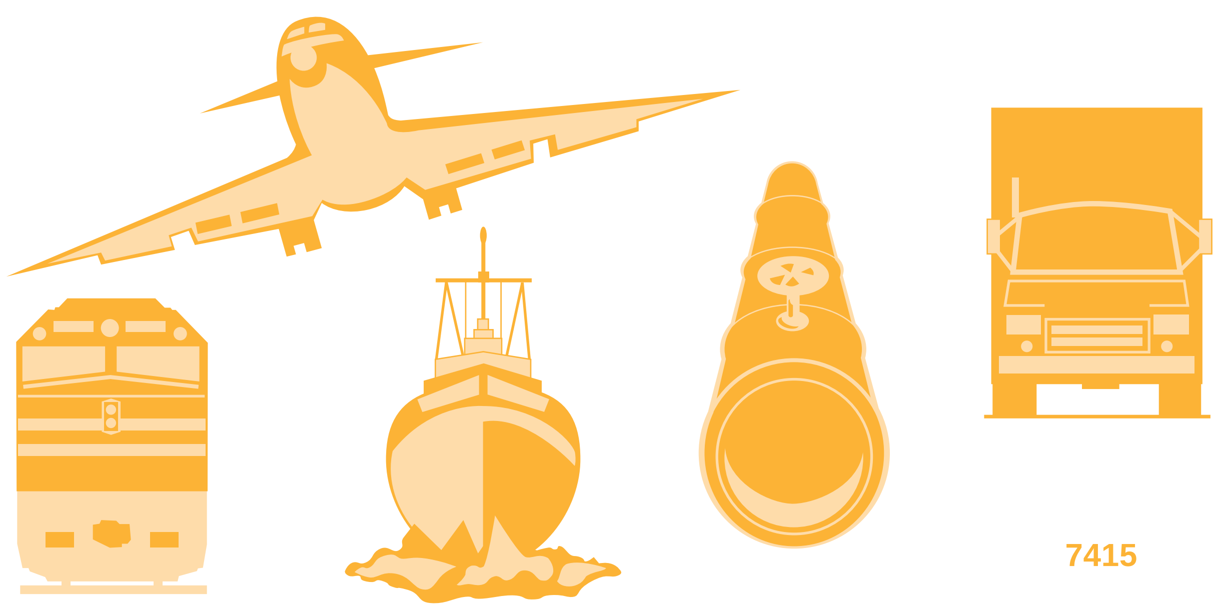
PB2001-916203
NTSB/HAR-01/03

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

HIGHWAY ACCIDENT REPORT

COLLISION OF CSXT FREIGHT TRAIN AND MURRAY COUNTY SCHOOL DISTRICT SCHOOL BUS AT RAILROAD/HIGHWAY GRADE CROSSING CONASAUGA, TENNESSEE MARCH 28, 2000



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Highway Accident Report

Collision of CSXT Freight Train and Murray County School District School Bus at Railroad/Highway Grade Crossing Conasauga, Tennessee March 28, 2000

NTSB/HAR-01/03
PB2001-916203
Notation 7415
Adopted December 11, 2001

National Transportation Safety Board
490 L'Enfant Plaza, S.W.
Washington, D.C. 20594

National Transportation Safety Board. 2001. ***Collision of CSXT Freight Train and Murray County School District School Bus at Railroad/Highway Grade Crossing in Conasauga, Tennessee, on March 28, 2000.*** **Highway Accident Report NTSB/HAR-01/03. Washington, DC.**

Abstract: On March 28, 2000, about 6:40 a.m. (sunrise was at 6:33 a.m.), a CSXT Transportation, Inc., freight train traveling 51 mph struck the passenger side of a Murray County, Georgia, School District school bus at a railroad/highway grade crossing near Conasauga, Tennessee. The accident occurred as the school bus was crossing the tracks at a speed of approximately 15 mph. During the accident sequence, the driver and three children were ejected. Two ejected passengers received serious injuries and one was fatally injured. The driver, who had been wearing a lap/shoulder belt that broke during the crash sequence, received minor injuries. Of the four passengers who remained inside the bus, two were fatally injured, one sustained serious injuries, and one, who was restrained by a lap belt, received minor injuries. The two train crewmembers were not injured.

