Collision Between Freight Train and Charter Motorcoach at High-Profile Highway–Railroad Grade Crossing
Biloxi, Mississippi
March 7, 2017

Accident Report

NTSB/HAR-18/01
PB2018-101328

National Transportation Safety Board

NTSB/HAR-18/01
PB2018-101328
Notation 57568
Adopted August 7, 2018

Highway Accident Report

Collision Between Freight Train and Charter Motorcoach at High-Profile Highway–Railroad Grade Crossing Biloxi, Mississippi March 7, 2017

National Transportation Safety Board

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

National Transportation Safety Board. 2018. *Collision Between Freight Train and Charter Motorcoach at High-Profile Highway–Railroad Grade Crossing, Biloxi, Mississippi, March 7, 2017*. Highway Accident Report NTSB/HAR-18/01. Washington, DC.

Abstract: On March 7, 2017, a 2016 Van Hool motorcoach, operated by ECHO Transportation and occupied by a driver and 49 passengers, was traveling northbound on Main Street in Biloxi, Mississippi. The motorcoach stopped in advance of a highway–railroad grade crossing on Main Street that had a high vertical profile. The crossing warning system was not in active mode when the motorcoach approached, stopped, and then moved onto the railroad tracks. As the driver attempted to drive over the crossing, the frame of the motorcoach came into contact with the pavement, and the vehicle became stuck on the crossing. An eastbound freight train operated by CSX Transportation was approaching the crossing. The grade crossing warning system activated when the train was about 29 seconds away. As soon as he became aware of the approaching train, the motorcoach driver opened the vehicle's loading door and told the passengers to evacuate. The train engineer put the train into emergency about 502 feet west of the crossing. About 14 seconds later, the train struck the left side of the motorcoach, pushing it 259 feet down the tracks before coming to a stop, with the motorcoach still in contact with the lead locomotive. Four motorcoach passengers died, the driver and 37 passengers sustained injuries, and 8 passengers were uninjured.

The investigation focused on the safety issues of high-profile grade crossings and emergency egress and extrication. As a result of this investigation, the National Transportation Safety Board (NTSB) makes new safety recommendations to the Federal Highway Administration, Federal Railroad Administration, Mississippi Department of Transportation, City of Biloxi, American Association of State Highway and Transportation Officials, American Railway Engineering and Maintenance-of-Way Association, Association of American Railroads, American Short Line and Regional Railroad Association, and Class I railroads. The NTSB reiterates and reclassifies one recommendation to the Federal Motor Carrier Safety Administration.

For more detailed background information on this report, visit the NTSB investigations website and search for NTSB accident ID HWY17MH010. Recent publications are available in their entirety on the Internet at the NTSB website. Other information about available publications 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.**

Copies of NTSB publications may be downloaded at no cost from the National Technical Information Service, at the National Technical Reports Library search page, using product number PB2018-101328. For additional assistance, contact: National Technical Information Service, 5301 Shawnee Road, Alexandria, VA 22312, (800) 553-6847 or (703) 605-6000 (see NTIS website).

Contents

Figures and Tables ..... **iv**

Acronyms and Abbreviations ..... **v**

Executive Summary ..... **vi**

1 Factual Information **1**
1.1 Crash Narrative 1
1.2 Injuries 3
1.3 Emergency Response, Evacuation, and Occupant Protection 6
  1.3.1 Initial Response 6
  1.3.2 Evacuation of Motorcoach Occupants 6
  1.3.3 Occupant Protection 7
1.4 Motorcoach 7
  1.4.1 Damage 8
  1.4.2 Rear Door 9
  1.4.3 Mechanical Inspection and History 11
  1.4.4 Data Recording Systems 12
1.5 Highway Factors and Railroad Grade Crossing 13
  1.5.1 Traffic Characteristics 13
  1.5.2 Main Street Configuration 14
  1.5.3 Main Street Grade Crossing Signage and Warning Systems 14
  1.5.4 Main Street Grade Crossing Vertical Profile 17
  1.5.5 Main Street Grade Crossing Maintenance and Incident History 19
  1.5.6 Other Grade Crossings in Biloxi 21
  1.5.7 Postcrash Actions 22
  1.5.8 National Grade Crossing Inventory 24
1.6 Railroad Operations 25
  1.6.1 Train Operation 25
  1.6.2 Rail Operation 26
  1.6.3 Train Crew 27
  1.6.4 Recorders 28
1.7 Motor Carrier Operations 29
  1.7.1 Carrier Training Program 29
  1.7.2 State and Federal Oversight 30
  1.7.3 Driver Grade Crossing Guidance 30
1.8 Motorcoach Driver 31
  1.8.1 Licensing, Experience, and Driving History 31
  1.8.2 Medical Certification, Health, and Toxicology 32
  1.8.3 Precrash Activities 32
  1.8.4 Route Selection 33
  1.8.5 Driver's Actions at Crossing and Postcrash Sight Distance Observations 34
1.9 Weather and Roadway Conditions 35

2 Analysis 36
2.1 Introduction 36
2.2 Operator Actions 37
2.2.1 Motorcoach Driver 37
2.2.2 Train Crew 38
2.3 High-Profile Grade Crossings 38
2.3.1 Signage and Reconstruction Guidelines 38
2.3.2 Coordination of Maintenance and Risk Monitoring 42
2.4 Emergency Egress and Extrication 45

3 Conclusions 49
3.1 Findings 49
3.2 Probable Cause 50

4 Recommendations 51
4.1 New Recommendations 51
4.2 Recommendation Reiterated and Reclassified in this Report 53

Appendix A: Investigation 54

References 55

Figures and Tables

Figure 1. Overhead view of crash location and forward view of northbound approach to Main Street grade crossing 2

Figure 2. Motorcoach and train final rest positions 3

Figure 3. Motorcoach seating chart........ 5

Figure 4. Motorcoach postcrash, showing contact damage to the left side 8

Figure 5. Motorcoach interior, showing the buckling of the floor and the lateral displacement of the seats 9

Figure 6. Interior of the motorcoach, showing the three assemblies necessary to open the rear door 11

Figure 7. Diagram of Main Street, grade crossing, and Esters Boulevard north and south of the crossing........ 15

Figure 8. Photograph showing the northbound approach to the grade crossing and cross-section diagram of the measured vertical profile of the approach's slope........ 18

Figure 9. Photograph showing the southbound approach to the grade crossing and cross-section diagram of the measured vertical profile of the approach's slope........ 19

Figure 10. Postcrash view of the northbound approach to the Main Street crossing........ 23

Figure 11. Activities of the motorcoach driver, March 4–7, 2017........ 33

Figure 12. Three alternative routes proposed for the motorcoach to travel from Hollywood Casino in Bay St. Louis to Boomtown Casino in Biloxi 34

Table 1. Injury levels for motorcoach occupants and train crew 4

Table 2. Roadway signs on the northbound Main Street approach to the grade crossing 16

Table 3. National summary of high-profile grade crossings and crash information........ 25

Table 4. Sequence of events near Main Street grade crossing on March 7, 2017, concerning the train's movement, the motorcoach's grounding, and the crash 29

Acronyms and Abbreviations

AAMVA	American Association of Motor Vehicle Administrators
AASHTO	American Association of State Highway and Transportation Officials
AREMA	American Railway Engineering and Maintenance-of-Way Association
BASICs	Behavior Analysis and Safety Improvement Categories
BFD	Biloxi Fire Department
BPD	Biloxi Police Department
CDL	commercial driver's license
CFR	*Code of Federal Regulations*
CSXT	CSX Transportation
DOT	[state] department of transportation
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
GPS	global positioning system
GVWR	gross vehicle weight rating
IC	incident commander
LGCGC	low ground clearance grade crossing
MDOT	Mississippi Department of Transportation
MUTCD	*Manual on Uniform Traffic Control Devices for Streets and Highways*
NHTSA	National Highway Traffic Safety Administration
NO&M	New Orleans & Mobile (CSXT railroad subdivision)
NTSB	National Transportation Safety Board
TRB	Transportation Research Board
TxDPS	Texas Department of Public Safety
US-90	US Route 90
USC	*United States Code*
USDOT	US Department of Transportation

Executive Summary

Investigation Synopsis

On Tuesday, March 7, 2017, about 2:11 p.m. central standard time, a 2016 Van Hool motorcoach, operated by ECHO Transportation and occupied by a 60-year-old driver and 49 passengers, ranging in age from 50 to 88, was traveling northbound on Main Street in Biloxi, Mississippi, having departed that afternoon from a casino in Bay St. Louis, Mississippi, to travel to a casino in Biloxi. The motorcoach stopped in advance of a highway–railroad grade crossing on Main Street that had a high vertical profile.

The grade crossing was marked with (1) a crossbuck, (2) warning lights that would activate at a train's approach, (3) a gate arm that would lower at a train's approach, and (4) a low ground clearance grade crossing warning sign with a "LOW GROUND CLEARANCE" plaque below it on the signpost. The crossing warning system was not in active mode when the motorcoach approached, stopped, and then moved onto the railroad tracks. As the driver attempted to drive over the crossing, the frame of the motorcoach came into contact with the pavement, and the vehicle became stuck on the crossing. The driver moved the motorcoach back and forth in an attempt to dislodge it from the crossing but was unsuccessful.

As the motorcoach became stuck on the crossing, an eastbound freight train operated by CSX Transportation was approaching the crossing at a recorded speed of 27 mph while continuously sounding its warning horn. The grade crossing warning system activated when the train was about 29 seconds away; first, the warning lights began to flash, and then the gate arm began to descend 3 seconds later. As soon as he became aware of the approaching train, the motorcoach driver opened the vehicle's loading door and told the passengers to evacuate. Due to their age and limited mobility, the passengers' evacuation was slow and the aisleway became congested; only six passengers had safely evacuated before the train struck the grounded motorcoach.

The train engineer told investigators that he had noticed the motorcoach on the tracks ahead, but he expected it to clear the crossing before the train reached it. Once the engineer realized that the motorcoach might not clear the tracks, he put the train into emergency about 502 feet west of the crossing. About 14 seconds later, by which time the train had decelerated to about 19 mph, it struck the left side of the motorcoach, pushing it 259 feet down the tracks before coming to a stop, with the motorcoach still in contact with the lead locomotive. Four motorcoach passengers died, the driver and 37 passengers sustained injuries, and 8 passengers were uninjured. The train crewmembers were uninjured.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the Biloxi, Mississippi, crash was the failure of CSX Transportation and the City of Biloxi to coordinate and take action to improve the safety of the Main Street grade crossing, a high vertical profile crossing on which motor vehicles were known to ground frequently; their inaction led to the grounding of the motorcoach that was subsequently struck by the CSX Transportation freight train. Contributing to the circumstances of the crash was the inadequate guidance from the Federal Highway Administration on how to mitigate the risks posed by grade crossings with high vertical profiles.

Safety Issues

The crash investigation focused on the following safety issues:

- ***High-profile grade crossings***. No current guidelines for high-profile grade crossings (1) describe the conditions under which signage that selectively excludes certain vehicle types from using the crossing should be installed or (2) define when a crossing should be reconstructed (or otherwise have its safety risk mitigated) due to its unsafe vertical profile. Also, railroad companies are not required to coordinate their maintenance plans with local and state highway transportation agencies, and crossing safety risk is not effectively monitored. The report explores approaches to improve grade crossing safety by addressing these deficiencies.
- ***Emergency egress and extrication***. The motorcoach was equipped with a secondary door in the rear, which was not used for emergency egress or passenger extrication. Had the rear door been used, it most likely would have expedited the postcrash extrication of the passengers. The report discusses pretrip safety briefings that might be used to enhance passengers' awareness of the secondary door as an emergency egress point and extrication route.

Recommendations

As a result of this investigation, the National Transportation Safety Board (NTSB) makes new safety recommendations to the Federal Highway Administration, Federal Railroad Administration, Mississippi Department of Transportation, City of Biloxi, American Association of State Highway and Transportation Officials, American Railway Engineering and Maintenance-of-Way Association, Association of American Railroads, American Short Line and Regional Railroad Association, and Class I railroads. The NTSB reiterates and reclassifies one recommendation to the Federal Motor Carrier Safety Administration.

1 Factual Information

1.1 Crash Narrative

On Tuesday, March 7, 2017, about 2:11 p.m. central standard time, a 2016 Van Hool motorcoach, operated by ECHO Transportation and occupied by a 60-year-old driver and 49 passengers, ranging in age from 50 to 88, was traveling northbound on Main Street in Biloxi, Mississippi.[1] The motorcoach's trip was part of a charter tour for senior citizens organized by Diamond Tours. This segment of the tour was taking the passengers from Hollywood Casino in Bay St. Louis, Mississippi, to Boomtown Casino in Biloxi.[2] The motorcoach stopped in advance of a highway–railroad grade crossing that had a high vertical profile.[3]

This active grade crossing was marked with (1) a crossbuck, (2) warning lights that would activate at a train's approach, (3) a gate arm that would lower at a train's approach, and (4) a low ground clearance grade crossing (LGCGC) warning sign with a "LOW GROUND CLEARANCE" plaque below it on the signpost (see figure 1).[4] The crossing warning system was not in its active mode when the motorcoach approached the crossing, stopped, and then moved onto the railroad tracks. As the driver attempted to drive across the grade crossing, the vehicle's frame came into contact with the pavement north of the railroad tracks, and the motorcoach became grounded on the crossing.[5] The driver moved the motorcoach back and forth to try to dislodge it, but he was unsuccessful.

[1] Unless otherwise indicated, all times cited in the report are central standard time.

[2] The trip and the route selection are discussed in section 1.8.4.

[3] Such grade crossings are known as "high-profile," "hump," or "humped" crossings.

[4] According to the Federal Railroad Administration (FRA), an active grade crossing consists of active warning and control devices such as bells, flashing lights, and gate arms that lower and rise, in addition to passive warning devices such as crossbucks.

[5] In this report, "grounding" refers to a significant contact between a vehicle frame and the surface of a grade crossing such that it prevents vehicle movement. Other terms describing such contact are "stuck" and "lodged."

Figure 1. Overhead view of crash location (top) and forward view of northbound approach to Main Street grade crossing (bottom).

While the motorcoach was stuck on the crossing, an eastbound freight train operated by CSX Transportation (CSXT)—comprising 3 locomotives, 27 loaded cars, and 25 empty cars—was approaching the crossing at a recorded speed of 27 mph with its horn continuously sounding, its headlights on, and its auxiliary lights flashing.[6] The grade crossing warning devices activated when the train was about 29 seconds away; first, the crossing warning lights began flashing, and then the crossing gate arms began to descend 3 seconds later. As soon as he became aware of the approaching train, the motorcoach driver opened the loading door and told the passengers to evacuate. Because of the passengers' age and limited mobility, the evacuation was slow and the aisleway became congested; only six passengers had safely evacuated before the train struck the grounded motorcoach.

[6] The train had left New Orleans, Louisiana, that morning, and its final destination was Waycross, Georgia.

The train engineer later said that he had noticed the motorcoach on the tracks, but he expected it to clear the crossing before the train arrived there. As soon as the engineer realized that the motorcoach was not clearing the tracks, when the train was about 502 feet west of the crossing, he put the train into emergency braking. About 14 seconds later, by which time it had decelerated to about 19 mph, the train struck the left side of the motorcoach, pushing it 259 feet down the tracks before coming to a stop, with the motorcoach still in contact with the lead locomotive (see figure 2).[7]

Figure 2. Motorcoach and train final rest positions. (Source: Biloxi Police Department)

1.2 Injuries

As a result of this crash, 4 motorcoach passengers died, the driver and 21 passengers sustained serious injuries, 16 passengers received minor injuries, and 8 passengers were uninjured. The train engineer and the conductor were also uninjured. Table 1 summarizes the distribution of injury severity.

[7] For additional information about the train's movement and the engineer's actions, see section 1.6.

Table 1. Injury levels for motorcoach occupants and train crew.[a]

	Fatal	Serious	Minor	None	TOTAL
Train crew	--	--	--	2	2
Motorcoach driver	--	1	--	--	1
Motorcoach passengers	4	21	16	8	49
TOTAL	4	22	16	10	52

[a] Although 49 *Code of Federal Regulations* (CFR) Part 830 pertains to the reporting of aircraft accidents and incidents to the National Transportation Safety Board (NTSB), section 830.2 defines fatal injury as any injury that results in death within 30 days of the accident, and serious injury as any injury that (1) requires hospitalization for more than 48 hours, commencing within 7 days from the date of injury; (2) results in a fracture of any bone (except simple fractures of fingers, toes, or nose); (3) causes severe hemorrhages, nerve, or tendon damage; (4) involves any internal organ; or (5) involves second- or third-degree burns, or any burn affecting more than 5 percent of the body surface.

Video from an interior-facing camera on the motorcoach showed that three of the passengers who died were attempting to exit the motorcoach when the train struck it.[8] One of those passengers had just stepped down from the loading door, while the other two were in the loading area and were ejected at impact; all three passengers were subsequently struck by the motorcoach and the locomotive. The fourth passenger who died was standing in the rear of the motorcoach, in the aisleway by row 14. He died as a result of cervical vertebrae fractures sustained at impact.

The 22 seriously injured motorcoach occupants sustained multiple blunt force injuries, including fractures, head injuries, and internal organ lacerations. The 16 passengers with minor injuries generally sustained contusions and abrasions. Of the eight motorcoach passengers who were uninjured, six had evacuated before the crash.

