the witness driver employed by MS Contracting included questions about navigating the crossing in the witness's vehicle, which was a dump truck with a manual transmission similar to the accident truck. The witness driver stated that the gravel on the grade near the crossing was "spongey" and caused trucks to bounce, and that he did not stop on the sloped grade near the crossing because of the difficulty of accelerating afterward. Instead, he would slow or stop on the flat portion of the grade. When informed of the speedometer and tachometer positions from the truck wreckage (about 5 mph and 1,100 rpm), he characterized the values as similar to the speed and rpm with which he drove through the crossing.

1.3.3 Sight Distance Observations

The NTSB's sight distance observations identified three trees near the tracks west of the crossing and about 30 feet south of track 2. Observations showed that this

[15] See AASHTO, *A Policy on Geometric Design of Highways and Streets*, 7th Edition, 2018. Washington, DC: AASHTO.

vegetation could obstruct a driver's view of an approaching eastbound train if the driver stopped about 50 feet south of the crossing. The vegetation would not obstruct the view from 15 feet south of the crossing.[16]

1.4 Personnel Information

1.4.1 Amtrak Personnel

The NTSB reviewed employment records for the engineer, conductor, and assistant conductor of train 4. The engineer had been employed by Amtrak since January 2, 1992, and had 27 years of experience as an engineer. He had completed his last recertification on January 7, 2021, and his last engineer recertification general knowledge exam on May 19, 2022. When interviewed by the NTSB, he reported feeling rested when he took control of the train about 9:00 a.m. The conductor had about 4 years of experience with Amtrak, and the assistant conductor had about 3 years of experience with Amtrak.

1.4.2 MS Contracting Personnel

The truck driver was employed by MS Contracting. He had a valid Missouri Class A commercial driver's license with no endorsements.[17]

1.5 Postcollision Toxicology Testing

Because the collision occurred at a grade crossing and there were no signs of crew failure to follow operating rules, the train engineer was not required to undergo testing for drugs and alcohol.[18]

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[16] Missouri state law requires vehicles to stop between 15 and 50 feet of a highway-railroad grade crossing when a stop is necessary. See section 1.6.3 for more details on the relevant traffic law.

[17] States issue commercial drivers' licenses to individuals under federal standards. A *Class A* license allows a driver to operate "Any combination of vehicles which has a gross combination weight rating or gross combination weight of 11,794 kilograms or more (26,001 pounds or more) whichever is greater, inclusive of a towed unit(s) with a gross vehicle weight rating or gross vehicle weight of more than 4,536 kilograms (10,000 pounds) whichever is greater" as described on the Federal Motor Carrier Safety Administration "Drivers" webpage, accessible at https://www.fmcsa.dot.gov/registration/commercial-drivers-license/drivers.

[18] See 49 *CFR* 219.201(a)(5) and 49 *CFR* 219.201(b) for testing requirements.

The Boone and Callaway County Medical Examiner's Office requested toxicological testing of a blood specimen from the truck driver. This testing detected ethanol at 0.012 grams per deciliter (g/dL). (The detection threshold for ethanol is 0.010g/dL.) Ethanol is the intoxicating alcohol in beer, wine, and liquor, but ethanol detected in postmortem specimens does not necessarily come from these sources. Ethanol can be produced by microbes in a person's body after death. This is more likely in cases of severe traumatic injury and can cause an affected specimen to test positive for ethanol while another specimen from the same person tests negative.

At the request of the NTSB, the Federal Aviation Administration Forensic Sciences Laboratory also tested specimens from the truck driver.[19] This testing detected ethanol at 0.012 g/dL in blood but did not detect ethanol in urine or vitreous fluid, specimen types which are generally less susceptible to postmortem ethanol production. N-propanol, another alcohol that can be produced by microbes in a person's body after death, was detected in the tested blood specimen.

1.6 Cell Phone Use

The NTSB reviewed phone records for the train engineer's and truck driver's personal cell phones. Records show that the train engineer did not make or answer calls, send text messages, or use an internet connection in the hour before the collision. The records also show that the truck driver did not make or answer calls or send text messages in the hour before the collision; information on internet connectivity was not available.

1.7 Regulations

1.7.1 Grade Crossing Protection

Federal regulations at 49 *CFR* 213.347 require active protection (a warning or barrier system) at highway-railroad grade crossings involving Class 7 track, where the maximum allowable speed for passenger trains is 110 mph. They do not require active protection for Class 5 and 6 track.

[19] The Federal Aviation Administration Forensic Sciences Laboratory tests specimens for a wide variety of substances including toxins, prescription and over-the-counter medications, and illicit drugs.

1.7.2 Horn Use and Testing

Federal regulations at 49 *CFR* 222.21(a) require that a locomotive horn be sounded four times as the locomotive approaches a public highway-railroad grade crossing. Usually, the horn should be sounded between 15 and 20 seconds before the locomotive enters the crossing, as described in 49 *CFR* 222.21(b)(2). However, under 49 *CFR* 221.21(b)(3), if a train is approaching a crossing at more than 60 mph, the horn must be sounded no more than one-quarter mile (1,320 feet) from the crossing even if this reduces the warning time to less than 15 seconds.