The following major safety issues were identified in this accident:

- The busdriver's performance.
- School district oversight, including busdriver monitoring and evaluation procedures and bus routing.
- Passive grade crossing safety, including previous initiatives related to passive grade crossing and school bus safety.
- Occupant kinematics and survival factors.

As a result of this accident investigation, the National Transportation Safety Board makes recommendations to the States, the National Highway Traffic Safety Administration, the Federal Highway Administration, the Georgia Department of Education, the National Association of State Directors of Pupil Transportation Services, and the school bus manufacturers. The Safety Board also reiterates a recommendation to the U.S. Department of Transportation.

The National Transportation Safety Board is an independent Federal agency dedicated to promoting aviation, railroad, highway, marine, pipeline, and hazardous materials safety. Established in 1967, the agency is mandated by Congress through the Independent Safety Board Act of 1974 to investigate transportation accidents, determine the probable causes of the accidents, issue safety recommendations, study transportation safety issues, and evaluate the safety effectiveness of government agencies involved in transportation. The Safety Board makes public its actions and decisions through accident reports, safety studies, special investigation reports, safety recommendations, and statistical reviews.

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Contents

Acronyms and Abbreviations

AASHTO	American Association of State and Highway Transportation Officials
ACN	automatic crash notification
CDL	commercial driver's license
CFR	*Code of Federal Regulations*
CSC	customer service center
CSXT	CSX Transportation, Inc.
DOE	Georgia Department of Education
DOT	U.S. Department of Transportation
EMS	emergency medical services
FHWA	Federal Highway Administration
FMVSS	Federal Motor Vehicle Safety Standard
FRA	Federal Railroad Administration
GPS	global positioning system
MADYMO	Mathematical Dynamical Models
NASDPTS	National Association of State Directors of Pupil Transportation Services
NCST	National Conference on School Transportation
NHTSA	National Highway Traffic Safety Administration
VCR	videocassette recorder
WBPAS	Web-based Accident Prediction System

Executive Summary

On March 28, 2000, about 6:40 a.m. (sunrise was at 6:33 a.m.), a CSX Transportation, Inc., freight train traveling 51 mph struck the passenger side of a Murray County, Georgia, School District school bus at a railroad/highway grade crossing near Conasauga, Tennessee. The accident occurred as the school bus was crossing the tracks at a speed of approximately 15 mph. During the accident sequence, the driver and three children were ejected. Two ejected passengers received serious injuries and one was fatally injured. The driver, who had been wearing a lap/shoulder belt that broke during the crash sequence, received minor injuries. Of the four passengers who remained inside the bus, two were fatally injured, one sustained serious injuries, and one, who was restrained by a lap belt, received minor injuries. The two train crewmembers were not injured.

The National Transportation Safety Board determines that the probable cause of the collision was the school bus driver's failure to stop before traversing the railroad/highway grade crossing. Contributing to the accident was the Murray County, Georgia, School District's failure to monitor busdriver performance and its lack of school bus route planning to identify hazards on school bus routes and to eliminate the necessity of crossing railroad tracks. Contributing to the injuries of the school bus passengers were incomplete compartmentalization and a lack of energy-absorbing material on interior surfaces.

The major safety issues discussed in this report are the busdriver's performance; school district oversight, including busdriver monitoring and evaluation procedures and bus routing; passive grade crossing safety, including previous initiatives related to passive grade crossing and school bus safety; and occupant kinematics and survival factors.

As a result of its investigation of this accident, the Safety Board makes recommendations to the States, the National Highway Traffic Safety Administration, the Federal Highway Administration, the Georgia Department of Education, the National Association of State Directors of Pupil Transportation Services, and the school bus manufacturers. The Safety Board also reiterates a recommendation to the U.S. Department of Transportation.

Factual Information

Accident Narrative

On March 28, 2000, about 6:40 a.m. (sunrise was at 6:33 a.m.), a southbound CSX Transportation, Inc., (CSXT) 33-car freight train, en route to Atlanta, Georgia, collided with the passenger side of a westbound Murray County, Georgia, School District school bus at a railroad/highway grade crossing near Conasauga, Tennessee. The accident occurred on Liberty Church Road in Polk County, Tennessee. The school bus was on its morning route to pick up children and had entered Liberty Church Road from U.S. Route 411 and was making a loop to return to Route 411. As the school bus traversed the passive grade crossing, it was struck.