Based on interviews with the surviving passengers and video from the interior-facing onboard camera, at the time of impact, 42 passengers were on the motorcoach; 23 were standing and 19 were seated. One passenger had stepped off the motorcoach just before the train struck it. As indicated in figure 3, the distribution of nonfatal injuries was similar among the seated and standing passengers, but their location within the motorcoach had a much greater effect on the extent of their injuries. The distribution of injury severity shows that most of the passengers—18 of 21—who sustained serious injuries were located in the front half of the motorcoach (row 7 and forward). Of the 20 passengers who were in the rear half of the motorcoach, 1 died, 3 received serious injuries, 14 received minor injuries, and 2 were uninjured.

[8] The motorcoach was equipped with Lytx DriveCam, an event-based driver-monitoring video system. For more details, see section 1.4.4.

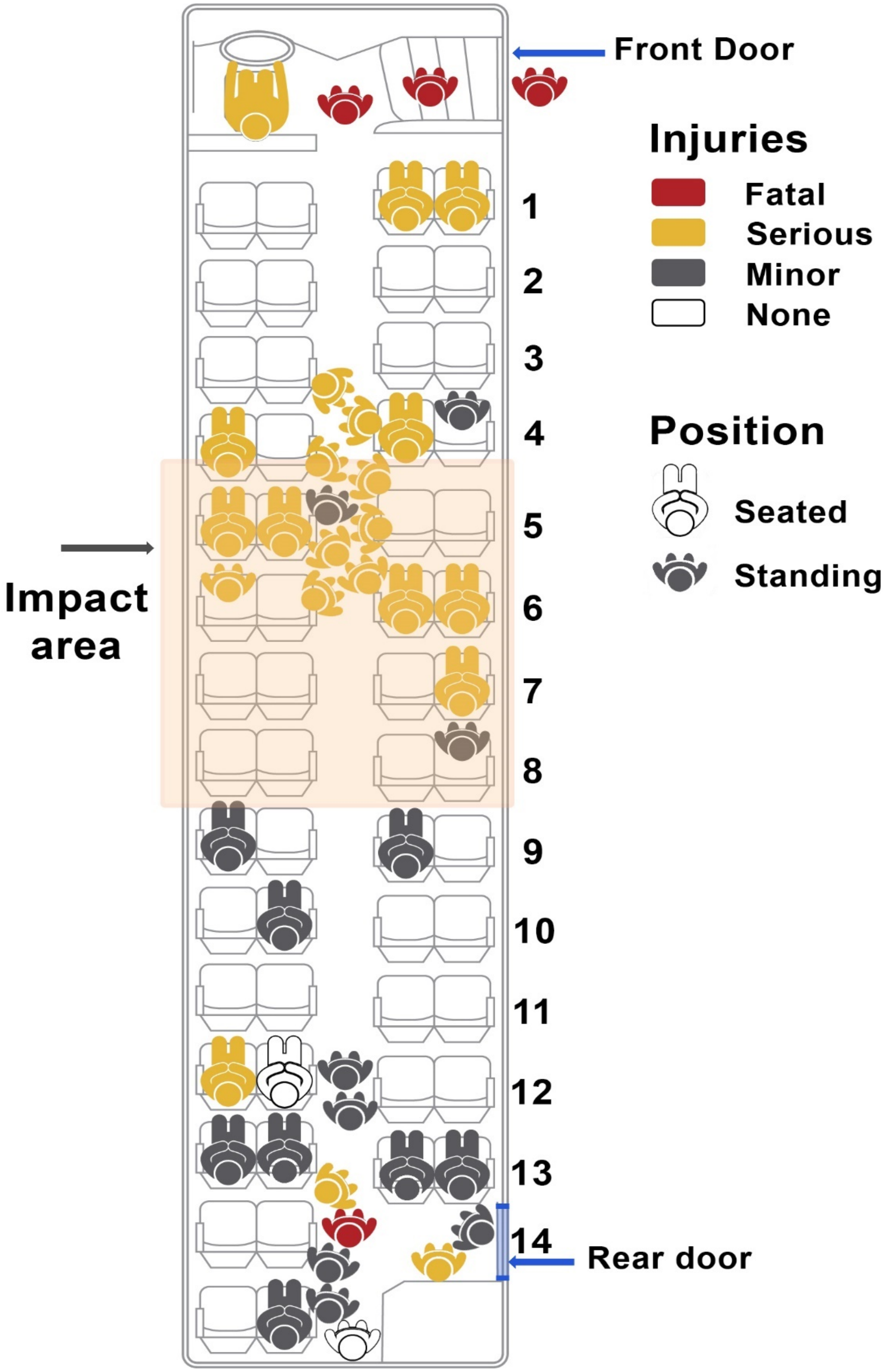

Figure 3. Motorcoach seating chart, showing the injury classifications and positions of the motorcoach driver and 43 passengers who were on or just outside the vehicle at the time of impact.

1.3 Emergency Response, Evacuation, and Occupant Protection

1.3.1 Initial Response

The City of Biloxi emergency communication center received a 911 call about the crash at 2:12 p.m.; the dispatcher immediately notified Biloxi Police Department (BPD) patrol units, the first of which arrived on the scene at 2:13 p.m. The first engine unit from the City of Biloxi Fire Department (BFD) was dispatched at 2:13 p.m.; this unit, which included the fire chief, arrived on the scene at 2:17 p.m. The fire chief assumed the role of incident commander (IC) upon arrival and declared a mass casualty incident. The BFD dispatched to the scene a total of eight engine units, two truck companies, one rescue truck, and one medivac unit.

Keesler Air Force Base, located minutes from the crash location, sent two ambulances to the scene, as well as additional physicians to a local hospital to help with incoming trauma patients. American Medical Response and Acadian Ambulance Services, which are the contracted emergency service providers for the area surrounding the crash, dispatched eight ambulances. American Medical Response transported 24 motorcoach occupants to area hospitals, and Acadian Ambulance Services transported 16 occupants. Although three medivac helicopters were dispatched to the scene, only one transported a passenger. The last motorcoach occupant was transported to a local hospital at 3:20 p.m.

The City of Biloxi has an emergency management plan based on the national incident management system and incident command system. As part of the plan, the City of Biloxi conducts annual disaster drills with neighboring jurisdictions, city agencies, and Keesler Air Force Base. The last drill before the crash was held on February 16, 2017.

1.3.2 Evacuation of Motorcoach Occupants

1.3.2.1 Preimpact. During postcrash interviews, several passengers reported having been alerted to the train's approach by the sound of its horn and the activation of the warning bells and lights at the crossing, as well as by the sound of the crossing arm striking the side of the motorcoach.[9] Passengers reported that, moments after they informed the motorcoach driver of the approaching train, he opened the loading door and told everyone to evacuate. The driver said that he heard the crossing warning bells after he had opened the loading door to permit passenger evacuation. The driver could not recall how many passengers had exited the motorcoach before the train struck.

After the crash, NTSB investigators measured the distance of the bottom step of the loading bay from the ground, using an exemplar motorcoach positioned as close as possible to the location of the crash motorcoach at the time of impact; the height from the ground was 22 inches.[10] The distance from the bottom step to the ground and the passengers' limited mobility (due to age) slowed the evacuation; as a result, many passengers were queued in the aisleway when the crash occurred. Several passengers reported that, having been unable to exit due to the congested aisleway, they moved to the back of the motorcoach to avoid the immediate impact area; others

[9] See section 1.6.4 for additional information about the activation times of the grade crossing warning system.

[10] In the grounded position, the loading door of the crash-involved motorcoach would have been positioned several inches north of the same door on the exemplar motorcoach, which would have made the distance between the ground and the crash motorcoach's bottom loading bay step several inches greater. (On a flat surface, the distance from the bottom step of the loading bay to the ground measured 12 inches.)

elected to remain seated and braced for impact. A small group of passengers was standing near the rear door as the train approached; they later told investigators that they had been unaware of the door's presence.

1.3.2.2 Postimpact. Several passengers reported that, when the motorcoach came to rest, the aisleway was blocked by fallen and injured passengers. First responders initially entered through the loading door and evacuated those passengers who were in the front of the motorcoach. Because multiple injured passengers were lying in the aisleway, blocking access to the rest of the motorcoach, first responders also entered through the rear windows to reach the injured passengers in the rear. First responders extricated these rear passengers or assisted them to exit through the windows; they helped some to climb down ladders placed against the side of the motorcoach. Several passengers had to be placed on backboards before they were evacuated and, due to the limited space available inside the motorcoach, their extrications were challenging.

Although the motorcoach was equipped with a secondary door in the rear, first responders were unable to open it. Because of the prolonged extrication process, the IC ordered the removal of the rear door to speed passenger evacuation. Two passengers were ultimately extricated through the rear door opening. (Section 1.4.2 discusses the rear door in additional detail.)

1.3.3 Occupant Protection

The motorcoach driver seat and all its passenger seats were equipped with lap/shoulder belts.[11] The driver and seven of the passengers reported having used the available lap/shoulder belts during a portion of the crash trip. Only two passengers reported having been belted at the time of the crash.[12]

The motorcoach driver had given a pretrip safety briefing to the primary group of passengers on the first day of travel—March 5, 2017—when he collected them in Bastrop, Texas. The briefing included a description of the emergency exit windows and an explanation of the use of lap/shoulder belts. The driver did not mention the rear door. Most of the passengers were members of a senior center in Bastrop, but some—friends of senior center members—were from Sealy, Texas. After beginning the trip in Bastrop, the motorcoach stopped in Sealy to pick up these passengers. When collecting the Sealy passengers, the driver did not provide a second pretrip briefing.

1.4 Motorcoach

The 56-passenger 2016 Van Hool CX 45 motorcoach was equipped with a Detroit Diesel DD13 500-horsepower engine and an Allison WTB500 automatic transmission. The motorcoach had a gross vehicle weight rating (GVWR) of 54,000 pounds, a wheelbase of 29.5 feet, and an overall length of 45.5 feet. It had 15 rows of passenger seats on the left (driver) side and 13 rows on the right side.

[11] Although not a factor in this crash, several seat belt buckles were not functional. Van Hool is working to reengineer the buckle or to find a new seat belt supplier.

[12] One of the two belted passengers was seated in the window seat on the right side in row 7 and sustained serious injuries; the other belted passenger was seated in the aisle seat on the right side in row 9 and received minor injuries.

1.4.1 Damage

1.4.1.1 External. The motorcoach sustained significant contact damage on the left side, which began about 16.3 feet from the rear and extended forward about 9.3 feet (see figure 4). The maximum lateral displacement occurred about 22.7 feet from the rear, where the left sidewall intruded 27 inches. This maximum intrusion was in the region of rows 5 through 7. The luggage compartment door just forward of the rear axle was displaced and the compartment door to its left was folded toward the front of the motorcoach. The location of the impact damage on the left side indicated that the front of the motorcoach was about 20.4 feet past the north side of the rail tracks when the locomotive struck it. The front end sustained no crash damage.

Figure 4. Motorcoach postcrash, showing contact damage to the left side.

On the motorcoach's right side, the sidewall was bowed out in the area corresponding to the impact on the left side. The maximum lateral displacement occurred about 25.7 feet from the rear of the motorcoach, where the right sidewall bowed outward about 18 inches.

1.4.1.2 Interior. The driver seat was intact, and the steering wheel was undamaged. The front interior of the motorcoach, up to about row 4, was largely undamaged, and the aisleway in this area retained its original width of 17 inches. Extensive interior damage began at row 5 on the left side and extended to slightly beyond row 8 (see figure 5). The area of these four rows showed evidence of intrusion that reduced the overall interior width of the motorcoach, sidewall to sidewall, by 16 inches. The aisle in this area decreased in width from 17 inches to 8 inches. As a result of the impact, the motorcoach floor buckled, starting in the aisleway at row 4. The floor in front of the seats in row 5 on the right side had buckled and partially collapsed, creating an opening in the floor that extended into the row 6 seats on the right side. As a result of this floor collapse, the aisle seat in row 5 on the right side had dropped about 2 inches below the floor level, intruding into the luggage compartment. The upward buckling of the floor in row 5 raised the floor level at this location by about 12 inches.

Figure 5. Motorcoach interior, showing the buckling of the floor and the lateral displacement of the seats.

1.4.1.3 Windows. The motorcoach was equipped with seven windows on each side, four of which on each side were configured as emergency exit windows. Four windows on the left side were displaced, two were partially pushed out of their frames, and one was removed during the extrication process.[13] The windshield, which consisted of two panes, had its left pane displaced; the right pane was intact. Two of the seven windows on the right side were missing from their frames; others were intact.[14] The motorcoach was equipped with two roof hatches above the aisleway, located above the third and twelfth rows of seats, respectively; the hatches were intact and closed.

1.4.2 Rear Door

The motorcoach was equipped with a secondary door in the rear, between the lavatory and the seatback of the last row of seats on the right side. The clearance between the lavatory wall and the back of the seatback was 17 inches. Using an exemplar motorcoach positioned as close as possible to the location of the crash motorcoach at the time of impact, NTSB investigators measured the distance from the motorcoach floor at the rear door to the ground as 4 feet 8 inches.

Van Hool originally designed the rear door on this model motorcoach for two potential uses: (1) operation/access for wheelchairs (per the Americans with Disabilities Act) or (2) secondary egress (this use is only possible when the wheelchair restraints are not prohibiting access to the rear door). Although the rear door can be used for either purpose, the purchasing motor carrier determines its configuration.

[13] Two of the displaced windows were emergency exit windows, and both of the windows that were partially pushed out of their frames were emergency exit windows.

[14] One of the displaced windows was an emergency exit window.

The rear door on the crash motorcoach was not configured for wheelchair access, and ECHO Transportation did not use it as a wheelchair access point. ECHO Transportation told investigators that it did not intend the door to be used for emergency access, because this was not required by US regulations. The door's design, however, made it a possible secondary egress point.

Secondary exit doors for motorcoaches are permitted but not required under the *Federal Motor Vehicle Safety Standards*. According to the standards, buses with GVWRs greater than 10,000 pounds are required to provide side emergency exit windows and to have optional configurations for other emergency exits in their midportion or rear.[15] The standards permit motorcoaches with a rear engine to have at least one emergency roof exit hatch instead of a rear exit door. The crash motorcoach, with its two roof hatches, met the requirements for emergency egress without the rear door.

In the European Union, a bus such as the crash motorcoach would be required to have at least two service doors, or one service door and one emergency exit door.[16] Van Hool motorcoaches with the same configuration of windows and doors as the crash motorcoach are sold in Europe and are considered to meet European Union requirements.

On the crash motorcoach, placards above, on the wall next to, and on the rear door indicated how to unlock the rear door. The wording on the placards is provided below in italics:

> Above the door: *EMERGENCY DOOR RELEASE* [turning this valve dumps the air that holds the door pistons in place]
>
> On the wall beside the door: *DOOR HANDLE FOR EMERGENCY USE ONLY* [once removed from this fixture, the door handle can be inserted into the handle placement fixture below to open the rear door]
>
> On the door just below the window: *REMOVE HANDLE WHEN DOOR IS SECURED* [putting the door handle onto the fixture at this location allows the handle to turn and open the rear door]

Turning the valve to release the emergency door, obtaining the door handle, and putting the handle into the release fixture (and turning it) opens the rear door. No driver action is required to open the rear door from the inside, but it can be opened only when the motorcoach speed is below 5 mph. Figure 6 shows the rear door and the elements required for its release.

---

[15] The crash motorcoach met the criteria for a commercial vehicle, per 49 CFR 390.5, and for a bus with a designed seating capacity greater than 10 persons, per 49 CFR 571.3.

[16] Section 7.6 of Economic Commission for Europe Regulation 107 defines various acceptable exit configurations, based on vehicle type and passenger capacity.

Figure 6. Interior of the motorcoach, showing the three assemblies necessary to open the rear door.

According to a passerby who entered the motorcoach after the crash but before the arrival of emergency responders, he attempted to open the rear door from inside the vehicle. He reported taking the handle that he saw mounted on the wall of the lavatory and placing it on the door in an attempt to open it, but he was unsuccessful.[17]

If the rear door is locked, it cannot be opened from outside the motorcoach. When the first responders attempted to open the rear door from the outside, they found it locked. Once inside the motorcoach, they were unable to locate the emergency door handle and could not open the door.[18]

1.4.3 Mechanical Inspection and History

NTSB investigators performed functional checks of the motorcoach's steering, electrical, suspension, and braking systems, and they examined its tires and wheels. They found no damage to any steering or electrical system components. The suspension system included (1) a "kneeling system" that allows a driver to lower the vehicle's front end to facilitate loading/unloading of passengers, and (2) a rear-lift system that enables a driver to increase the height of the rear suspension air springs, elevating the rear of the motorcoach by 4 inches. At the time of the crash, the kneeling system was not engaged, but the rear-lift system was engaged.[19] Investigators found no evidence of damage or defects affecting the suspension system. The motorcoach was equipped with pneumatic antilock brakes on all axles. Examination of the brake components, including the linings, showed that they were within specifications. The tread depths on the tires were sufficient to meet minimum requirements, and no noncollision defects were found on any tires or wheels.[20]

[17] The attempt to open the rear door was most likely unsuccessful because the passerby did not release the emergency door valve.

[18] First responders later found the handle in debris.

[19] Investigators examined whether raising the rear of the motorcoach affected the height of the front of the vehicle but found it unchanged.

[20] Title 49 CFR 393.75(b) provides requirements for the minimum tread depths for tires on various axles.