Federal regulations for locomotive horns in 49 *CFR* 229.129 state that each locomotive must be equipped with a horn that produces a minimum sound level of 96 decibels, A-weighted (dB(A)), 100 feet forward of the locomotive in its direction of travel.[20] The regulations also provide for testing of new or remanufactured locomotives. Federal Railroad Administration (FRA) test records from 2010 for the lead locomotive involved in the collision showed that the horn could produce a sound level of 101.4 dB(A) as measured 100 feet forward of the locomotive.

1.7.3 Highway Traffic

Missouri state law requires any vehicle driver approaching a grade crossing to operate the vehicle in a manner that allows a stop between 15 and 50 feet of the nearest rail. The driver must stop within this range and not proceed until it safe to do so if "an approaching railroad train is visible and is in hazardous proximity to such crossing" or if "any other traffic sign, device or any other act, rule, regulation or statute requires a vehicle to stop at a railroad grade crossing" (Title 19 *Revised Statutes of Missouri* Section 304.035).

The crossing involved in the collision was equipped with stop signs facing both directions of highway approach.

1.8 Survival Factors

The NTSB conducted on-site examinations of derailed equipment on June 28, 2022. Not all railcars could be safely and thoroughly examined before the equipment was recovered and moved, and the NTSB conducted postrecovery examinations on June 29, 2022. Both sets of examinations found that lower-level window assemblies on the downturned (right) sides of the overturned railcars sustained damage

[20] The unit dB(A) reflects *decibels* (dB) adjusted by *A-weighting*, a mathematical correction that measures audibility better than does the pure sound pressure value given by dB.

from impact with the ground, and that several exterior doors had deformed inward, allowing track ballast and soil to enter the baggage and occupant compartments.[21] The interiors of several passenger cars showed signs of occupant injury.

Two of the passenger fatalities occurred in the vestibule of the lounge car, the seventh piece of equipment in the consist and fifth railcar behind the locomotives. The cause of death was compression asphyxia.[22] Postrecovery examination of windows on the right side identified a circular shatter in a curved window on the upper level and two dislodged windows on the lower level. Roadway ballast and soil had accumulated inside the passenger compartment near the dislodged windows. A right-side door had deformed inward, allowing a 1–4-foot pile of ballast and soil to accumulate in the vestibule where both deceased passengers were found.

The investigation could not identify the original position or circumstances of the third passenger fatality, who was evacuated to a hospital. The cause of death was blunt force trauma.

The NTSB recently completed its investigation of a passenger train derailment involving comparable equipment, damage, injuries, and fatalities. On September 25, 2021, Amtrak train 7 derailed eight railcars near Joplin, Montana.[23] As in the Mendon derailment, the train consist included Superliner I, Superliner II, and Viewliner II coach, sleeper, lounge, dining, and baggage cars; four passenger cars derailed onto their sides. Three passengers were killed, and 49 people were injured. On July 25, 2023, the NTSB reiterated three safety recommendations to the FRA regarding occupant protection in passenger cars:

> 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)
>
> 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)

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[21] *Track ballast* is the material that comprises the track bed, usually gravel or crushed stone.

[22] In *compression asphyxia*, an external force applies pressure to the body and prevents breathing.

[23] For more information, see Railroad Investigation Report NTSB/RIR-23-08, *Derailment of Amtrak Passenger Train 7 on BNSF Railway Track, Joplin, Montana, September 25, 2021*.

> When the research specified in Safety Recommendation R-16-35 identifies safety improvements, use the findings to develop occupant protection standards for passenger railcars to mitigate passenger injuries likely to occur during derailments and overturns. (R-16-36)

The NTSB classified Safety Recommendation R-14-74 Open—Acceptable Response and Safety Recommendations R-16-35 and R-16-36 as Open—Unacceptable response. A summary of the history of these recommendations and FRA actions is included in the Joplin investigation report.[24]

1.9 Postcollision Actions

After the collision, Chariton County closed the involved crossing. In collaboration with the City of Chillicothe and the Missouri Department of Transportation, Chariton County has developed a plan to close several other passive crossings and redesign local roads to direct traffic through active crossings. Chariton County proposed its plan during a public meeting in April 2023 and is in the process of obtaining state or federal funding to make the planned changes. As of July 2023, the Missouri state budget includes $50 million for improving grade crossing safety, and the Missouri Department of Transportation plans to use a portion of those funds to address passive grade crossings.

2 Analysis

2.1 Introduction

In this collision, Amtrak train 4 struck a loaded dump truck that had entered a passive highway-railroad grade crossing without stopping at a stop sign and crossbucks protecting the crossing. Train 4 derailed, and seven passenger cars tipped onto their sides. The truck sustained severe damage. As a result of the collision and derailment, the truck driver and 3 train passengers died; an additional 146 train passengers and crewmembers were transported to hospitals for treatment.