The school bus was equipped with video recording equipment to monitor passenger behavior on the bus. An examination of the videotapes found on the bus showed that the school bus did not stop, as required, before attempting to cross the railroad tracks on the day of the accident, nor had it stopped at this crossing on eight previous occasions.

During the accident sequence, the driver and three children were ejected. Two ejected passengers received serious injuries and one was fatally injured. The driver, who had been wearing a lap/shoulder belt that broke, received minor injuries. Of the four passengers who remained inside the bus, two were fatally injured, one sustained serious injuries, and one, who was restrained by a lap belt, received minor injuries. The two train crewmembers were not injured.

School Bus

On the day of the accident, the driver made her regularly scheduled first pickup about 6:35 a.m. The school bus was northbound on Route 411 when it turned right (east) onto Liberty Church Road in Georgia (see figure 1). The busdriver usually picked up passengers on Liberty Church Road, crossed the railroad tracks, and exited back onto Route 411 southbound in Tennessee, approximately 0.2 mile from the Georgia State line.

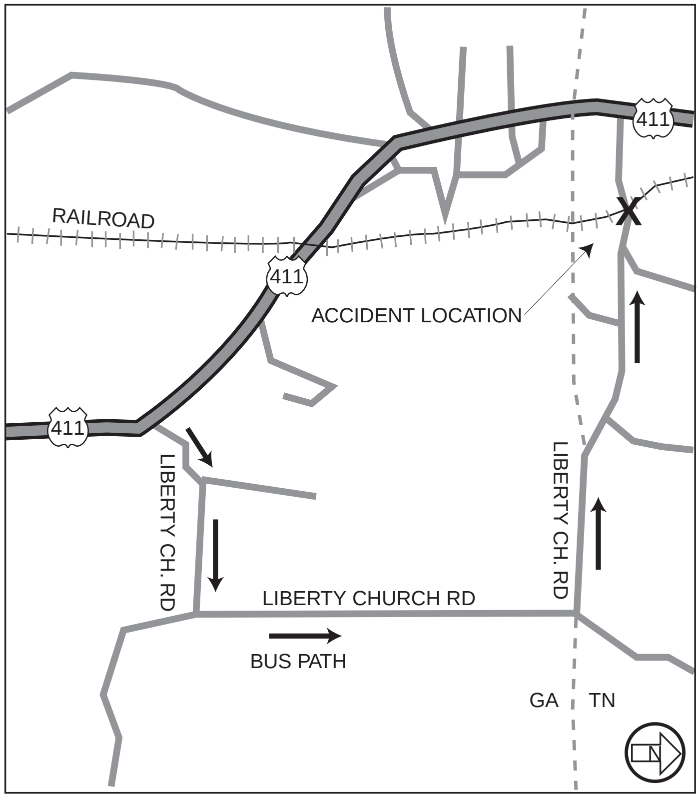

Figure 1. Map of Liberty Church Road area.

On its approach to the crossing, the school bus encountered two advisory signs. The first was a round railroad advance warning sign[1] with a placard that stated "ONE LANE." The second was a diamond-shaped warning sign[2] that stated "LIMITED SIGHT DISTANCE." Beneath the second sign was a speed advisory sign[3] that stated "10 MPH." Also at the crossing was a railroad crossing sign (crossbucks)[4] on the right side of the approach (see figure 2).

In a postaccident interview with the Tennessee State District Attorney's Office on March 28, 2000, the busdriver stated that she was "coming down the hill, came to a complete stop"; looked left then right, left then right; pulled open the door and closed it. She said that she looked in the rearview mirror to make sure all the children were sitting down, then looked to the left and right again, and the train came out of nowhere. She stated, "It was like it fell from the sky." The busdriver refused any further interviews.

[1] Sign W10-1 in the *Manual of Uniform Traffic Control Devices.*

[2] This sign is no longer included in the *Manual of Uniform Traffic Control Devices*.

[3] W13-1.

[4] R15-1.

In an interview after the accident, one of the passengers on the bus indicated that the day of the accident was her second day riding the bus. She told the Tennessee State District Attorney's Office that she got on the bus, sat in the second row, and buckled her lap belt.[5] She could not remember whether the driver's window was open or closed. The passenger stated, "The bus went down the hill and across the track without stopping, just the same way the driver did the day before, without stopping." She said she did not hear the train horn.