The motorcoach had passed its most recent annual inspection on April 7, 2016. The service records indicated regular maintenance and repair. The motorcoach was not subject to any safety recalls.

1.4.4 Data Recording Systems

1.4.4.1 Global Positioning System. The motorcoach driver used his personal global positioning system (GPS) device—a Garmin DEZL 570MT—for navigation; the device was found in the motorcoach postcrash. Although the GPS device was damaged, its data were retrievable. Data from the GPS showed that the motorcoach reached the stop line of the Main Street grade crossing at 2:11:08 p.m. This time corresponds to about 35 seconds before the crash, based on the clock from the locomotive's forward-facing camera (see section 1.6.4 for more details on train recorders).[21] The GPS recorded three coordinate points at this location—12 and 31 seconds apart—showing the motorcoach arriving at the stop line, being on the tracks, and being about 20 feet north of the tracks.[22]

The Garmin DEZL 570MT is designed to aid in the navigation of commercial vehicles, such as a motorcoach. A driver can input the dimensions of a vehicle, which allows the system to navigate it away from routes with conflicting limitations, such as height restrictions.[23] Although the device can display warning signs that are present in the environment, the system does not avoid routing vehicles over high-profile grade crossings, unless prohibitory signs are present.[24]

Using the same model Garmin GPS, NTSB investigators inputted the dimensions of the crash motorcoach and tested the device's navigation by monitoring and documenting the suggested directions while driving from Hollywood Casino in Bay St. Louis to Boomtown Casino in Biloxi. After reaching US Route 90 (US-90), the GPS device suggested a route that included traversing the Main Street grade crossing.[25] When approaching the crossing, the device sounded an auditory alert and its screen depicted the railroad tracks and showed an LGCGC warning in the upper right corner. When the warning was tapped, the device screen displayed a banner across its top that read "Risk of Grounding."

NTSB investigators contacted HERE Technologies, which provides Garmin with geospatial mapping data. HERE stated that the Main Street grade crossing has been present in its database since at least August 2013, when the information about the LGCGC warning sign at this

---

[21] Although the GPS clock was not synchronized with the clocks from the locomotive recorders and the recorded location represented a midpoint of the accuracy diameter, NTSB investigators determined that the time of the motorcoach's approach to the railroad tracks about 35 seconds before the crash was reasonably consistent with data from the train recorders.

[22] According to Garmin, its GPS devices are accurate within 10 meters, and possibly within an even narrower range, depending on the number of satellites the device is tracking. If the calculated GPS location is outside the roadway, the reported location typically corrects the vehicle position to the nearest roadway location.

[23] The driver reported that he selected the commercial vehicle operation mode and inputted the motorcoach's dimensions into the GPS device. The device was damaged in the crash, which kept investigators from verifying the mode of operation at the time of the crash.

[24] The capability of the GPS to display warning signs that are present in the environment or to restrict navigation over certain grade crossings depends on whether the device is accessing the latest data, such as information that a specific grade crossing has a sign prohibiting transit by certain vehicles.

[25] Although the Garmin unit that the NTSB investigators tested was the same model GPS device as the one used by the motorcoach driver, it was running a newer software version. NTSB investigators were unable to roll back the older version of the software onto the test device or to find an identical unit still using the older software.

location was added. In January 2015, HERE added information about this grade crossing's protected status—the presence of the crossing gates.[26]

1.4.4.2 Engine Control Module. The motorcoach engine was controlled by a Detroit Diesel Electronic Control IV system, which can store vehicle parameters and record trip activity, including diagnostic information associated with engine or sensor faults. The module can also store last stop events, which are recorded when the vehicle stops and idles for at least 2 minutes or when it stops and the engine powers off. The extracted data from the control module showed that the motorcoach stopped at 2:11:55 p.m., which corresponds to the approximate time the motorcoach came to its final rest.

1.4.4.3 Lytx DriveCam. The motorcoach was also equipped with Lytx DriveCam, a monitoring and recording device that continually tracks driving performance metrics and records pertinent information when triggered by critical events, such as stability control or hard braking.[27] The DriveCam was mounted near the midpoint on the left edge of the right windshield pane (near the center of the full windshield); the device included a two-channel image recorder for recording video from forward- and interior-facing cameras. The extracted data showed that the DriveCam system captured crash-relevant information, including 8 seconds of video data from both cameras.

The video from the motorcoach's interior-facing camera shows 8 seconds of preimpact and 4 seconds of postimpact events. The beginning of the video shows the open loading door, and four passengers evacuate through the door before the train strikes the motorcoach. Based on postcrash interviews with motorcoach occupants and autopsy records, three of those passengers evacuated to a safe distance, and one died. The video also shows two passengers attempting to evacuate from the loading door area and their being ejected through the door at impact; both of these passengers died. This video does not show the other three passengers who safely evacuated before the start of the recording.

1.5 Highway Factors and Railroad Grade Crossing

1.5.1 Traffic Characteristics

1.5.1.1 Highway. The Gulf Regional Planning Commission collects traffic volume information for the Main Street crossing about every 3 years; the last collection was completed in 2016. At the request of NTSB investigators, the City of Biloxi conducted a traffic count for the Main Street grade crossing on July 15, 2017. The traffic count indicated daily traffic of 2,117 vehicles, 99 percent of which were cars and similar noncommercial vehicles.[28] The speed limit on this section of Main Street was 25 mph.

[26] Following the crash, the City of Biloxi installed a sign at the Main Street grade crossing prohibiting certain vehicle types from using that crossing (see section 1.5.7). Once information about the prohibitory sign is in the HERE database, an up-to-date commercial navigation device would not suggest a route using the Main Street grade crossing for the prohibited vehicle types.

[27] The threshold for triggering a stability control event is lateral movement of at least 0.4 g (force of gravity); for a hard-braking event, the trigger is a 9-mph deceleration in 1 second.

[28] This count was conducted after the City of Biloxi took the postcrash action of placing selective exclusion signs prohibiting certain vehicle types from transiting the crossing (see section 1.5.7).

1.5.1.2 Railroad. The average daily train volume at the Main Street grade crossing was 12.5 trains in 2016; it was 11.5 trains in 2017. The speed limit on this section of the railroad tracks, as established by CSXT, was 45 mph.

1.5.2 Main Street Configuration

Main Street is a north–south road that crosses the tracks at railroad milepost 726.6. The grade crossing is bordered to the north and south by Esters Boulevard, two streets of the same name that run parallel to the tracks on both sides. (This report refers to the parallel streets as Esters Boulevard N and Esters Boulevard S, to indicate their positions relative to the tracks.)

1.5.2.1 South of Esters Boulevard S. South of Esters Boulevard S, each direction of travel on Main Street consists of a single 11-foot-wide travel lane, a single 5-foot-wide bicycle lane, and an 8-foot-wide parking lane. The two directions of travel are separated by two 4-inch-wide solid yellow pavement stripes; the bicycle lanes in both directions are separated from both the travel lane and the parking lane by 4-inch-wide solid white stripes.

1.5.2.2 Between Esters Boulevard S and N. Between Esters Boulevard south and north of the tracks, Main Street consists of a 12-foot-wide northbound and a 16-foot-wide southbound lane of travel. The two lanes are delineated by two 4-inch-wide solid yellow pavement stripes.[29]

1.5.3 Main Street Grade Crossing Signage and Warning Systems

The northbound approach to the Main Street grade crossing includes multiple signs and warning systems notifying roadway users of the upcoming grade crossing. The warning features include pavement markings, warning signs, and an active grade crossing warning system.

1.5.3.1 Pavement Markings. The northbound approach to the Main Street grade crossing is marked with a grade crossing pavement symbol, about 155 feet south of the railroad tracks (see figure 7). The southbound approach (north of the tracks) is not marked with a grade crossing pavement symbol. Both the northbound and southbound approaches to the crossing have worn, but visible, 2-foot-wide white stop lines. The line is located about 22.5 and 23 feet, respectively, from the nearest rail track on the northbound and southbound approaches.

[29] The solid yellow markings are faded and partially covered by recently applied asphalt.

Figure 7. Diagram of Main Street, grade crossing, and Esters Boulevard north and south of the crossing.

1.5.3.2 Signage. Warning and advisory signs are present on both the northbound and southbound approaches to the crossing. Along the northbound approach, at the time of the crash, multiple signs notified road users of the upcoming grade crossing (see table 2). They included the following: (1) grade crossing advance warning sign, located 382 feet from the tracks; (2) LGCGC warning sign, located 25 feet from the tracks; (3) “LOW GROUND CLEARANCE” plaque, located just below the LGCGC warning sign on the same signpost; (4) “CONSTRUCTION AHEAD” temporary traffic control sign, located 24 feet from the tracks; (5) 15-mph advisory speed limit plaque, located just below the “CONSTRUCTION AHEAD” sign on the same signpost; and (6) grade crossing crossbuck, located 13 feet from the tracks.[30] The southbound approach to the crossing contained the same crossing-specific signs.[31]

[30] The “CONSTRUCTION AHEAD” sign indicated road work that started at Esters Boulevard N. At the time of the crash, there was no construction, and all lanes were open to traffic.

[31] The southbound approach to the grade crossing had the same signage as the northbound approach, except for the “CONSTRUCTION AHEAD” sign and advisory speed limit plaque. The southbound approach also had a “No Turnaround” plaque below an additional LGCGC warning sign, located about 1,500 feet north of the grade crossing.

Table 2. Roadway signs on the northbound Main Street approach to the grade crossing.

Name	Design	Dimensions	Distance to Crossing
Grade crossing advance warning		36-inch diameter	382 feet
LGCGC warning		30-inch x 30-inch	25 feet
"LOW GROUND CLEARANCE" plaque		24-inch x 18-inch	25 feet
"CONSTRUCTION AHEAD" temporary traffic control warning		36-inch x 36-inch	24 feet
15-mph advisory speed limit plaque		18-inch x 18-inch	24 feet
Grade crossing crossbuck		36-inch x 36-inch	13 feet

Esters Boulevard south and north of the grade crossing also had warning signs alerting drivers to the upcoming Main Street grade crossing. Parallel grade crossing and intersection advance warning signs were located at distances 105–170 feet from the grade crossing.

1.5.3.3 Grade Crossing Warning System. The southbound and northbound approaches to the Main Street crossing each have a flashing light signal and an automatic gate assembly. The flashing light signals are mounted on a mast and consist of two sets of 12-inch-diameter red LED lights mounted back-to-back, such that they are visible to traffic on Main Street approaching the crossing from both directions. Two additional sets of 12-inch-diameter red LED lights are mounted back-to-back on the mast, such that they are visible to traffic on Esters Boulevard approaching Main Street from either direction.

The automatic gate consists of a drive mechanism, three red lights, and a gate arm marked with reflective red and white tape. In the down position, the gate arm extends across the approaching traffic lane; the light nearest the arm's tip is continuously illuminated and the other two lights flash alternately, in unison with the mast-mounted flashing light signal. The flashing light signal and the gate assemblies are located about 13 feet and 13.5 feet from the nearest rail for the northbound and southbound approaches, respectively. An emergency notification sign, providing information about the grade crossing location and the phone number for reporting emergencies to CSXT dispatch, is also on each side of the track.

1.5.4 Main Street Grade Crossing Vertical Profile

NTSB investigators measured the vertical grade of the Main Street grade crossing in the northbound direction of travel. South of the railroad tracks, the average slope is +4.2 percent (uphill) with an approximate maximum slope of 7.5 percent, measured about 5.7 feet south of the tracks. North of the railroad tracks, the average slope is -13.3 percent (downhill) with an approximate maximum slope of -24.4 percent, measured about 10.6 feet north of the tracks.[32]

NTSB investigators also measured the average vertical grades of travel at 30 feet from the nearest rail. At 30 feet from the nearest rail, the road surface is 14.4 inches and 45.4 inches below the track level, south and north of the tracks, respectively. These levels correspond to vertical grades of 4.2 percent south and -13.3 percent north of the tracks.

The American Association of State Highway and Transportation Officials (AASHTO) and the Federal Highway Administration (FHWA) have each developed guidance for grade crossing design, including the maximum recommended vertical profile; the guidance is published in AASHTO's *A Policy on Geometric Design of Highways and Streets* and the FHWA's *Railroad-Highway Grade Crossing Handbook* (AASHTO 2011 and FHWA 2007). Both sources recommend that the crossing surface be level with the top of the rails for at least 2 feet beyond the rails.[33] Additionally, both recommend that the road surface be no more than 3 inches higher or lower than the track level at 30 feet from the nearest rail (see figures 8 and 9). Following this guidance would result in a maximum grade of 0.89 percent. The American Railway Engineering and Maintenance-of-Way Association (AREMA), a railway industry group, also provides guidance on the vertical profiles of grade crossings (AREMA 2011). The AREMA guidance matches the AASHTO and FHWA recommendations. Although the Mississippi Department of Transportation (MDOT) provides its own guidance on the design of grade crossings in its *Roadway Design Manual* (MDOT 2001), since 2010, MDOT has relied on the FHWA guidance for approval of grade crossing projects.[34]

---

[32] Because the grade crossing's approach and departure slopes are vertical curves, the grade measurements constantly change over the length of the crossing. The reported average grade measurements were calculated from the difference in vertical total station (a surveying instrument) survey measurements taken at distances of 2 feet and 30 feet from the nearest rail. The maximum reported slope value for each approach was obtained from the steepest total-station survey data segment along the measured profile line. Data points along the profile line were collected at intervals of about 1 foot; reported measurements should therefore be considered approximate values.

[33] For the Main Street crossing, at 2 feet south of the railroad tracks, the road surface was 0.1 inch below the track level. At 2 feet north of the tracks, the road surface was 0.5 inch below the track level.

[34] At the time of the collision, the MDOT manual recommended that, at 10 feet from the nearest rail, a crossing surface should be no more than 6 inches below the track level or 3 inches above the track level. An MDOT rail engineer told NTSB investigators that the office has relied on FHWA/AASHTO guidance since 2010, when he became an MDOT rail engineer. As of July 2018, MDOT was in the process of updating its grade crossing guidance to match the guidance of the FHWA and AASHTO.

Figure 8. Photograph showing the northbound approach to the grade crossing (top)—what the driver would have seen—and cross-section diagram of the measured vertical profile of the approach's slope (bottom). The blue line in the diagram represents the maximum elevation difference between the crossing and the approach as recommended by the FHWA and AASHTO, and the gray line represents the actual elevation difference at the grade crossing.

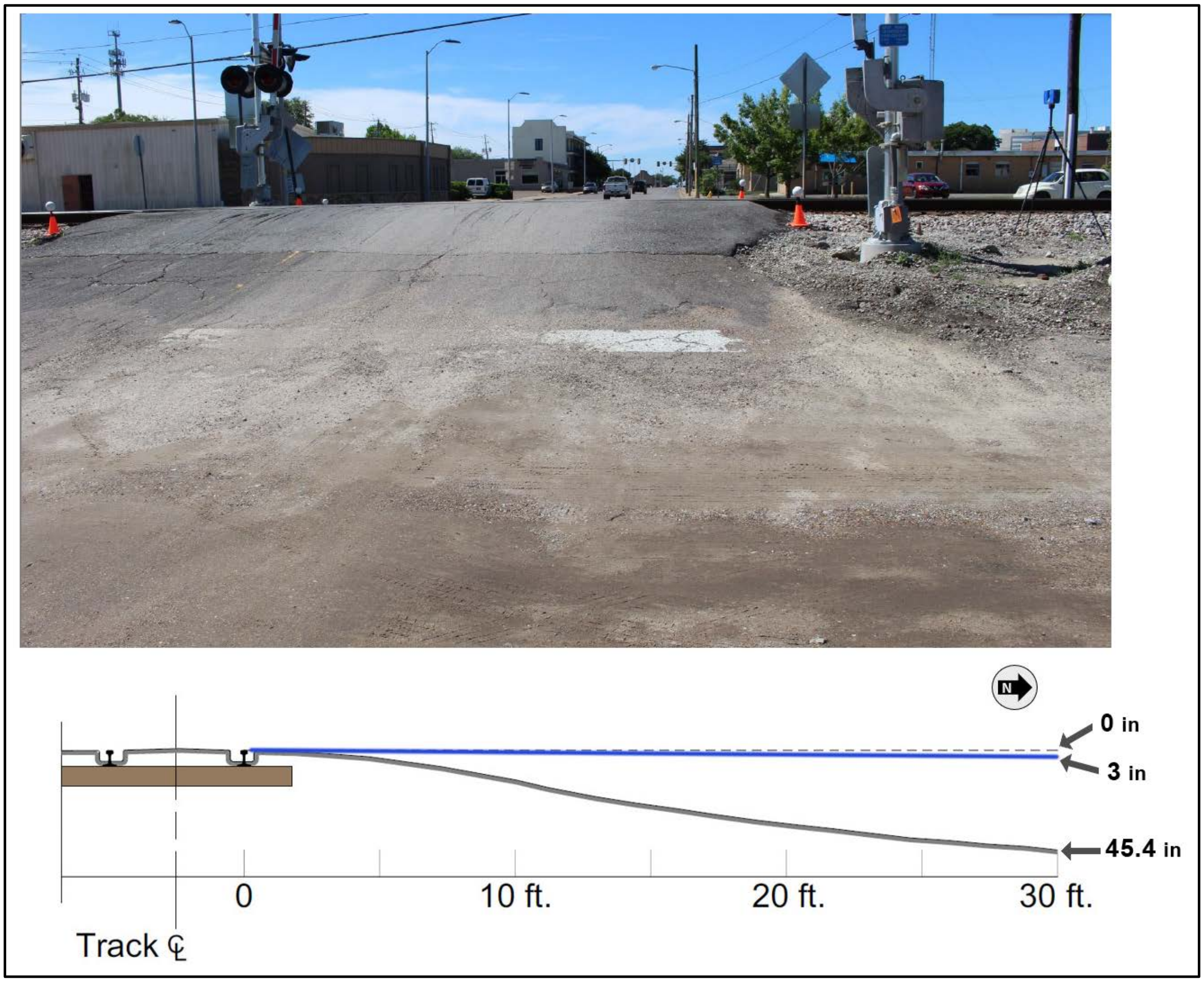

Figure 9. Photograph showing the southbound approach to the grade crossing (top) and cross-section diagram of the measured vertical profile of the approach's slope (bottom). The blue line in the diagram represents the maximum elevation difference between the crossing and the approach as recommended by the FHWA and AASHTO, and the gray line represents the actual elevation difference at the grade crossing.