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[24] For more complete information about these recommendations, use CAROL Query or the following links:

R-14-74, classified Open—Acceptable Response
R-16-35, classified Open—Unacceptable Response
R-16-36, classified Open—Unacceptable Response

2.2 Truck Movement through the Crossing

The NTSB's review of forward-facing image recorder data from the lead locomotive showed that the truck proceeded into the crossing without stopping. Missouri state law requires highway traffic to stop between 15 and 50 feet from a highway-railroad grade crossing if the crossing is equipped with a stop sign or if a train is within hazardous proximity—conditions that were both present as the truck neared the crossing before the collision. However, the truck driver maintained a speed of about 5–6 mph through the crossing as shown by image recorder data. The stopped tachometer and speedometer recovered after the collision showed values of about 1,100 rpm and 5 mph, which were consistent with the image recorder data. A driver of a similar dump truck who was familiar with the crossing and saw the collision (the witness driver) characterized this speed and rpm as typical for crossing the tracks. The witness driver also said that he did not usually stop at the crossing as required by Missouri law because the steep grade made starting again difficult. The collision truck driver's movement through the crossing was therefore consistent with how the witness driver would proceed with no train present. This suggests that the driver involved in the collision did not see the train as he approached and entered the crossing.

2.3 Grade Crossing Design Factors

The train's horn was compliant with federal regulations and sounded at the regulation-specified distance from the crossing; the driver was not using a cell phone; toxicological testing did not indicate that the driver was impaired; the train was traveling at an authorized speed; and there were no weather-related risk factors for reduced visibility or audibility. The NTSB identified three design factors relevant to the driver's decision to proceed through the crossing without stopping: the steepness of the road grade, the angle of the intersection, and the presence of vegetation.

The average slope 30 feet from the crossing was 10.8%, as measured by the NTSB on June 30, 2022. This is 13 times the maximum slope recommended by AASHTO in its current standards, and the steepness of the grade made accelerating through the crossing difficult if a truck came to a complete stop as required by Missouri law. The witness driver—who was also employed by MS Contracting and drove a dump truck similar to the one involved in the collision—told MSHP that he normally did not stop on the sloped part of the grade because of the difficulty of starting again. Instead, he slowed or stopped on the level part of the grade, which MSHP measurements from the day of the collision placed 152 feet from the nearside rail, or about three times the maximum distance at which a highway vehicle must stop as required by Missouri law.

The 45° angle of the intersection between the rail line and highway made approaching trains harder for drivers to see. AASHTO standards recommend constructing intersections as close as practicable to 90° and no less than 75°, or 30° more than the crossing involved in the collision. The NTSB's on-site observations with an exemplar truck found that the angle of the crossing caused the B-pillar of the truck to interfere with the driver's vision; the driver had to lean forward and twist far to the left to see an approaching train when near the crossing. Whether the driver of the collision truck used this method or any other to look for approaching trains is unknown. However, the NTSB's observations indicate that the driver's B-pillar would have posed a greater obstacle to the driver seeing an approaching train than it would have at a 90° crossing.

The NTSB's sight distance observations found that three trees west of the crossing and south of the tracks obstructed views of eastbound trains for a driver positioned about 50 feet south of the crossing. The evidence available to the NTSB did not indicate where or whether the collision truck driver attempted to look for trains and therefore whether obstructing vegetation contributed to the collision.

The three risk factors identified in the investigation were properties of the passive crossing's design or environment. After the collision, Chariton County closed the crossing. The county is working with local, state, and federal partners to close other passive crossings and direct highway traffic through active crossings. As of July 2023, the Missouri Department of Transportation plans to fund grade crossing improvements.

2.4 Survival Factors

Postcollision on-site and postrecovery examinations of passenger cars found signs of occupant injuries, dislodged windows, deformed exterior doors, and accumulations of track ballast and dirt within occupant compartments. The NTSB has seen similar survival factors issues in other derailments, which prompted the NTSB to further evaluate them during the investigation of the Joplin, Montana, derailment. In the Joplin derailment, as in Mendon, overturned passenger cars sustained dislodged windows, and debris entered occupant compartments. On July 25, 2023, the NTSB reiterated three related safety recommendations to the FRA addressing passenger car occupant protection: R-14-74, R-16-35, and R-16-36.

3 Probable Cause

The National Transportation Safety Board determines that the probable cause of the collision between Amtrak train 4 and the MS Contracting LLC dump truck was the truck driver proceeding for unknown reasons into the highway-railroad grade crossing without stopping despite the presence of a stop sign and approaching train. Contributing to the collision was the grade crossing's design, which reduced drivers' ability to see approaching trains and made stopping as required by Missouri law difficult for heavy trucks.

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