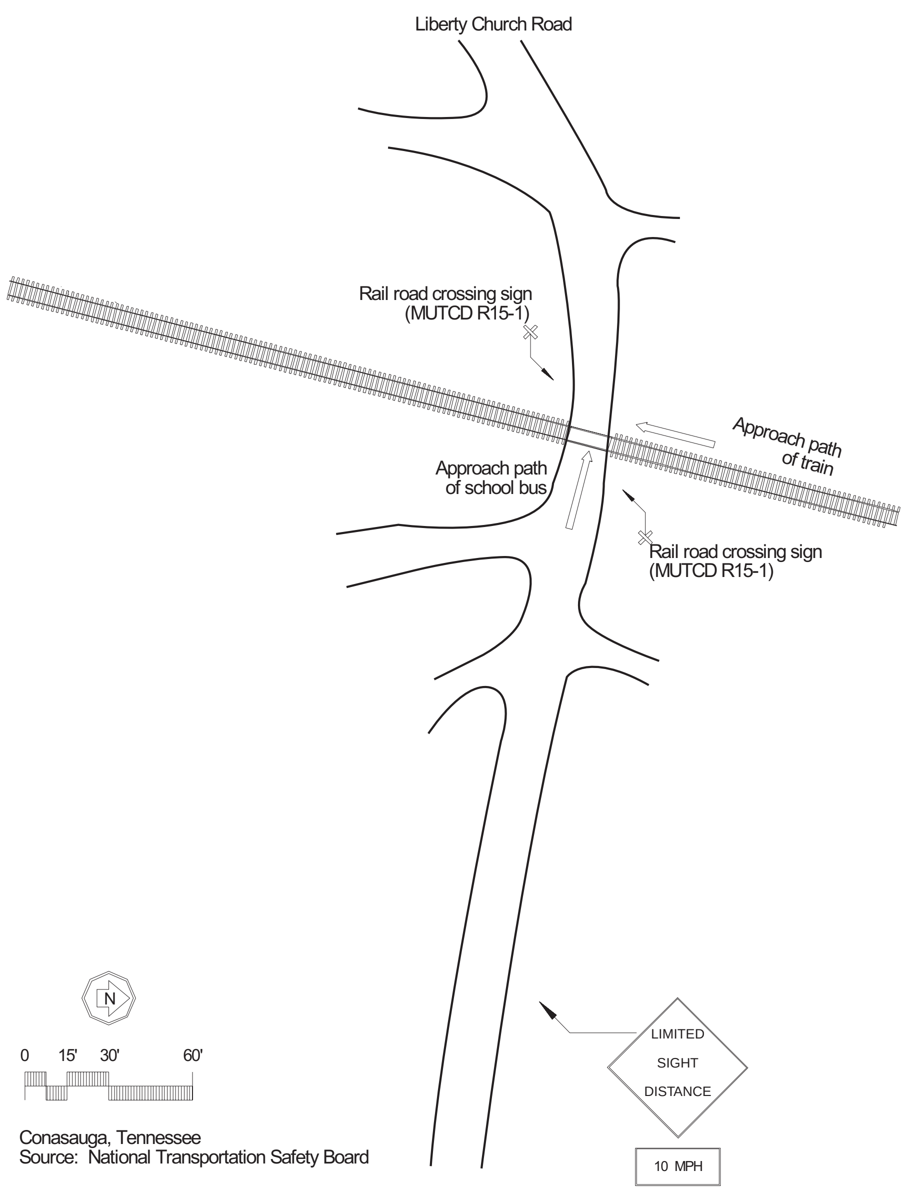

Figure 2. Scene diagram.

[5] The first two rows of seats on the bus were equipped with lap belts at each of the three seating positions so that child restraint systems could be used for small children requiring them.

Train

Train S-213-25 was holding at the Ocoee siding,[6] approximately 9.5 miles north of Liberty Church Road, when the conductor and engineer were called on duty at 2:20 a.m.; they arrived at the siding about 4:00 a.m. Upon arrival, the conductor released several handbrakes on the cars as the engineer inspected the single locomotive. The engineer conducted a set-and-release test of the airbrakes,[7] then pulled the train to the south end of the siding and, using the train brakes, stopped it as a way of measuring the effectiveness of the brakes. The train continued to hold at the siding until approximately 6:18 a.m., when the crew received a "medium clear"[8] signal from the dispatcher-controlled signal at the south end of the siding. The locomotive event recorder data indicated that the train moved out of the siding and accelerated after the last car was on the main track. The crew encountered a "clear"[9] signal at each subsequent signal location prior to the accident site.