1.5.5 Main Street Grade Crossing Maintenance and Incident History

1.5.5.1 Maintenance History. Although the exact date of the initial construction of the Main Street grade crossing is unavailable, City of Biloxi records indicate that the crossing has existed since at least 1870. It was most recently reconstructed in 1977. The reconstruction plans specified a 12.3-percent downgrade slope north of the tracks. At the time of this reconstruction, the American Railroad Engineering Association offered the only source of guidance on grade crossing design.[35]

[35] In 1997, the American Railroad Engineering Association combined with two other engineering associations to form AREMA.

Since the 1977 reconstruction, railroad maintenance has been performed in the area of the grade crossing. In February 2014, CSXT replaced wooden railroad ties along the section of track that included the Main Street crossing. Tie replacement typically results in raising the track by about 1.5 inches.[36] MDOT was not informed of this planned maintenance or of the resulting increase in track elevation.[37] It would have been standard practice for CSXT to inform the City of Biloxi of the 2014 track maintenance, because it would have affected the grade crossing's availability for use by highway traffic. However, investigators found no evidence indicating that CSXT informed the city about the nature of the maintenance, specifically, that it would affect the crossing's vertical profile.[38]

The City of Biloxi was unable to provide records of Main Street grade crossing maintenance before 2008 because any records of work done before that date were lost in a 2008 flood. CSXT told NTSB investigators that it did not have any Main Street grade crossing maintenance records before January 2012, when it replaced the steel tracks; this track replacement maintenance would not have affected the track elevation.

The most recent precrash maintenance on Main Street in the vicinity of the grade crossing occurred in March 2016. This work included milling the pavement of Esters Boulevard north of the rail tracks and the adjacent segment of Main Street, as well as applying a temporary surface on the same sections of the roadway; the closest milling to the rail tracks was about 25 feet away. According to the road repair plans, the resurfacing was not expected to affect the elevation of the roadway surface. NTSB investigators examined the milled and resurfaced section of the road and determined that the transition between the existing asphalt surface and the milled asphalt was smooth; there was no noticeable drop-off between the two road areas.

1.5.5.2 Maintenance Responsibilities. NTSB investigators discussed the responsibilities for grade crossing maintenance with CSXT representatives, as well as with City of Biloxi officials. The CSXT personnel stated that they believed the City of Biloxi was responsible for maintaining the approach to the Main Street grade crossing. Although the City of Biloxi has responsibility for maintenance of local roads, including Main Street, city representatives stated that they believed that only CSXT could conduct maintenance in the immediate vicinity of the tracks and that the city had to seek approval from the railroad before performing any type of work in that area. Mississippi statutory authority grants MDOT a certain level of authority over public roadway/railroad crossings, including the following power:

> After having made proper investigation, and after notice and hearing, if requested, to abolish any public roadway/railroad crossing heretofore or hereafter established, to vacate and close that part of the roadway on such crossing abolished, and to erect

[36] A CSXT engineer described to NTSB highway investigators the process of replacing wooden ties. He stated that tracks are initially elevated by about 2 inches, but that settlement and compaction reduce the elevation by about 0.5 inch. NTSB railroad investigators confirmed the accuracy of this statement.

[37] NTSB investigators obtained this information during a conversation with an MDOT rail engineer.

[38] The City of Biloxi reported that, as part of the maintenance conducted in February 2014, CSXT lowered the gates at the Main Street grade crossing and other crossings affected by the maintenance. The city publicized the grade crossing closure on its traffic notifications website.

> barricades across the roadway in such a manner as to prevent the use of such crossing as a roadway (*Miss. Code. Ann.* § 65-1-175 [2013]).

Additionally, MDOT can require the installation of warning and flashing signs at grade crossings and prescribe a portion of the cost of the installation and maintenance of such signage to railroad carriers and local highway authorities. Further, MDOT's approval is required for the construction of new, or reconstruction of existing, grade crossings.

1.5.5.3 Crashes and Incidents. According to the grade crossing accident reports provided by the FRA, 18 collisions involving train impacts took place on the Main Street grade crossing between November 1976 and March 2017. Eleven of those collisions involved a train striking a car (or similar noncommercial vehicle), six involved a train striking a commercial vehicle, and one involved a train striking a pedestrian. In addition to the subject (motorcoach) crash, two collisions in this period had fatal outcomes; both involved a car (or similar noncommercial vehicle). Since the February 2014 track maintenance that raised the track elevation, two more crashes, in addition to the subject crash, involved a vehicle—a commercial vehicle in both cases—that was stalled or grounded on the Main Street crossing.[39] The last crash before this maintenance occurred in 2003.

NTSB investigators examined the CSXT incident tickets, the documented instances of vehicle groundings on the Main Street grade crossing, and the records from various City of Biloxi departments concerning the crossing. These records showed numerous incidents involving a vehicle becoming grounded on the crossing. In addition to the 3 vehicle groundings that resulted in a crash, in the 5-year period before the subject crash, 24 other incidents occurred in which a vehicle was reported as grounded on the crossing; 20 of these incidents involved a truck-tractor combination vehicle.[40] In each of the 24 cases, either the vehicle was dislodged before a train approached the crossing or the CSXT train crew was notified early enough to safely decelerate and stop the train before reaching the crossing.

Twenty-four of the 27 grounding incidents (including the one resulting in the subject crash) that took place at the crossing in the 5-year period occurred after February 2014, when the last CSXT track maintenance raised the elevation of the railroad tracks. In most of these 27 grounding incidents, both the BPD and CSXT were notified.[41] CSXT had records for 25 of these incidents; the City of Biloxi had records for 22.

1.5.6 Other Grade Crossings in Biloxi

Biloxi contains about 8.6 miles of railroad track, and 29 grade crossings are within the city limits. Twenty-two of the crossings are in southeastern Biloxi, along 2.6 miles of railroad track. NTSB investigators measured the slopes of all 29 grade crossings in Biloxi and found that all have

[39] One of the crashes occurred on August 28, 2014; it involved a truck-tractor combination vehicle and resulted in injury to one railroad employee. The second crash occurred on January 5, 2017; it involved a single-unit truck and resulted in injury to two railroad employees.

[40] The other four incidents involved a motorcoach, a truck with an attached horse trailer, an unspecified truck, and an unspecified vehicle.

[41] The City of Biloxi Engineering Department had records for only a few of the incidents that the BPD recorded.

a vertical slope (on either the northbound or the southbound approach) greater than the maximum recommended by the FHWA/AASHTO for new and reconstructed grade crossings.[42]

According to FRA grade crossing accident reports, 190 collisions occurred on grade crossings in Biloxi between June 1975 and March 2017; of these, 172 occurred on crossings other than the Main Street crossing.[43] NTSB investigators also examined CSXT incident tickets that recorded vehicle groundings on a grade crossing that did not result in a collision with a train. Between March 2012 and the March 7, 2017, crash date, 15 incidents of vehicle grounding took place on grade crossings in Biloxi other than the Main Street crossing.

When the March 7, 2017, crash occurred, both the BFD and the Biloxi Public School District had restrictions on their vehicles' use of certain grade crossings in the city. One particular BFD vehicle was allowed to use only 3 of the 29 grade crossings in Biloxi; it was prohibited from using the Main Street grade crossing. Additionally, the district's school buses were prohibited from using two of the other grade crossings in Biloxi.[44]

1.5.7 Postcrash Actions

On March 10, 2017, the City of Biloxi placed three selective exclusion signs bearing the *No Trucks* icon, in combination with "NO BUSES TRUCKS RVs" plaques, near the Main Street crossing. Two of the exclusion signs were placed on northbound Main Street, 234 feet and 25 feet from the rail tracks, respectively. The third exclusion sign was placed on southbound Main Street, 104 feet from the tracks. (See figure 10 for a view of the new *No Trucks* icon sign and exclusion plaque located nearest the tracks on the northbound approach to the crossing.) Also, on March 13, the city installed two more LGCGC warning signs, accompanied by "LOW GROUND CLEARANCE" plaques, at the crossing. One was put on the southwest corner of the crossing, 25 feet from the tracks and facing northbound traffic; the other sign was put on the northeast corner, 12 feet from the tracks and facing southbound traffic.

[42] (a) The measurements were conducted in the same manner as the measurement for the Main Street grade crossing, as described earlier in this report. (b) MDOT also measured the slopes of these grade crossings at 30 feet from the nearest rail and found them to be outside the FHWA/AASHTO-recommended guidance. Due to differences in the accuracy of the surveying equipment (NTSB investigators used an advanced system), there are slight differences in the recorded slope measurements between MDOT and NTSB calculations.

[43] Five collisions occurred while a vehicle was grounded on a grade crossing.

[44] (a) According to a BFD directive from 1999, the department's aerial apparatus vehicle, Aerial-1, was allowed to use only the Oak Street, Caillavet Street, and Reynoir Street grade crossings. (b) Biloxi Public School District school buses were prohibited from using the Querens Avenue and Benachi Avenue grade crossings. After the March 2017 crash, the district added another five grade crossings, including the Main Street crossing, to its list of prohibited crossings.

Figure 10. Postcrash view of the northbound approach to the Main Street crossing, showing the new vehicle exclusion sign and plaque (circled in yellow) posted by the City of Biloxi after the crash.

As a result of this crash, the MDOT Rails Division initiated a safety program in April 2017. As part of this program, MDOT met with local municipalities along the 74 miles of CSXT track in Mississippi and identified all grade crossings with vertical profiles exceeding the slope limits recommended in the FHWA/AASHTO design guidance. MDOT offered the local municipalities free access to LGCGC warning signs and accompanying "LOW GROUND CLEARANCE" plaques for installation at those crossings not meeting the design guidelines. As of July 2018, of the 12 entities eligible to receive the signs, 6 had requested them.

According to CSXT incident tickets, only one vehicle grounding occurred on the Main Street crossing in the year following the March 2017 crash.[45]

The City of Biloxi has requested funding from the Gulf Regional Planning Commission to conduct a route planning study for commercial vehicle traffic for the city. The study is designed to identify the optimal routes for commercial vehicle movement through Biloxi, including identifying grade crossings involved in the routing. When the study is complete, the City of Biloxi intends to publicize the commercial vehicle route (or routes) through the installation of advisory signage throughout the city. The city also intends to work with navigational device makers and geospatial mapping developers to electronically disseminate the commercial vehicle routing information for Biloxi.

[45] (a) CSXT dispatch received a call about a vehicle—a car—on the tracks; the car had cleared the crossing by the time that CSXT staff arrived. It is unclear whether the vehicle had been grounded or stalled on the tracks. (b) The NTSB received incident reports from CSXT for March 8, 2017, to April 6, 2018.

1.5.8 National Grade Crossing Inventory

In 1975, the FRA, in cooperation with the FHWA, National Highway Traffic Safety Administration (NHTSA), Association of American Railroads, and American Short Line and Regional Railroad Association, established a national grade crossing inventory. The inventory contains current and historical records on grade crossings, including the crash history for each listed crossing and whether an LGCGC warning sign is posted at the crossing. The FRA maintains the inventory and updates it with information provided by state departments of transportation (DOT) and railroad companies when they complete the grade crossing inventory form (FRA form 6180.71).[46]

States and railroad companies are required to complete different sections of the inventory form. State DOTs are responsible for completing information about grade crossing warning devices and signage. The Rail Safety Improvement Act of 2008 (49 *United States Code* [USC] Section 20160), which had an enforcement date of August 9, 2016, directs that state DOTs shall report to the Secretary of Transportation "current information, including information about warning devices and signage, as specified by the Secretary, concerning each previously unreported public crossing located within its borders." The act further directs that states shall provide this information within 6 months of opening for a new crossing and once a year for all grade crossings. The railroad companies are responsible for providing details of railroad operations, such as types of trains, speed limits, track characteristics, and types of train detection equipment.

To be considered a high-profile grade crossing in the FRA national inventory, (1) the crossing must be posted with an LGCGC warning sign, and (2) the presence of the sign must be recorded on FRA form 6180.71. NTSB investigators obtained grade crossing inventory information for a 5-year period before the Biloxi crash. Table 3 shows the percentages of high-profile grade crossings in the nation and the numbers of crashes that have occurred on those crossings. There has been a large increase in the number of high-profile crossings reported in the national inventory since 2015. The number of reported crossings increased by 113 percent in 2016, and by an additional 216 percent in the first 3 months of 2017. This increase most likely is due to improved recording of the presence of LGCGC warning signs on the grade crossing inventory form—as required by the Rail Safety Improvement Act—rather than from a sudden surge in the installation of the signs. According to FRA personnel, the number of reported high-profile crossings is expected to rise until August 2019, because all previously reported grade crossings are required to update within 3 years of the act's enforcement date.

[46] For a description of the reporting responsibilities concerning grade crossings for state DOTs and railroad companies, see *Federal Railroad Administration Guide for Preparing U.S. DOT Crossing Inventory Forms*, accessed March 16, 2018.

Table 3. National summary of high-profile grade crossings and crash information. (2017 data are preliminary)

Year	Total Crossings	High-Profile Crossings	Percent of High-Profile Crossings	Crashes at All Crossings	Crashes at High-Profile Crossings (total and percent)
2012	129,661	1,582	1.2%	1,694	35 (2.1%)
2013	130,308	1,618	1.2%	1,756	33 (1.9%)
2014	130,345	1,587	1.2%	1,942	51 (2.6%)
2015	130,971	1,595	1.2%	1,767	44 (2.5%)
2016	131,462	3,400	2.6%	1,724	57 (3.3%)
2017[a]	131,775	10,740	8.2%	449	45 (10.0%)

[a] Includes data from January 1 through March 31, 2017.

All of the 31 grade crossings that NTSB investigators examined in the Biloxi and Gulfport area exceeded the vertical profile guidance provided by the FHWA and AASHTO, yet, at the time of the crash, only 4 of these 31 crossings were marked with LGCGC warning signs.[47] Only one of these four grade crossings appeared in the FRA inventory as a high-profile crossing (this crossing appeared in the inventory accompanied by a check mark indicating that an LGCGC warning sign was present). Neither the Main Street crossing nor the other two crossings posted with LGCGC signs appeared as high-profile crossings in the FRA inventory database.

According to MDOT, it has been updating its sections of the crossing inventory forms for all Mississippi grade crossings. MDOT plans to update the state's grade crossing inventory yearly, during annual railroad track inspections. MDOT is also developing a mobile application to assist rail inspectors in gathering and logging the inventory-related information.

1.6 Railroad Operations

1.6.1 Train Operation

The train consisted of 2 locomotives, 27 cars loaded with mixed freight (19 of which carried hazardous materials), and 25 empty cars. The train was 3,164 feet long, and it weighed 3,990 tons. It was equipped with two-way telemetry and a trip optimizer.[48] The lead locomotive was equipped with the required headlight, auxiliary lights, and horn warning device; it was additionally instrumented for positive train control, a forward-facing digital video recorder, a locomotive event

[47] Investigators examined all 29 grade crossings in Biloxi and 2 in Gulfport. All four grade crossings with an LGCGC warning sign were in Biloxi.

[48] (a) Telemetry is the combination of a head-of-train device on the controlling locomotive and an end-of-train device on the train's rear car that can communicate train-related information to and from the controlling locomotive. (b) A trip optimizer is an intelligent, fuel-saving cruise control system for a locomotive that optimizes fuel consumption.

data recorder, and an alerter.[49] Postcrash, an FRA inspector tested the devices on the locomotive and found them operational.

1.6.2 Rail Operation

This crash occurred in the CSXT New Orleans & Mobile (NO&M) Subdivision, Atlanta Division. Train movements on the NO&M Subdivision are governed by operating rules, timetable instructions, and signal indications from the traffic control system. Two control points—signal stations that are remotely controlled by a train dispatcher—are near the Main Street grade crossing; the South End Ocean Springs control point is east of the crossing, and the North End Beauvoir control point is west of it.