After passing a wayside defect detector,[10] the crew received an automated voice radio transmission from the detector indicating the train had no defects. The detector-recorded time was 6:25 a.m. and the train speed was 35 mph. The train increased speed to 56 mph while traveling on a descending grade. Thereafter, as it ascended a 3,173-foot grade, its speed decreased gradually to about 51 mph. The locomotive horn and bell were sounded at several grade crossings prior to reaching Liberty Church Road, according to the locomotive event recorder.

As the train approached Liberty Church Road, the engineer stated that he saw the bus approaching the crossing and yelled, "Hey! Hey!" The conductor jumped up and both crewmembers were concerned about the action of the bus. The conductor said that the yellow bus was illuminated by the sunlight and he noted road dust swirling behind it. The engineer said that he held the horn valve down continuously in an effort "to blow her down,"[11] but the bus did not stop. The engineer stated that when the bus continued to move toward the crossing, he placed the train in emergency braking using the automatic brake valve. According to the conductor, who was on the left side of the train and saw the bus before it crossed the tracks, the driver was looking straight ahead when she crossed the tracks. When the bus was on the crossing, the engineer said the driver turned to look at the train, just prior to collision. Both the conductor and engineer stated that before the collision they noticed that the door of the bus was closed.

[6] The dispatcher held the train at the siding to allow several northbound trains to pass.

[7] Reported by the conductor and confirmed by the locomotive event recorder.

[8] A "medium clear" signal indication permits a train to proceed at 30 mph, per CSXT operating rule 283.

[9] A "clear" signal indication permits a train to proceed at the maximum timetable speed, per CSXT operating rule 281, which was 60 mph on this track.

[10] Wayside detectors monitor passing trains for mechanical defects, such as dragging equipment, and typically record train speed, time, axle count, ambient temperature, and other data.

[11] Alert the busdriver.

Collision

The train struck the school bus on the passenger side between the axles. During the accident sequence, the bus body and its chassis struck the crossbucks and separated, and the chassis came to rest 64 feet west-southwest of the center of the grade crossing; the chassis was facing east. The front of the bus body, including the section to which the driver's seat was attached, separated from the rest of the body and remained with the chassis, which rolled on its passenger side and later rolled back upright. The body, pushed down the tracks by the locomotive before pivoting off and rotating clockwise about 180 degrees, came to rest 192 feet west-southwest of the center of the crossing (see figure 3). That part of the bus body immediately behind the separation point was flush with the train body (see figure 4). Broken branches and scrape marks were found on rows of trees approximately 112 feet and 157 feet from the grade crossing. The train did not derail, and the locomotive came to rest about 1,990 feet from the crossing. During the accident sequence, the bus body scraped several branches and struck a tree near the area where the bus came to rest. Bus tire rub marks were found on the inside of the rail.