The track configuration in Biloxi consists of a single main track. The maximum authorized train speed on the CSXT NO&M Subdivision is 60 mph for freight trains, with permanent speed restrictions between posted timetable mileposts. The maximum authorized train speed over the Main Street grade crossing is 45 mph. The segment of track preceding the crash location (west to east) is straight for 1 mile before the crossing and for 1,584 feet after the crossing. There is a 0.26-percent descending grade in the train's direction of travel. No buildings or vegetation obstructed the view for the train crew or the motorcoach driver. NTSB investigators examined the CSXT track inspection records for the previous 3 months and determined that the railroad had completed the required twice-weekly inspections of the tracks and had found no exceptions to the FRA standards.[50]

The warning system at the Main Street crossing was controlled by a Safetran Grade Crossing Predictor, a monitoring and recording system.[51] Data extracted from the recording unit showed that the system detected the train and initiated a warning sequence. As part of this sequence, the system activated the crossing warning bells and flashing lights when the train, at its current speed, was 29 seconds from the crossing; 3 seconds later, the crossing gate arm for the roadway began to descend to a horizontal position.[52] Title 49 CFR 234.5 requires a grade crossing warning system to activate at least 20 seconds before the arrival of a train.

After the crash, NTSB investigators, with FRA investigators and CSXT staff, conducted operational tests of the warning system, and examined documents, photographs, and data. They found no evidence of problems with the grade crossing warning system.

[49] (a) According to 49 USC 20157(i)(3), positive train control is a system designed to prevent train-to-train collisions, over-speed derailments, incursions into established work zone limits, and movement of a train through a switch left in the wrong position. (b) Title 49 CFR Part 229 defines an alerter as a device or system installed in the locomotive cab to promote continuous, active locomotive engineer attentiveness by monitoring certain engineer-induced control activities.

[50] The section of the tracks where the crash occurred was considered class 4 track and was maintained to that standard. Class 4 tracks must be inspected at least twice weekly, with at least 1 calendar day between inspections.

[51] The Safetran Grade Crossing Predictor model 3000ND2 continually monitors the track approach to railroad grade crossings, computes the arrival time of a detected train, and activates the crossing-protection equipment at a predetermined time before the train's predicted arrival.

[52] Although the time it took for the gate arm to reach the fully horizontal position was not recorded, this movement is typically completed in 10–12 seconds.

1.6.3 Train Crew

1.6.3.1 Experience and History. The train engineer was a 47-year-old male who has been employed in this position by CSXT since 2004. He reported that he was in good health, had good vision and hearing, and was not regularly taking any medications. No postcrash toxicological testing was conducted, because the circumstance of this crash did not meet the requirements of US Department of Transportation (USDOT) regulations (49 CFR 219.201[b]) concerning such testing.[53] Cell phone records indicated that the engineer did not use his cell phone during the train's operation. He reported making about three roundtrips each week along the section of the track where the crash occurred. Based on the engineer's postcrash interview statements, his work schedule, and his cell phone records, in the 3 nights preceding the crash, he had obtained about 11.5 hours, 5.0 hours, and 8.5 hours (night before the crash) of sleep, respectively.

The train conductor was a 37-year-old male who had been hired by CSXT in 2008; he was certified as both a conductor and an engineer. He told investigators that he was in good health, had good vision and hearing, and was not regularly taking any medications. He reported that he usually worked with the same engineer and that he regularly operated on the section of the track where the crash occurred. Cell phone records indicated that the conductor did not use his cell phone during the train's operation.

1.6.3.2 Crash Trip and Sight Distance Observations. During a postcrash interview, the engineer stated that he had clear signals as he approached the Main Street grade crossing, and he estimated the train speed as 28 mph.[54] He said that he monitored up to three crossings ahead but focused his attention on the nearest crossing. He reported that he did not see the motorcoach enter the Main Street grade crossing but first saw it on the railroad tracks about 15 seconds before he activated the train's emergency brake.

He said that he did not immediately react to the motorcoach because he frequently encounters vehicles on grade crossings, and he expected the motorcoach to clear the tracks. The engineer reported putting his hand on the emergency brake moments later. He and the conductor both reported discussing the motorcoach's presence on the crossing and whether it was going to move off it in time.[55] The engineer also stated that he did not want to apply the brakes unnecessarily because he was concerned about the hazardous materials on the train and the potential for a hazardous materials spill in a populated area in case of train derailment. The engineer said that, although he expected the motorcoach to move off the tracks, he told the conductor that he intended to apply the emergency brakes and then did so. Even then, he believed that the motorcoach would clear the crossing.

[53] For conditions that require train crews to undergo postcrash toxicological testing, see 49 CFR 219.201.

[54] Earlier in the trip, as instructed by a CSXT dispatcher, the engineer had stopped the train due to a report of a vehicle being stuck on a grade crossing about 16 miles west of the Main Street crossing. When the engineer began moving the train, he decided to maintain the lower speed—the speed limit was 45 mph—due to upcoming speed restrictions on a drawbridge about 2 miles east of the Main Street crossing.

[55] They told investigators that they saw no indication that the motorcoach was "in distress."

The engineer reported that, on this section of the railroad, because of the streets that run parallel to the tracks, he encounters vehicles on the tracks on a daily basis. He described these vehicles as waiting on the tracks for traffic to clear. The engineer also reported that, earlier on this same trip, CSXT dispatch had instructed him to stop his train due to a vehicle being stopped on a (different) grade crossing about 16 miles ahead. The conductor estimated that about once a week they heard about or were involved in a situation in which CSXT dispatch instructed a train crew to stop its train due to a possible vehicle on a grade crossing.

NTSB investigators conducted sight distance observations to determine the approximate distance at which the train crew could have perceived the motorcoach on the Main Street grade crossing. Because an exemplar motorcoach would be at risk of grounding, investigators instead placed a truck on the tracks, which, because of its higher ground clearance, could more safely represent the crash motorcoach. Then, an exemplar CSXT locomotive, moving about 10–15 mph and operated by an experienced engineer, approached the crossing from the west. The engineer reported being able to perceive the truck at 3,850 feet from the Main Street grade crossing.

1.6.4 Recorders

NTSB investigators examined data from the locomotive event data recorder, the digital video recorded by the forward-facing locomotive camera, and the signal stations to determine the actions of the train engineer, the visibility conditions, the timing of the crash, and the timing of the grade crossing warning system activation. Table 4 shows the sequence of the crash events involving these factors.

Table 4. Sequence of events near Main Street grade crossing on March 7, 2017, concerning the train's movement, the motorcoach's grounding, and the crash.

Time (p.m.)	Event	Source
2:05:45 – 2:11:28	Speed of the train varies between 27 mph and 29 mph	Train event data recorder
2:09:26 – crash	Horn activates nearly continuously (with one 2-second break)	Train event data recorder
~2:11	Motorcoach arrives on the crossing	Driver's GPS
2:11:14	Warning bells and flashing lights at the crossing activate	Warning system recorder
2:11:15	Object is visible at the Main Street crossing	Forward-facing locomotive camera[a]
2:11:17	Gate arms start to lower	Warning system recorder
2:11:21	Object at the Main Street crossing is identifiable as a motorcoach	Forward-facing locomotive camera
2:11:28 – crash	Motorcoach at the Main Street grade crossing appears stationary	Forward-facing locomotive camera
2:11:29	Engineer engages emergency brake (502 feet west of the crossing)	Train event data recorder
2:11:43	Crash	Forward-facing locomotive camera
	Train speed is 19 mph at impact	Train event data recorder
2:12:00	Train comes to a complete stop, 259 feet east of the crossing	Forward-facing locomotive camera

[a] NTSB investigators and party representatives derived the description of the video from the forward-facing locomotive camera, after a frame-by-frame viewing of the recording. See the Onboard Image Recorder (Train) report in the NTSB public docket for this investigation (HWY17MH010) for additional descriptive information on the recording from the locomotive camera.

1.7 Motor Carrier Operations

ECHO Tours and Charters, doing business as ECHO Transportation, is domiciled in Dallas, Texas, and began operating as an interstate carrier in 2011. At the time of the crash, the carrier operated 109 vehicles and employed 169 drivers.

The carrier's primary terminal is in Dallas—the motorcoach driver's home terminal—and it has satellite operations in four other Texas locations. For-hire charter operations represent the largest part of ECHO Transportation's business.

1.7.1 Carrier Training Program

ECHO Transportation employs a safety manager who, with other staff, implements and oversees the carrier's safety and training programs. According to carrier documentation, all ECHO Transportation drivers receive new driver training, new driver onboard training, continual performance monitoring, and defensive driving training. The new driver training program consists of 9 days of classroom and on-the-road training. Continual performance monitoring is conducted using Lytx DriveCam. The safety manager monitors DriveCam events and provides coaching to drivers if a recorded event is determined to have presented a safety risk; some recorded events may result in disciplinary action. All drivers also complete defensive driving training every 6 months. The carrier provided NTSB investigators with several written policies, including those addressing seat belt and cell phone use, as well as a policy on proper procedures for transiting railroad crossings. The railroad crossing policy included a step-by-step guide outlining the Federal Motor Carrier Safety Administration (FMCSA) requirements for speed, safe following distance, and operating in adverse weather while traversing grade crossings. The carrier's policy did not include any guidance pertaining to LGCGC warning signs.

1.7.2 State and Federal Oversight

Although the Texas Department of Public Safety (TxDPS) Commercial Vehicle Enforcement Service has authority over intrastate motor carriers, it does not inspect interstate carriers like ECHO Transportation. As such, TxDPS Commercial Vehicle Enforcement did not perform any compliance reviews of ECHO Transportation, but it did conduct regular roadside inspections of the carrier's vehicles, including three inspections of the motorcoach involved in this crash. None of the three inspections, the most recent of which occurred on January 24, 2017, resulted in violations.

The FMCSA conducted two compliance reviews of ECHO Transportation, in April 2012 and September 2014; both resulted in "satisfactory" ratings. The Motor Carrier Management Information System showed that ECHO Transportation had no Behavior Analysis and Safety Improvement Categories (BASICs) in alert status at the time of the crash.[56] The records indicated that the carrier had two reportable crashes before the Biloxi grade crossing crash, but neither involved the crash driver.[57] As a result of the Biloxi crash, the FMCSA initiated a compliance review of the motor carrier on April 5, 2017. This review identified two noncritical safety violations and resulted in a "satisfactory" rating.[58]

1.7.3 Driver Grade Crossing Guidance

In the *Manual on Uniform Traffic Control Devices for Streets and Highways* (MUTCD), the FHWA provides guidance on the LGCGC warning sign at grade crossings; however, this guidance is intended for traffic engineers and describes the roadway conditions under which LGCGC signs should be installed. The MUTCD provides no guidance to drivers on such signage (FHWA 2009). Neither the Texas nor the Mississippi commercial motor vehicle drivers' handbook/manual mentions the LGCGC warning sign (TxDPS 2014 and MDOT 2012). No guidance from the FMCSA or the American Association of Motor Vehicle Administrators (AAMVA) addresses the LGCGC warning sign at grade crossings. These organizations do issue warnings about the dangers of becoming grounded on a grade crossing, and they highlight the risk

[56] The FMCSA uses data from roadside inspections—including all safety-based violations, state-reported crashes, and the Federal Motor Carrier Census—to quantify a carrier's performance in seven BASICs. These BASIC categories are (1) unsafe driving, (2) hours-of-service compliance, (3) driver fitness, (4) controlled substances and alcohol, (5) vehicle maintenance, (6) hazardous materials compliance (if applicable), and (7) crash indicator. A carrier's rating for each BASIC depends on its number of adverse safety events, the severity of its violations or crashes, and when the adverse safety events occurred (more recent events are weighted more heavily).

[57] Neither of the drivers involved in the other two reportable crashes was issued a citation.

[58] The two noncritical safety violations were (1) using a driver who has not completed and furnished an employment application and (2) false or inaccurate record-of-duty status report.

of grounding for vehicles with low trailers. For example, AAMVA guidance to commercial drivers (AAMVA 2016, 2-28 to 2-30) states that—

> Hanging up on a railroad crossing is a dangerous predicament, and is becoming too common as more very low trailers are manufactured. Lowboy trailers, car carriers, moving vans, and possum-belly livestock trailers are particularly susceptible, as are single-axle tractors pulling a long trailer with landing gear which is set to accommodate a tandem-axle tractor.

Motorcoaches are not discussed as types of vehicles susceptible to grounding on high-profile grade crossings in any of the guidance material for commercial drivers examined by NTSB investigators.

1.8 Motorcoach Driver

1.8.1 Licensing, Experience, and Driving History

The motorcoach driver was a 60-year-old male who obtained his first commercial driver's license (CDL) in June 2006, when he operated school buses for the Fort Worth Independent School District. In February 2013, he was employed by Gotta Go Trailways, which was later purchased by ECHO Transportation. At the time of the crash, the driver held a Texas class B CDL with passenger and school bus endorsements; the license had no restrictions.

The motorcoach driver completed Gotta Go Trailways new-hire training in March 2013. He also completed a recertification class in December 2015, took a driver training class in January 2017, and attended three company safety meetings.[59] Between November 2015 and March 2017, the driver had 34 DriveCam events, 27 of which resulted in coaching sessions; none of these events incurred suspension.[60]

NTSB investigators examined multiple sources to obtain the motorcoach driver's history of traffic violations, including CDL information systems, Texas Department of Motor Vehicle records, and driver qualification files from previous employers. The records showed that the driver had two speeding violations in personal vehicles since 2015 and a non-USDOT-reportable accident in August 2015.[61] Additionally, the driver underwent two roadside safety inspections, one in July 2016 in Peach Springs, Arizona, and the other following the Biloxi crash. Although both inspections resulted in safety violations for the driver, none were considered out-of-service violations. The driver received no citations in connection with this crash.

[59] (a) The driver completed a recertification class due to an employment termination in January 2015 that resulted from a non-driving-related incident. The carrier investigated the circumstances of the incident and offered to rehire the driver in September 2015. The recertification class is a shorter version of new-hire training. (b) The topics of company safety meetings vary depending on the current need and may include subjects such as winter driving, hours of service, or customer service.

[60] Most of the coaching sessions resulted from DriveCam events showing the driver allowing traffic to shorten his following distance. This driver's overall number of coaching sessions was similar to those provided to other drivers at the carrier.

[61] This event occurred while the driver was operating a commercial vehicle; he made a sharp turn and slightly contacted the fender of a parked vehicle. Because the crash did not result in towing of either vehicle or injuries, it was not required to be reported to the USDOT. The driver's employer provided the record of this crash.

1.8.2 Medical Certification, Health, and Toxicology

The motorcoach driver obtained his most recent precrash CDL medical certificate in January 2017; it was valid for 2 years. On the medical examination report form, the driver indicated that he had not taken any medications in the past 5 years, and he did not report any injuries or medical conditions that could affect his ability to operate a vehicle safely. The results of the examination, which included visual acuity and urinalysis, were within normal limits. NTSB investigators also obtained medical records from the motorcoach driver's primary care physician. These records did not indicate any significant chronic medical conditions.

The driver submitted to a USDOT preemployment drug test before beginning work for ECHO Transportation; the results of the test were negative. The carrier's records indicated that the driver had not been selected for random drug testing since employment. Postcrash, the carrier requested that the hospital where the driver was taken perform toxicology testing as required by USDOT regulation. The breath test analysis performed at 4:35 p.m.—about 2 hours 20 minutes after the crash—was negative for alcohol. The testing of the driver's urine, which was collected at 5:10 p.m.—about 3 hours after the crash—was negative for other drugs.[62] At the request of NTSB investigators, the Federal Aviation Administration (FAA) Bioaeronautical Sciences Research Laboratory performed additional testing on the driver's blood sample. It was negative for alcohol and other drugs, including the prescription medications that NTSB investigators found in the motorcoach after the crash.[63]

1.8.3 Precrash Activities

NTSB investigators used information obtained from cell phone records, interviews with the motorcoach driver and passengers, the charter tour plan, and hotel records to reconstruct the driver's activities in the days before the crash.

The motorcoach driver reported obtaining good quality sleep and not taking any sleeping medications. He stated that he typically works during the day and sleeps at night and that he goes to sleep before 10:00 p.m. when working the next day. The driver said that for the 3 nights before the crash, he obtained about 7.5–9.5 hours of sleep each night. On March 5, after having slept for about 9.5 hours, he began driving at 6:45 a.m., when he picked up passengers in Bastrop, Texas; he arrived in Lafayette, Louisiana, about 4:45 p.m. that day. On the following morning of March 6, after obtaining about 7.5 hours of sleep, the driver began driving at 9:00 a.m.; the motorcoach arrived at Hollywood Casino in Bay St. Louis, Mississippi, at 1:30 p.m.

On March 7, the day of the crash, after having had a 9-hour opportunity for sleep, the motorcoach driver picked up the passengers from the casino hotel about 1:00 p.m. and began the

[62] The tests provide evidence of use of the following 11 substances: amphetamine, methamphetamine, MDMA, MDA, MDEA, tetrahydrocannabinol (the active compound in marijuana), cocaine, codeine, morphine, heroin, and phencyclidine.

[63] (a) The laboratory conducted analyses to detect amphetamines, opiates, marijuana, cocaine, PCP, benzodiazepines, barbiturates, antidepressants, antihistamines, and commonly used prescription and over-the-counter drugs. For a comprehensive list of the drugs tested for, see the FAA WebDrugs website, accessed April 13, 2018. (b) NTSB investigators found several prescription medication bottles in the driver's name in the motorcoach, including vitamin D, etodolac, amoxicillin, ibuprofen, cyclobenzaprine, and meloxicam. These medications were prescribed to be taken as needed.

trip to Boomtown Casino in Biloxi. When the crash occurred, the driver had been on duty and driving for less than 2 hours. Figure 11 shows the driver's activities for the 3 days before the crash.