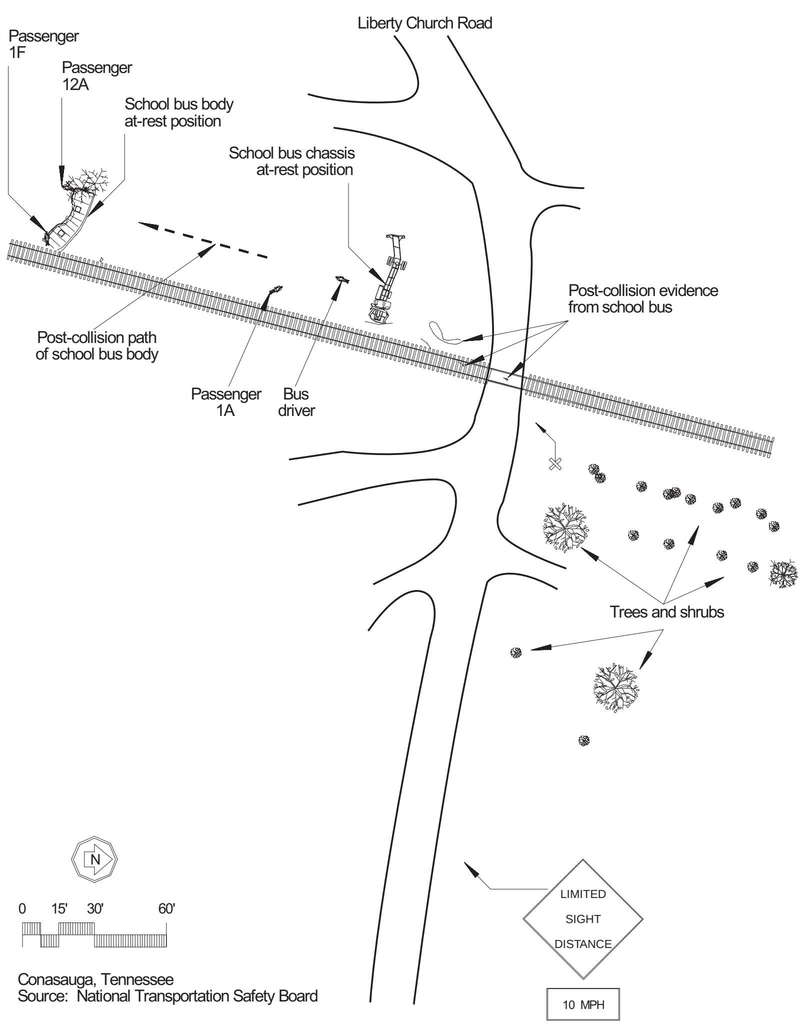

Figure 3. Postaccident scene diagram.

Figure 4. Accident bus.

Injuries

The following table is based on the International Civil Aviation Organization's injury criteria,[12] which the National Transportation Safety Board uses in accident reports for all transportation modes.

Table 1. Injuries.

Injuries	Driver	Train crew	Bus passengers	Total
Fatal	0	0	3	3
Serious	0	0	3	3
Minor	1	0	1	2
None	0	2	0	2
Total	1	2	7	10

[12] Title 49 *Code of Federal Regulations* 830.2 defines a fatal injury as any injury that results in death within 30 days of the accident. It defines a serious injury as one that requires hospitalization for more than 48 hours, commencing within 7 days from the date the injury was received; results in a fracture of any bone (except simple fractures of the fingers, toes, or nose); causes severe hemorrhages, nerve, muscle, or tendon damage; involves any internal organ; or involves second or third degree burns or any burns affecting more than 5 percent of the body surface.

Medical and Pathological Information

The busdriver was wearing a lap/shoulder belt, which broke during the accident sequence, resulting in her ejection from the bus. Her minor injuries included a fractured nose, contusions, abrasions, and lacerations. The passenger seated in the second row (seat 2A) (see figure 5) also sustained minor injuries, including blunt abdominal trauma with abrasions and contusions. This passenger was reportedly wearing a lap belt.

One of the ejected passengers (seat 1A), who was ejected through the front opening of the bus body after its separation from the chassis and was severely injured, sustained a closed head injury, multiple scalp lacerations, left arm and leg fractures, and wedging of several thoracic vertebrae. The seriously injured passenger who was ejected and found pinned under the front passenger-side corner of the bus (seat 1F) sustained a closed head injury, liver contusions, multiple facial lacerations, abrasions, and contusions. The seriously injured passenger who was seated across from the area of intrusion (seat 6A) sustained a closed head injury with intraventricular hemorrhage, a right frontal lobe contusion, right first rib fracture, and multiple facial lacerations.