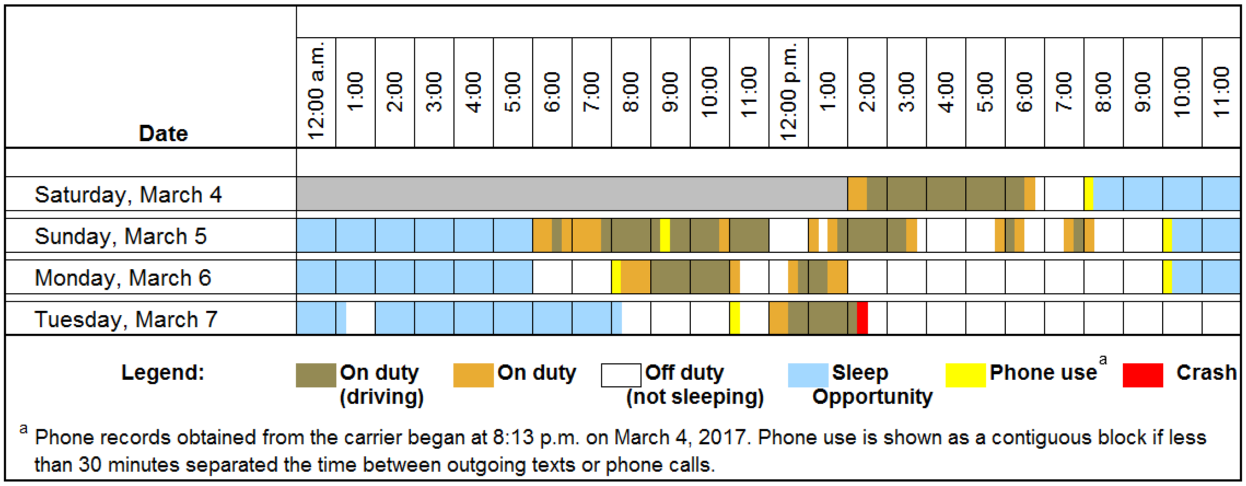

Figure 11. Activities of the motorcoach driver, March 4–7, 2017. (Driver's activity on March 4 before 2:00 p.m. is unknown.)

1.8.4 Route Selection

When the motorcoach driver left Hollywood Casino in Bay St. Louis on the day of the crash, his vehicle was one of three charter motorcoaches—organized by Diamond Tours—each operated by a different motor carrier. Although the three motorcoaches left locations at different times and traveled separately, because they were all part of the Diamond Tours charter, they all followed the same itinerary. For this part of the charter tour, the established itinerary included directions from Hollywood Casino to Boomtown Casino in Biloxi, which instructed drivers to take Interstate 10, a route that would not have included traversing the grade crossing on Main Street in Biloxi.

Before the three motorcoaches departed Bay St. Louis on March 7, the Diamond Tours manager sent a text message to the driver and group leader of each motorcoach, suggesting that they take an alternative, optional, scenic route along US-90; the message included directions and instructions for this optional route.[64] The new directions instructed the drivers to exit on Caillavet Street in Biloxi, resulting in a route that did not include traversing the grade crossing on Main Street.[65] The crash motorcoach driver, who was operating the ECHO Transportation motorcoach, was not sent these instructions from Diamond Tours; instead, the text message was mistakenly sent twice to the group leader for that motorcoach. The group leader for the ECHO Transportation motorcoach later told investigators that she did not receive the text message.

On the morning of March 7, during breakfast at the Hollywood Casino hotel, some of the passengers and the group leader from the ECHO Transportation motorcoach learned about the

[64] One passenger on each of the three motorcoaches in the tour was designated as the group leader for that motorcoach. The group leader served as a contact point with Diamond Tours.

[65] Like Main Street, Caillavet Street runs north–south in Biloxi. It is located about 0.4 mile west of Main Street. Although Caillavet Street crosses the railroad tracks, the crossing has a considerably lesser slope than the Main Street crossing.

scenic route from passengers from the other two tour motorcoaches comprising the Diamond Tours charter. At the start of the trip from Bay St. Louis, the ECHO Transportation motorcoach driver inputted the address of the Biloxi Boomtown Casino into his GPS device and programmed the device for commercial vehicle operation.

Soon after the ECHO Transportation motorcoach left Bay St. Louis, its group leader asked the driver if they could take a scenic route along US-90 to travel to the Boomtown Casino. In response, the driver began driving toward US-90. At that time, his GPS device recalculated its navigational instructions, which now directed the driver to Main Street in Biloxi and across the grade crossing. This GPS-provided scenic route, which the crash driver followed, was different both from the route included in the original Diamond Tours itinerary and from the optional scenic route with specific directions suggested by the Diamond Tours manager in her text message sent on the morning of the crash. (See figure 12 for a map showing the three routes from Bay St. Louis to Biloxi discussed above.)

Figure 12. Three alternative routes proposed for the motorcoach to travel from Hollywood Casino in Bay St. Louis to Boomtown Casino in Biloxi. The route in blue is the original planned route from the Diamond Tours itinerary; the route in yellow is the optional scenic route proposed by the Diamond Tours manager on the morning of the crash trip; and the route in red is the one indicated by the motorcoach driver's personal GPS device. The route in red is the crash route.

1.8.5 Driver's Actions at Crossing and Postcrash Sight Distance Observations

1.8.5.1 Motorcoach Driver's Actions. During a postcrash interview, the motorcoach driver stated that, as he approached the Main Street grade crossing, he noticed the LGCGC warning sign; he described it as depicting a truck with a lowboy trailer. The driver said that, as he approached the tracks, he stopped at the stop line, turned on his hazard flashers, raised the rear of the motorcoach, and looked down the tracks in both directions.[66] He stated that the grade crossing

[66] The driver said that, because of the incline, he decided to raise the rear of the motorcoach to avoid scraping the rear bumper when crossing. As was noted earlier, this motorcoach had a rear-lift system that allowed the driver to raise the height of the rear suspension air springs, elevating the rear of the motorcoach by 4 inches.

warning lights were not flashing and, because he did not see a train, he began to drive across the tracks.

The driver reported that he became aware of the steepness of the north side of the grade crossing only after the vehicle had crested the crossing. By that time, the motorcoach had become grounded on the crossing. The driver stated that he attempted to free the motorcoach from the crossing by pulling forward and reversing, but he was not successful. He reported that the passengers then told him that a train was coming, at which point, he opened the loading door and told the group leader that everyone should evacuate the motorcoach.

1.8.5.2 Postcrash Sight Distance Observations. NTSB investigators conducted sight distance observations to assess the motorcoach driver's description of his actions at the crossing. Driving an exemplar motorcoach, an experienced CDL driver approached the Main Street grade crossing from the south, replicating the crash motorcoach's northbound path. Moving his vehicle very slowly, the exemplar driver reported his observations about the steepness of the crossing on the north side of the tracks. The exemplar driver said that, while stopped at the stop line, he could not perceive the degree of the slope north of the rail tracks. He reported that, until he had moved the exemplar motorcoach beyond the stop line, it appeared to him that the grade crossing was safely traversable. The exemplar driver also stated that, while accelerating normally from the stop line, a motorcoach driver would find it difficult to perceive the steepness of the north slope in time to prevent the vehicle's grounding on the crossing.

1.9 Weather and Roadway Conditions

Data from the weather station at Keesler Air Force Base in Biloxi, about 2.5 miles from the crash site, indicated that, at 1:58 p.m. on March 7, 2017, the temperature was 72°F, and there was a south wind of 11.5 mph, no precipitation, and visibility of 10 miles. The crash occurred in daylight.

2 Analysis

2.1 Introduction

The crash sequence began when a motorcoach carrying passengers to a casino in Biloxi, Mississippi, attempted to travel across a highway–railroad grade crossing on Main Street in Biloxi and became grounded on the tracks. Within the next minute, a CSXT train approaching the grade crossing from the west struck the motorcoach and pushed it about 259 feet eastward. Four motorcoach passengers died, and the driver and 37 passengers sustained minor-to-serious injuries.

The analysis first examines the motorcoach driver's decision-making that led him to deviate from the originally planned route and attempt to traverse the grade crossing, and then the train crew's response to the grade crossing hazard and activation of the emergency braking system. The analysis also discusses the following safety issue areas:

- High-profile grade crossings, specifically—
  - Signage and reconstruction guidelines.
  - Coordination of maintenance activities and monitoring of crossing safety risk.
- Emergency egress and extrication.

As a result of this investigation, the NTSB established that the following factors did not cause or contribute to the crash:

- ***Motorcoach driver and train crew licensing and experience:*** The motorcoach driver held a CDL with appropriate endorsements and had more than 10 years of commercial driving experience. The train engineer and conductor each had appropriate certifications and more than 7 years of experience.
- ***Cell phone distraction, fatigue, substance impairment, and medical conditions:*** Cell phone records gave no indication that the motorcoach driver or the train crewmembers were engaged in texting or cell phone conversation at the time of the crash. Based on interviews, cell phone records, and witness accounts, the investigation found no evidence of fatigue for the motorcoach driver or the train crew. Postcrash toxicology test results revealed no evidence that the motorcoach driver had used alcohol or other drugs before the crash. (Consistent with federal regulations, no toxicological tests were performed on the train crew.) Examination of the motorcoach driver's available medical records showed no evidence of medical conditions that could have affected his ability to operate the vehicle.
- ***Vehicle condition, railroad track condition, and rail signal system operation:*** NTSB investigators examined the motorcoach and found no preexisting mechanical conditions that would have contributed to the circumstances of the crash. The investigators also examined the railroad track and signal system and found them to have been functioning as designed at the time of the crash.

- ***Weather:*** There was no precipitation at the time of the crash, the road surface was dry, and the visibility was adequate.
- ***Emergency response:*** First responders provided appropriate and efficient emergency medical services, and they followed appropriate IC handover and communication protocols. Although responders had to cut the rear door from the motorcoach to expedite extrication of the passengers, medical evidence suggests that, in this case, the additional time required to remove the door did not affect the survival of any passengers (see section 2.4 for additional information).

The NTSB therefore concludes that none of the following were causal or contributory factors in the crash: (1) motorcoach driver licensing or experience; (2) train engineer or conductor licensing or experience; (3) motorcoach driver cell phone distraction, substance impairment, or medical condition; (4) train engineer or conductor cell phone distraction; (5) mechanical condition of the motorcoach; (6) railroad track condition or signal system operation; or (7) weather. The NTSB further concludes that the emergency response to the crash was timely and effective.

2.2 Operator Actions

2.2.1 Motorcoach Driver

Shortly after departing Bay St. Louis, at the suggestion of the onboard tour group leader and as a scenic alternative, the motorcoach driver deviated from the tour's original planned route to the Boomtown Casino in Biloxi and instead traveled along US-90. The new route was navigated by the driver's personal GPS, which he had preprogramed for commercial vehicle travel. This GPS-provided route included travel on Biloxi's Main Street and over the grade crossing where the crash occurred. The manager of Diamond Tours had proposed a different scenic route for this segment of the charter tour, which did not include travel on Main Street or over this grade crossing; however, the motorcoach driver did not receive the text from Diamond Tours that provided the directions for this alternative route. The NTSB concludes that the motorcoach driver's decisions to take a scenic route and to rely on a portable GPS device programmed for commercial vehicle navigation were reasonable.

When interviewed by NTSB investigators, the motorcoach driver stated that he had noticed the LGCGC warning sign that preceded the Main Street grade crossing. In anticipation of a high slope, he raised the rear of the motorcoach to prevent the rear bumper from scraping the crossing. The driver also said that, by the time he could see the steepness of the slope on the north side of the railroad tracks, the motorcoach was already grounded. NTSB investigators confirmed the crash driver's statement by conducting a postcrash test drive with an exemplar motorcoach driven by an experienced CDL driver. Based on his test drive at the crossing, the exemplar vehicle driver stated that, under normal acceleration, it would have been difficult to perceive the steepness of the north slope in time to prevent the motorcoach from grounding on the crossing.

The NTSB concludes that, given that (1) the motorcoach driver most likely could not have perceived the steepness of the northern slope before beginning to traverse the crossing, (2) he took the precaution of raising the rear of the motorcoach to prevent scraping the crossing, and (3) no signage prohibited transiting the crossing in a commercial vehicle, the driver's decision to travel over the Main Street grade crossing was reasonable.

2.2.2 Train Crew

When interviewed by NTSB investigators, the train engineer stated that he monitored up to three grade crossings ahead of his train but focused his attention on the nearest crossing. He reported not seeing the motorcoach enter the Main Street grade crossing but estimated that he first saw it on the tracks about 15 seconds before he applied the train's emergency brake. At that time, the train was traveling 27–29 mph.

After seeing the motorcoach and realizing that it might not move off the tracks before his train arrived at the crossing, the engineer placed his hand on the emergency brake, briefly discussed with the conductor the likelihood of the motorcoach clearing the crossing, and considered the risk of putting the train into emergency, which would include the potential for train derailment and a release of hazardous materials cargo in a populated area. He then activated the emergency brake. The engineer reported that, even then, he still expected the motorcoach to clear the crossing before a collision occurred. The data from the locomotive event data recorder showed that the engineer engaged the emergency brake about 14 seconds before the crash (when the train was about 502 feet west of the crossing).

Using the clock time from the motorcoach driver's personal GPS to establish when the motorcoach reached the Main Street crossing stop line (about 35 seconds before the crash), the NTSB estimated that the train would have been about 1,364 feet from the crossing at that time.[67] The sight distance observations conducted by NTSB investigators showed that a vehicle on the Main Street grade crossing could be perceived by a train crew at that distance. However, at that location, a train crew could also see three other grade crossings that preceded the Main Street crossing.[68] Train engineers are trained to monitor up to three grade crossings ahead but to focus on the nearest crossing. Engineers and conductors encounter vehicles crossing railroad tracks daily without collision and, based on that experience, they have a reasonable expectation that a vehicle will clear the crossing before their train reaches it.

The NTSB concludes that, given the speed of the train, the brief period that the motorcoach spent grounded on the tracks before the crash, the numerous grade crossings in this area, and how frequently the train crew encountered vehicles on crossings that ultimately cleared them safely, the estimated time that the train engineer took to detect the motorcoach on the tracks was reasonable, and his response time before engaging emergency braking was acceptable.

2.3 High-Profile Grade Crossings

2.3.1 Signage and Reconstruction Guidelines

2.3.1.1 LGCGC Warning Signs. AASHTO and the FHWA both provide guidance for the design of new and reconstructed grade crossings, including providing the maximum recommended vertical profile, which is 3 inches above or below track level at 30 feet from the nearest rail. The vertical profile of the Main Street grade crossing was well beyond the maximum recommended

[67] The train traveled 502 feet after the emergency brake was engaged, 14 seconds before the crash. At an average speed of 28 mph, the train would travel 862.4 feet in 21 seconds (35 – 14 = 21). Thus, the total distance the train traveled in the 35 seconds before the crash would have been about 1,364.4 feet (502 feet + 862.4 feet).

[68] The three other grade crossings are on Magnolia Street, Delauney Street, and Lameuse Street, for a train traveling from west to east toward Main Street.

guidance; at 30 feet north of the rail tracks, Main Street was 45.4 inches below the track level, corresponding to a 13.3-degree slope. The Main Street grade crossing was not unique in this respect; in an area spanning 2.6 miles in Biloxi, there were 22 grade crossings, all of which had vertical profiles beyond the recommended limit.

Although a grade crossing that falls outside the recommended parameters for vertical profile can be termed a high-profile crossing, there is no single, comprehensive definition of a high-profile grade crossing. The FRA defines a high-profile grade crossing simply as one that is posted with an LGCGC warning sign that is also noted on the grade crossing inventory form; however, it is highway authorities (state or local) that decide whether to post such a sign, based on the subjective interpretation of a traffic engineer. Moreover, the guidance concerning countermeasures to address the safety risks posed by high-profile grade crossings is limited.

Signage is a frequently used countermeasure, and one that was present at the Main Street grade crossing at the time of the crash. Ahead of the crossing, an LGCGC warning sign alerted road users of the crossing's high vertical profile. The MUTCD provides broad guidance describing the conditions under which an LGCGC warning sign should be installed, as follows: "…if the highway conditions are sufficiently abrupt to create a hang-up situation for long wheelbase vehicles or for trailers with low ground clearance…" (FHWA 2009). The term "sufficiently abrupt" is vague and open to interpretation, which could result in inconsistent installation of warning signs. For example, at the time of the crash, the Lee Street grade crossing in Biloxi was posted with an LGCGC warning sign; however, three other grade crossings in Biloxi and two in the neighboring city of Gulfport with higher vertical profiles than the Lee Street crossing did not have LGCGC warning signs.[69]

LGCGC warning signs inform road users of a grade crossing's steeper-than-normal slope. They do not specify the steepness of the slope, nor do they adequately inform road users about exactly what types of vehicles are at risk. At the time of the crash, four grade crossings in the Biloxi and Gulfport areas were posted with LGCGC warning signs. NTSB investigators examined the approach slopes at those crossings and found that the top grades ranged from -11.4 to -21.5 percent.[70] These differences in the approach slopes are drastic, and the degree of discrepancy is not effectively conveyed by posting identical LGCGC warning signs at these various locations. The LGCGC warning sign at the Main Street crossing was accompanied by a "LOW GROUND CLEARANCE" plaque at the time of the crash, and, although the motorcoach driver took precautions in response to the warning signage, the vehicle still grounded on the crossing.[71] The current design of an LGCGC warning sign does not convey what a driver should do in response to it. Even the driver of a truck with a lowboy trailer—as is pictured in the LGCGC

[69] NTSB investigators measured the approach grades of all grade crossings in Biloxi (29 crossings) and Gulfport (2 crossings). In Biloxi, the higher slope on the Lee Street grade crossing measured 11.4 percent; the higher slopes on the Holley Street, Nixon Street, and Benachi Avenue crossings measured 13.7 percent, 17.6 percent, and 16.4 percent, respectively. The higher slope of two grade crossings in Gulfport—Walston Avenue and Gulf Avenue—measured 23.5 percent and 16 percent, respectively.

[70] For comparison, according to the FHWA/AASHTO guidance, the maximum acceptable height difference of 3 inches at a distance of 30 feet from the tracks corresponds to a grade of 0.89 percent.

[71] At the same time, when approaching the crossing, the GPS device sounded an auditory alert and its screen depicted the railroad tracks and showed an LGCGC warning in the upper right corner. If the warning were tapped, the device screen displayed a banner across its top that read "Risk of Grounding."

sign—would not know from the sign whether to take another route to avoid the crossing, to cross it slowly, to accelerate quickly over it, etc.

Additionally, based on pertinent vehicle dimensions, such as length, ground clearance, and rear overhang, many types of vehicles are at risk of grounding on a high-profile crossing. For instance, motorcoaches, such as the one involved in the Biloxi crash, are at risk for grounding on high-profile grade crossings due the ratio of their length to ground clearance; yet neither AAMVA nor FMCSA guidance mentions motorcoaches as low ground clearance vehicles with a strong potential for grounding. Moreover, the guidance does not specifically discuss the meaning of, and appropriate responses to, LGCGC warning signs. NTSB investigators reviewed the available literature but had difficulty in finding evidence of the effectiveness of LGCGC warning signs, primarily due to their nonspecific purpose and measure of success.

Between February 2014, when CSXT performed maintenance that raised the level of the tracks at the Main Street grade crossing, and the March 7, 2017, crash date, 23 incidents were reported of a vehicle grounding at the crossing, 2 of which resulted in collisions. Clearly, the LGCGC warning sign and "LOW GROUND CLEARANCE" plaque, which were present throughout this period, were not effective in preventing long wheelbase vehicles, vehicles with significant rear overhang, and those with low ground clearance from traversing this grade crossing. However, we cannot determine whether the grounding incidents might have been still more frequent had the LGCGC warning signage been absent.

The NTSB concludes that, based on the high frequency of grounding incidents at the Main Street grade crossing, which was posted with LGCGC warning signage, and the lack of evidence of the safety benefits provided by LGCGC warning signs, the effectiveness of such signs in promoting safety at grade crossings may be negligible.

2.3.1.2 Grade Crossing Exclusion Signs. Following the crash, the City of Biloxi posted a selective exclusion sign at the Main Street grade crossing, which specifically prohibited access to buses, trucks, and recreational vehicles. Unlike LGCGC warning signs, which provide a generic warning and rely on the driver to determine the appropriate response, an exclusion sign leaves no room for interpretation—drivers can see that the specified vehicle types are prohibited from using the crossing.

The MUTCD does not provide any guidance for determining when a jurisdiction should install exclusion signs at grade crossings, although it does provide guidelines for the installation of other types of grade and low clearance warning signs. For example, if a downgrade of a road poses a potential hazard to road users, the MUTCD recommends that a "hill grade" sign be installed to convey specific information about the severity of the grade. If a road crosses under a low overhead structure, the MUTCD recommends that a "low overhead clearance" sign be installed to convey information about maximum vehicle height (FHWA 2009). Grade crossings pose more complex decision-making problems, because the risk of grounding is dependent not only on the approach slope but also on the vehicle's wheelbase and ground clearance.

Traffic engineers could benefit from guidance specifying the conditions under which they should consider the installation of exclusion signs, as well as which vehicle types the signage should exclude. Guidelines or standards for placing an exclusion sign can be based on various criteria, particularly including (1) the grade crossing's topographical profile (its slope or curvature) and (2) the frequency of crashes or vehicle groundings taking place on the crossing. Guidance based on a crossing's topographical profile could be considered proactive, with the possibility of preventing future vehicle groundings. However, given the variability in the topographical profiles of grade crossings and the possible combinations of vehicle types based on their various pertinent dimensions—wheelbase length, ground clearance, rear overhang, etc.—it may be challenging to develop solely topographical standards that apply to all grade crossings and vehicle types. In contrast to topographical standards, guidance based on the frequency of past grounding incidents on a grade crossing might be considered reactive, but such a system has the advantage of using real-world data that are specific to a particular grade crossing. Using both proactive and reactive methods to develop signage standards would combine their advantages.

A multipronged approach to developing appropriate standards is used when determining the need for other types of highway safety treatments. For example, the criteria for installing median barriers that prevent or reduce instances of median crossovers and head-on crashes are typically based on the location's high-risk factors, such as median width and average annual daily traffic. However, some states add a criterion for making the decision—the frequency of median crossovers—regardless of median width or traffic volume. The dual approach of considering both the roadway characteristics and the crash rate allows traffic engineers to address sections of a highway that have a high incidence of crossovers but that do not meet the conventional roadway definition of being at high risk for such events. Similarly, a standard for placing exclusion signs at grade crossings that considers the frequency of vehicle groundings would address those grade crossings that are at high risk for groundings, even if they do not have the topographical features of a typical high-profile crossing.

The FHWA can develop such a standard for grade crossing signage and include it as a recommended practice in the MUTCD. However, incorporating new standards into the MUTCD can be a lengthy process. As an interim measure, the FHWA has the option of issuing an official interpretation of a guidance practice that already exists. The interpretations are issued "when unique situations arise for device applications that might require interpretation or clarification of the Manual (FHWA 2009)."[72] As such, the guidance practice for installing LGCGC warning signage could include an interpretation specifying other options that traffic engineers might adopt for high-profile grade crossings, such as the use of exclusion signs.

The NTSB concludes that traffic engineers would benefit from clear guidance that describes when vehicle exclusion signs should be installed at grade crossings. Therefore, the NTSB recommends that the FHWA issue an interpretation of the guidance practice for LGCGC warning signage in the MUTCD to suggest the use of other signage, such as vehicle exclusion signs, to address safety issues at high-profile grade crossings; and inform the state DOTs of the new interpretation. Additionally, the NTSB recommends that the FHWA develop and establish a guidance practice addressing the circumstances in which vehicle exclusion signs should be installed to restrict access to high-profile grade crossings and the types of vehicles to which the exclusions should apply; and incorporate the guidance practice into the MUTCD.

[72] The FHWA official interpretations are included in section 1A.10 of the MUTCD. For additional information, see the FHWA MUTCD website, accessed June 25, 2018.

2.3.1.3 Grade Crossing Reconstruction. AASHTO, the FHWA, and AREMA provide guidance on the maximum acceptable vertical profile for a new or newly reconstructed grade crossing. However, neither highway nor rail guidance documents specify the maximum vertical profile that a grade crossing may reach during its service life before it should be reconstructed.

One common consequence of regular railroad maintenance—specifically, the replacement of wooden ties—is to increase the vertical profiles of grade crossings. The effects of such maintenance were evident in the dramatic increase in the frequency of vehicle groundings at the Main Street grade crossing following the February 2014 replacement of wooden railroad ties. The NTSB concludes that, due to the February 2014 track maintenance work, which increased the crossing's vertical profile and resulted in increased frequency of vehicle groundings, the Main Street grade crossing had been unsafe for certain types of vehicles for several years before the fatal March 2017 crash.

Since the crash, the City of Biloxi has installed a selective vehicle exclusion sign and begun plans to develop a commercial vehicle route through Biloxi. According to CSXT, there was only one vehicle grounding at the crossing in the year following the crash. Postcrash, the City of Biloxi considered reconstructing the Main Street grade crossing, but, due to the high cost and the lack of funding, it ultimately determined to proceed with other countermeasures. Although the cost of reconstructing a grade crossing is a critical decision-making factor for local authorities, the lack of guidance or standards for establishing a maximum acceptable vertical profile of an existing grade crossing also presents a challenge when determining whether reconstruction is necessary. Because neither the FHWA nor the FRA provides guidance indicating what the maximum vertical profile of a crossing should be, a jurisdiction's decision on crossing reconstruction is essentially subjective.

The NTSB concludes that traffic engineers would benefit from clear guidance that describes the maximum vertical profile a grade crossing may have before comprehensive risk mitigation options, including crossing reconstruction, should be considered to improve safety. The NTSB recommends that the FHWA, with assistance from the FRA, AASHTO, and AREMA, develop specific criteria to establish when an existing grade crossing should be reconstructed, closed, or otherwise have the risk posed by its unsafe vertical profile comprehensively mitigated; and incorporate the guidance into its *Railroad-Highway Grade Crossing Handbook*.

2.3.2 Coordination of Maintenance and Risk Monitoring

2.3.2.1 Early Coordination on Maintenance. The Main Street grade crossing had last been reconstructed in 1977. The reconstruction plans specified a downgrade slope of 12.3 percent north of the tracks, which is well beyond the current recommended guidance for maximum slope. Since 1977, CSXT has performed regular maintenance of the tracks, including replacing wooden railroad ties, a procedure that raises the track level by about 1.5 inches each time it is performed. Over the years, this accumulation of track level elevations can substantially raise the railroad track above its original construction level. Moreover, even a single track elevation can have a substantial impact on grade crossing safety.

At the Main Street crossing, the wooden railroad ties had last been replaced in February 2014. The 23 vehicle groundings that were reported at the crossing in the 3 years after the February 2014 track maintenance—compared to only 3 reported groundings for the previous 2 years—

suggest that the last elevation of the tracks substantially increased the risk of vehicle groundings on the crossing. Railroad maintenance that affects a grade crossing's vertical profile can have a considerable safety impact on all road users, particularly when it increases the crossing's vertical profile beyond recommended parameters, as specified by both highway (AASHTO and the FHWA) and railroad (AREMA) organizations.

The FRA does not require railroad companies to coordinate with, or even inform, local and state transportation agencies when they conduct maintenance on railroad tracks. MDOT was not informed of the track maintenance that CSXT conducted in February 2014. Although CSXT most likely informed the City of Biloxi that it planned to carry out some railroad work—given that the work required closure of the affected crossings—NTSB investigators uncovered no evidence that CSXT gave the city details about the work being done, or specifically, that it would raise the crossings' vertical profiles.

The Transportation Research Board (TRB) has published research on practices pertaining to the review and implementation of projects between highway agencies and railroad companies, including work on improving and reconstructing grade crossings (TRB 2010). As part of this research, practitioners from more than 50 highway agencies and railroad companies were interviewed, and TRB identified 20 commonly desired practices, including (1) early formal coordination between a railroad company and state and local highway agencies, and (2) periodic and ongoing reviews of the project throughout its development.

Although early coordination on grade crossing maintenance projects can be beneficial, the extent to which such coordination about the February 2014 track maintenance might have affected the circumstances of this crash cannot be determined. We do not know whether MDOT or the City of Biloxi might have realized that raising the vertical profile of the Main Street crossing could increase the risk of vehicle grounding, or whether either agency would have elected to take effective countermeasures based on such knowledge. At a minimum, however, with better communication, MDOT and the City of Biloxi would have had the opportunity to consider the potential for increased risk of vehicle groundings on the crossing. By not communicating effectively with MDOT and the city about the crossing maintenance and its consequences, CSXT denied them this opportunity.

The NTSB concludes that, had CSXT communicated and coordinated with the City of Biloxi and MDOT about planned railroad projects that might affect the vertical profiles of grade crossings in their jurisdictions, it would have provided them the opportunity to assess and monitor the risks of vehicle groundings and, if necessary, to take proactive action to reduce those risks. Therefore, the NTSB recommends that all Class I railroads implement a process to notify and coordinate with the local and state transportation agencies responsible for highway maintenance at grade crossings as early as possible before conducting any planned maintenance work that has the potential to increase track elevation.

2.3.2.2 Risk Monitoring. There is some confusion as to which entity is responsible for safety associated with grade crossing maintenance. CSXT and the City of Biloxi each claimed that the other party was responsible for maintaining grade crossings. The NTSB examined a 1977 agreement between CSXT and the City of Biloxi, as well as the relevant case law. Although the agreement indicates that the city assumed the entire expense of construction, installation, maintenance, and operation of any grade crossings in its jurisdiction, including any warning devices, some subsequent case law indicates that a railroad may not contract away its duties and liabilities concerning the safety of public grade crossings. In addition, Mississippi statutes (*Miss. Code. Ann.* § 65-1-175 [2013]) grant MDOT a certain level of authority over public roadway/railroad crossings, including the power to abolish or close a crossing, require new safety-related signage, or approve the construction of new or existing crossings.

It is outside the scope of this investigation to make a definitive determination as to which entity bears the responsibility for maintenance of the Main Street grade crossing; however, both CSXT and the City of Biloxi were aware of the frequency of vehicle groundings in the 3 years following the February 2014 track maintenance that increased the crossing's vertical profile.[73] The NTSB concludes that, although CSXT and the City of Biloxi knew that numerous vehicle groundings had occurred on the Main Street grade crossing after track maintenance was performed in early 2014, neither took action to reduce the safety risk posed by the crossing to both railroad and highway traffic.

Many state DOTs have negotiated standard legal agreements with railroad companies regarding grade crossing maintenance and reconstruction. For example, in 1976, the state of Iowa initiated a grade crossing surface repair program with the primary objective of reconstructing all grade crossings and providing subsequent regular maintenance (TRB 2010). Under the program, grade crossings throughout the state are reviewed, scored as to their need for reconstruction (determined by multiple factors, including average annual daily traffic, elevation differential, and approach profile), and then selected for improvement. By agreement, these projects are funded by contributions from state and local governments, as well as from railroad companies. Some states, like Iowa and Washington, have centralized coordination of all highway projects related to rail operations, which allows the state to prioritize projects and ensure consistency in negotiating and establishing agreements with railroad companies.

Although Mississippi does not have centralized coordination of highway–railroad projects, MDOT does have limited authority over grade crossings, including the power to close any it deems unsafe. MDOT is divided into six districts that communicate with local municipalities and relay significant safety issues to MDOT management. However, incidents of vehicle groundings on grade crossings are not communicated to MDOT. Given sufficient information, MDOT may be in the best position to provide oversight, facilitate communication, and assist in arbitrating situations when a railroad company and a local authority disagree on maintenance responsibilities. Local municipalities are critical sources of information on the safety of individual grade crossings, including the incidence of vehicle groundings and secondary measures of risk, such as the crossing's slope and average annual daily traffic of commercial vehicles. However, the local highway transportation departments that communicate with MDOT may not have complete records of all such incidents within their municipalities. For example, although the BPD was aware of nearly all grounding incidents on the Main Street grade crossing, the Biloxi Engineering Department had records for only a fraction of these incidents.

[73] As noted earlier, after the February 2014 maintenance, there were 23 incidents of vehicle grounding on the Main Street grade crossing, 2 of which ended in collisions. The BPD was aware of 18 of these incidents, and CSXT had records for 22 of them.

The NTSB concludes that, because MDOT has authority to close grade crossings in the state, increasing the department's awareness of the safety conditions of grade crossings through enhanced communication with local municipalities might enable it to prioritize improvements to Mississippi grade crossings and assist in improving grade crossing safety. Therefore, the NTSB recommends that MDOT establish communication channels with local municipalities, particularly the City of Biloxi, to monitor the safety of grade crossings, focusing particularly on incidents of vehicle groundings, and, as necessary, assist municipalities in improving the safety of high-risk grade crossings. Additionally, the NTSB recommends that the City of Biloxi implement a program to document incidents of vehicle groundings at grade crossings and to share this information with MDOT.

Although various agencies in the City of Biloxi were aware of the incidents of vehicle groundings at the Main Street grade crossing, other, especially smaller, municipalities may not maintain such records. If state DOTs rely solely on local municipalities to monitor the safety of grade crossings, particularly through the evidence of incidents of vehicle groundings, they may be insufficiently informed. CSXT, on the other hand, keeps records of vehicle grounding incidents, a practice typical of railroad companies. Railroad companies are highly incentivized to share information about high-risk grade crossings with agencies able to effect safety improvements. Such grade crossings represent a safety risk not only to highway vehicles but also to trains, because emergency braking, and especially crashes, can cause derailments. Considering that grounding data can be critical in determining the safety of a grade crossing and in predicting the likelihood of future crashes, such grounding incident information should be shared. Therefore, the NTSB concludes that if railroads shared their information on incidents of vehicle groundings on grade crossings with state DOTs, it would enable state authorities to continuously monitor and assess the safety of the grade crossings in their jurisdictions. Therefore, the NTSB recommends that all Class I railroads implement a process to make information about incidents of vehicle groundings at grade crossings that did not result in a crash on their railroad available to the appropriate state departments of transportation.

Moreover, to ensure that the railroad industry as a whole is aware of the important safety issues associated with coordinating and communicating with local authorities about both grade crossing risk and maintenance work at crossings, the NTSB further recommends that the Association of American Railroads and the American Short Line and Regional Railroad Association inform their members of the circumstances of the March 7, 2017, Biloxi, Mississippi, grade crossing crash, and emphasize the importance of communication with local and state highway transportation agencies regarding railroad maintenance activities and vehicle grounding incidents on grade crossings.

2.4 Emergency Egress and Extrication

Emergency evacuation from the motorcoach occurred both before and after the collision. Based on data from various recorders, the motorcoach was grounded on the crossing for a brief period before the grade crossing warning system activated, which occurred about 29 seconds before the crash. When the passengers noticed the crossing lights and bells activating, and saw the approaching train and heard its horn, they told the driver, who opened the loading door and told them to evacuate. It is unclear when the driver opened the loading door but, based on the onboard video from the motorcoach's interior-facing camera—which shows about 7 seconds of preimpact events, an already-open loading door, and passengers evacuating—and postcrash interviews with the passengers, the door was open for more than 8 seconds before the crash. Six passengers safely evacuated before the impact; the evacuation of three of these passengers was captured by the camera, and the other three passengers had safely evacuated before the video began. Two of the passengers who died were attempting to exit the motorcoach at the time of impact, while a third passenger who died had stepped off the vehicle just before the impact.

Preimpact evacuation was a safer option than remaining on the motorcoach, but only for those passengers who had sufficient time to reach a safe distance from the crash area before the collision. All the passengers were attempting to evacuate via the loading door, which crowded the aisleway exit path and limited the time available for safe egress by this route. The passengers were mostly members of a senior center, and their limited mobility, as well as the (at least) 22-inch distance from the loading door's bottom step to the ground (while the motorcoach was stuck on the track), most likely reduced the speed of evacuation through the loading door.

None of the passengers who remained on the motorcoach attempted to use the rear door or the emergency windows as means of precrash egress, and it is difficult to determine whether any would have had time to safely evacuate through these alternate egress points before the impact. The time between the driver's order to evacuate and the train's impact was brief. The NTSB concludes that, with respect to preimpact evacuation, because of the brief period during which the motorcoach was grounded on the crossing before the train struck it and the limited mobility of many of the passengers, it is unlikely that many more passengers could have safely evacuated before the collision occurred, regardless of which means of egress was used.

Although the motorcoach was equipped with a secondary door at the rear, no attempts were made to use the door during the preimpact evacuation. Even had the passengers' evacuation parameters been optimal—proximity to egress point, good physical condition, sufficient time to reach a safe area, etc.—their ability to open the rear door would depend on their being aware of its existence and their understanding of how to operate it. Some passengers, who were trapped in the rear of the motorcoach because of the overcrowded aisle, were standing near the rear door before the collision, but they told investigators that they had been unaware of its presence.

Although it is debatable whether the rear door could have been safely used for egress before the train struck the motorcoach, particularly because its bottom edge was about 4 feet 8 inches above the ground, the door's potential postcrash usefulness is clear. The train's impact reduced the aisle width in the middle section of the motorcoach to about 8 inches, and it caused the floor to buckle and tear. Also, some injured passengers were on the floor, which—combined with the reduced aisle width—caused significant aisle congestion and prevented passengers at the rear of the motorcoach from exiting through the loading door. First responders assisted the passengers in the rear to evacuate through the windows but, due to the limited mobility of many of the passengers and the need to extricate some on backboards, evacuation via the windows was challenging.

By the time emergency responders were removing occupants from the motorcoach, the rear door was inoperative from inside the motorcoach. Although the rear door was undamaged, its emergency handle had been removed and displaced by a passerby who entered the motorcoach ahead of emergency responders. Eventually, responders cut away the entire rear door to help speed the extrication process. Had the passengers been aware of the presence of the rear door and been able to open it immediately after the impact, its use most likely would have reduced the evacuation time. Although the rear door's considerable distance from the ground would have made it challenging for passengers to use it to jump from the motorcoach unaided, the door would have provided responders with an easy extrication access point. However, based on the evidence of the injuries sustained by passengers, it is unlikely that the injury outcomes would have been changed had the first responders been able to evacuate rear passengers sooner.

As a result of a 2014 motorcoach crash in Orland, California, in which damage and a postcrash fire made passengers' egress difficult, contributing to the severity of their injuries (NTSB 2015), the NTSB recommended that NHTSA require new motorcoaches to include a secondary door for use as an emergency exit (Safety Recommendation H-15-13, which is classified "Open—Acceptable Response"). Although the rear door on the Biloxi motorcoach was not designated as an emergency exit, it would have been considered one on some differently configured motorcoaches. The design of this door would have allowed it to be used as a secondary egress point; yet, for the reasons indicated earlier, it was not used for that purpose in this case.

As a result of the Orland investigation, the NTSB also recommended that the FMCSA—

> Require all passenger motor carrier operators to (1) provide passengers with pretrip safety information that includes, at a minimum, a demonstration of the location of all exits, explains how to operate the exits in an emergency, and emphasizes the importance of wearing seat belts, if available; and (2) also place printed instructions in readily accessible locations for each passenger to help reinforce exit operation and seat belt usage. (H-15-14)

This recommendation is classified "Open—Acceptable Response."

In its most recent correspondence concerning this recommendation, dated March 2018, the FMCSA stated that, due to the wide variance in vehicles operated by passenger carriers, it does not believe that Safety Recommendation H-15-14 is viable; consequently, it does not plan to implement the necessary rulemaking. However, the FMCSA stated that it will continue to recommend that carriers voluntarily provide safety-related information to passengers. Although the NTSB acknowledges the challenges in implementing this recommendation among the various types of passenger vehicles and operations to which it applies, we reject the FMCSA's conclusion that the recommendation is not viable.

The motorcoach driver in this case did provide a pretrip safety briefing to the initial group of passengers, which included a description of the emergency exit windows; however, he did not mention the rear door as a means of emergency egress.[74] ECHO Transportation stated that, because federal regulations do not require the use of a secondary door for emergency egress, it did not train its drivers on how to operate the rear door or inform passengers about the door's function. Secondary exit doors are permitted under the *Federal Motor Vehicle Safety Standards*, and they are considered designated emergency exits on certain buses. Van Hool motorcoach models with

[74] The driver did not provide any safety briefing to the second group of the passengers that he picked up shortly after the Bastrop loading stop. Also, he gave the briefing only on the first day of the trip, March 5, 2017.

the same configuration of windows and doors as the Biloxi motorcoach are sold in Europe; to meet the European Union requirements, the rear door is considered a designated emergency exit.[75]

The NTSB concludes that, with respect to postimpact evacuation, although use of the rear door might not have improved the passengers' injury outcomes, a pretrip safety briefing that included a demonstration of how to operate the rear door might have enabled the passengers to open that door after the impact, expediting the postcrash evacuation and extrication process. As a result, the NTSB reiterates Safety Recommendation H-15-14 to the FMCSA and reclassifies it "Open—Unacceptable Response."

[75] Section 7.6 of Economic Commission for Europe Regulation 107 defines various configurations of acceptable exits according to vehicle type and passenger capacity.

3 Conclusions

3.1 Findings

1. None of the following were causal or contributory factors in the crash: (1) motorcoach driver licensing or experience; (2) train engineer or conductor licensing or experience; (3) motorcoach driver cell phone distraction, substance impairment, or medical condition; (4) train engineer or conductor cell phone distraction; (5) mechanical condition of the motorcoach; (6) railroad track condition or signal system operation; or (7) weather.

2. The emergency response to the crash was timely and effective.

3. The motorcoach driver's decisions to take a scenic route and to rely on a portable global positioning system device programmed for commercial vehicle navigation were reasonable.

4. Given that (1) the motorcoach driver most likely could not have perceived the steepness of the northern slope before beginning to traverse the crossing, (2) he took the precaution of raising the rear of the motorcoach to prevent scraping the crossing, and (3) no signage prohibited transiting the crossing in a commercial vehicle, the driver's decision to travel over the Main Street grade crossing was reasonable.

5. Given the speed of the train, the brief period that the motorcoach spent grounded on the tracks before the crash, the numerous grade crossings in this area, and how frequently the train crew encountered vehicles on crossings that ultimately cleared them safely, the estimated time that the train engineer took to detect the motorcoach on the tracks was reasonable, and his response time before engaging emergency braking was acceptable.

6. Based on the high frequency of grounding incidents at the Main Street grade crossing, which was posted with low ground clearance grade crossing (LGCGC) warning signage, and the lack of evidence of the safety benefits provided by LGCGC warning signs, the effectiveness of such signs in promoting safety at grade crossings may be negligible.

7. Traffic engineers would benefit from clear guidance that describes when vehicle exclusion signs should be installed at grade crossings.

8. Due to the February 2014 track maintenance work, which increased the crossing's vertical profile and resulted in increased frequency of vehicle groundings, the Main Street grade crossing had been unsafe for certain types of vehicles for several years before the fatal March 2017 crash.

9. Traffic engineers would benefit from clear guidance that describes the maximum vertical profile a grade crossing may have before comprehensive risk mitigation options, including crossing reconstruction, should be considered to improve safety.

10. Had CSX Transportation communicated and coordinated with the City of Biloxi and the Mississippi Department of Transportation about planned railroad projects that might affect the vertical profiles of grade crossings in their jurisdictions, it would have provided them

the opportunity to assess and monitor the risks of vehicle groundings and, if necessary, to take proactive action to reduce those risks.

11. Although CSX Transportation and the City of Biloxi knew that numerous vehicle groundings had occurred on the Main Street grade crossing after track maintenance was performed in early 2014, neither took action to reduce the safety risk posed by the crossing to both railroad and highway traffic.

12. Because the Mississippi Department of Transportation has authority to close grade crossings in the state, increasing the department's awareness of the safety conditions of grade crossings through enhanced communication with local municipalities might enable it to prioritize improvements to Mississippi grade crossings and assist in improving grade crossing safety.

13. If railroads shared their information on incidents of vehicle groundings on grade crossings with state departments of transportation, it would enable state authorities to continuously monitor and assess the safety of the grade crossings in their jurisdictions.

14. With respect to preimpact evacuation, because of the brief period during which the motorcoach was grounded on the crossing before the train struck it and the limited mobility of many of the passengers, it is unlikely that many more passengers could have safely evacuated before the collision occurred, regardless of which means of egress was used.

15. With respect to postimpact evacuation, although use of the rear door might not have improved the passengers' injury outcomes, a pretrip safety briefing that included a demonstration of how to operate the rear door might have enabled the passengers to open that door after the impact, expediting the postcrash evacuation and extrication process.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of the Biloxi, Mississippi, crash was the failure of CSX Transportation and the City of Biloxi to coordinate and take action to improve the safety of the Main Street grade crossing, a high vertical profile crossing on which motor vehicles were known to ground frequently; their inaction led to the grounding of the motorcoach that was subsequently struck by the CSX Transportation freight train. Contributing to the circumstances of the crash was the inadequate guidance from the Federal Highway Administration on how to mitigate the risks posed by grade crossings with high vertical profiles.

4 Recommendations

4.1 New Recommendations

As a result of its investigation, the National Transportation Safety Board makes the following new safety recommendations:

To the Federal Highway Administration:

Issue an interpretation of the guidance practice for low ground clearance grade crossing warning signage in the *Manual on Uniform Traffic Control Devices for Streets and Highways* to suggest the use of other signage, such as vehicle exclusion signs, to address safety issues at high-profile grade crossings. Inform the state departments of transportation of the new interpretation. (H-18-23)

Develop and establish a guidance practice addressing the circumstances in which vehicle exclusion signs should be installed to restrict access to high-profile grade crossings and the types of vehicles to which the exclusions should apply. Incorporate the guidance practice into the *Manual on Uniform Traffic Control Devices for Streets and Highways*. (H-18-24)

With assistance from the Federal Railroad Administration, American Association of State Highway and Transportation Officials, and American Railway Engineering and Maintenance-of-Way Association, develop specific criteria to establish when an existing grade crossing should be reconstructed, closed, or otherwise have the risk posed by its unsafe vertical profile comprehensively mitigated. Incorporate the guidance into your *Railroad-Highway Grade Crossing Handbook*. (H-18-25)

To the Federal Railroad Administration:

Assist the Federal Highway Administration (FHWA) in developing specific criteria to establish when an existing grade crossing should be reconstructed, closed, or otherwise have the risk posed by its unsafe vertical profile comprehensively mitigated, to be incorporated into the FHWA *Railroad-Highway Grade Crossing Handbook*. (R-18-11)

To the Mississippi Department of Transportation:

Establish communication channels with local municipalities, particularly the City of Biloxi, to monitor the safety of grade crossings, focusing particularly on incidents of vehicle groundings, and, as necessary, assist municipalities in improving the safety of high-risk grade crossings. (H-18-26)

To the City of Biloxi, Mississippi:

Implement a program to document incidents of vehicle groundings at grade crossings and to share this information with the Mississippi Department of Transportation. (H-18-27)

To the American Association of State Highway and Transportation Officials:

Assist the Federal Highway Administration (FHWA) in developing specific criteria to establish when an existing grade crossing should be reconstructed, closed, or otherwise have the risk posed by its unsafe vertical profile comprehensively mitigated, to be incorporated into the FHWA *Railroad-Highway Grade Crossing Handbook.* (H-18-28)

To the American Railway Engineering and Maintenance-of-Way Association:

Assist the Federal Highway Administration (FHWA) in developing specific criteria to establish when an existing grade crossing should be reconstructed, closed, or otherwise have the risk posed by its unsafe vertical profile comprehensively mitigated, to be incorporated into the FHWA *Railroad-Highway Grade Crossing Handbook.* (R-18-12)

To the Association of American Railroads and the American Short Line and Regional Railroad Association:

Inform your members of the circumstances of the March 7, 2017, Biloxi, Mississippi, grade crossing crash, and emphasize the importance of communication with local and state highway transportation agencies regarding railroad maintenance activities and vehicle grounding incidents on grade crossings. (R-18-13)

To all Class I railroads:

Implement a process to notify and coordinate with the local and state transportation agencies responsible for highway maintenance at grade crossings as early as possible before conducting any planned maintenance work that has the potential to increase track elevation. (R-18-14)

Implement a process to make information about incidents of vehicle groundings at grade crossings that did not result in a crash on your railroad available to the appropriate state departments of transportation. (R-18-15)

4.2 Recommendation Reiterated and Reclassified in this Report

The National Transportation Safety Board also reiterates and reclassifies the following safety recommendation:

To the Federal Motor Carrier Safety Administration:

> Require all passenger motor carrier operators to (1) provide passengers with pretrip safety information that includes, at a minimum, a demonstration of the location of all exits, explains how to operate the exits in an emergency, and emphasizes the importance of wearing seat belts, if available; and (2) also place printed instructions in readily accessible locations for each passenger to help reinforce exit operation and seat belt usage. (H-15-14)

This recommendation is reiterated and reclassified "Open—Unacceptable Response" in section 2.4 of this report.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

ROBERT L. SUMWALT, III
Chairman

EARL F. WEENER
Member

T. BELLA DINH-ZARR
Member

Adopted: August 7, 2018

Appendix A: Investigation

The National Transportation Safety Board (NTSB) received notification of this crash on March 7, 2017, and launched an investigative team to address highway, vehicle, human performance, and survival factors; motor carrier and railroad operations; and onboard recorders. The NTSB team included staff from the Offices of Board Member Robert L. Sumwalt; Highway Safety; Railroad, Pipeline, and Hazardous Materials; Research and Engineering; Safety Recommendations and Communications; and Chief Information Officer. Board Member (now Chairman) Robert L. Sumwalt was the NTSB spokesperson on scene.

The Federal Highway Administration, the Federal Railroad Administration, the Federal Motor Carrier Safety Administration, the Mississippi Department of Transportation, the Biloxi Police Department, the Biloxi Department of Engineering, CSX Transportation, TBL Group–ECHO Tours and Charters, and ABC Companies (c/o Van Hool) were parties to the investigation.

References

AASHTO (American Association of State Highway and Transportation Officials). 2011. *A Policy on Geometric Design of Highways and Streets,* 6th edition. Washington, DC: AASHTO.

AAMVA (American Association of Motor Vehicle Administrators). 2016. *Commercial Driver's License Manual*. Arlington, Virginia: AAMVA.

AREMA (American Railway Engineering and Maintenance-of-Way Association). 2011. *AREMA Manual for Railway Engineering*. Landover, Maryland: AREMA.

FHWA (Federal Highway Administration). 2007. *Railroad-Highway Grade Crossing Handbook*, revised 2nd edition. Washington, DC: FHWA.

——. 2009. *Manual on Uniform Traffic Control Devices for Streets and Highways*. Washington, DC: FHWA.

MDOT (Mississippi Department of Transportation). 2001. *Mississippi Roadway Design Manual*. Jackson, Mississippi: MDOT.

——. 2012. *Mississippi Professional Driver's Manual for Class A, B & C Commercial Driver License*. MDOT. Accessed July 23, 2018, https://driving-tests.org/mississippi/ms-cdl-handbook/.)

NTSB (National Transportation Safety Board). 2015. *Truck-Tractor Double Trailer Median Crossover Collision With Motorcoach and Postcrash Fire on Interstate 5, Orland, California, April 10, 2014*. Highway Accident Report NTSB/HAR-15/01. Washington, DC: NTSB.

TRB (Transportation Research Board). 2010. *Strategies for Improving the Project Agreement Process Between Highway Agencies and Railroads (SHRP 2)*. Report S2-R16-RR-1. Washington, DC: TRB.

TxDPS (Texas Department of Public Safety). 2014. *Texas Commercial Motor Vehicle Drivers Handbook*. Austin, Texas: TxDPS. [Note: Handbook indicates that its content was created for and provided to state driver license agencies by the American Association of Motor Vehicle Administrators in 2005.]