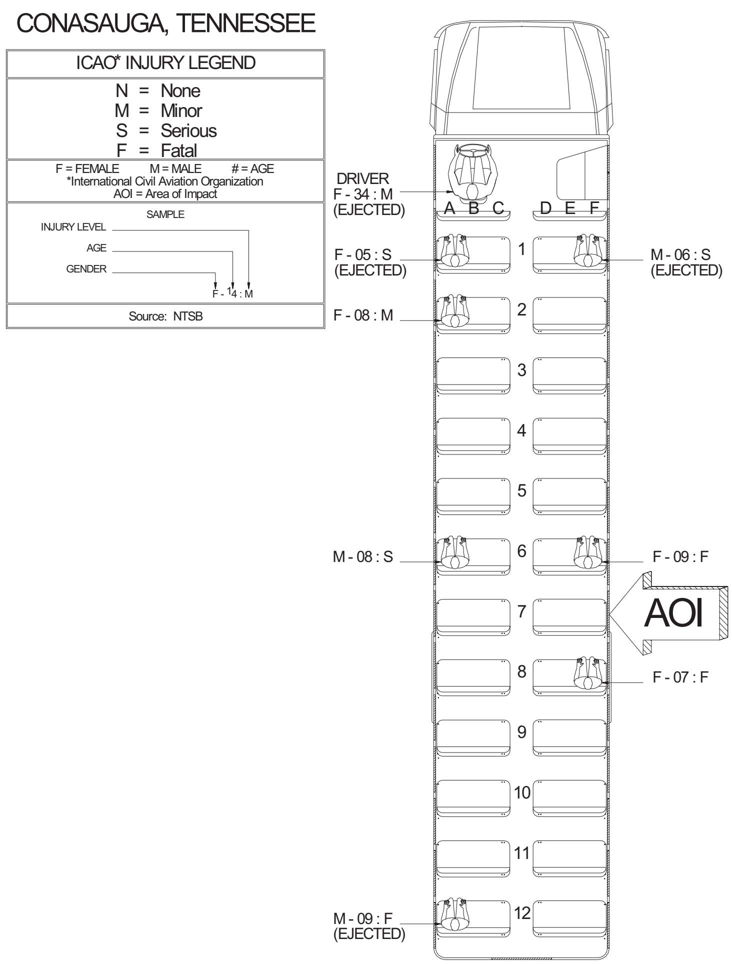

Figure 5. Seating chart.

Two fatally injured passengers (seats 6F and 8F) were seated in the area of impact, and each sustained a linear skull fracture, left subdural hemorrhage, cerebral cortical contusions, lacerations, and contusions. In addition, the passenger in seat 6F received a posterior right rib fracture with right hemothorax, hemoperitoneum, and spleen laceration. The passenger in seat 8F also received a severe facial fracture, subarachnoid hemorrhage, and left femur fracture. The fatally injured passenger seated in the last row (seat 12A), who was ejected, sustained a transected aorta; lacerations of the right atrium, liver, and spleen; bilateral hemothorax; left lateral pericardial sac hemopericardium; fractures to the left ribs, right clavicle, and right tibia-fibula; and multiple contusions, lacerations, and abrasions. This passenger also had abrasions and linear contusions from the chest midline extending laterally to the right and left of the chest midline.

Toxicological Tests

The Federal Motor Carrier Safety Regulation at 49 *Code of Federal Regulations* (CFR) 382.303 requires that in accidents such as the Conasauga collision, postaccident alcohol and drug testing be performed on the busdriver; 49 CFR 40.21 specifies that the drug testing be done for marijuana, cocaine, opiates, amphetamines, and phencyclidine. Erlanger Medical Center in Chattanooga, Tennessee, conducted the postaccident toxicological testing on the accident driver, and the results were negative. According to the *Federal Motor Carrier Safety Regulations*, the test was invalid because it did not test for phencyclidine.

Safety Board investigators sent samples of the busdriver's blood and urine to the Civil Aerospace Medical Institute for further testing. Results revealed the presence of pseudoephedrine and ephedrine in the blood and urine. Phenylpropanolamine was present in the urine but not in the blood. All of these substances are common ingredients in over-the-counter cold medications and weight-loss products. No evidence of alcohol or illicit drugs was found in either sample.

Neither Federal regulations nor CSXT policy require toxicological testing for a train crew after a grade crossing collision. The engineer and the conductor volunteered to be tested, and the results were negative for drugs and alcohol for both employees.

Survival Aspects

Emergency Response

Dispatch Center. When a driver who had turned onto Liberty Church Road from Route 411 came upon the accident scene, she placed a 911 call to the Murray County 911 Center from her cellular telephone at 6:41 a.m. She stated that a school bus and train had collided at a railroad crossing, but she did not know the precise location because there was no signage (this was not her usual route). She believed the accident occurred 1/2 mile north of St. Claire's gas station. At 6:45 a.m. she called the 911 center again, this time from St. Claire's gas station on Route 411, where she had learned that the road at the accident scene was Liberty Church Road. This information was then relayed to the fire, rescue, and emergency medical services (EMS) units, which had been dispatched at 6:44 a.m., and were already en route to the scene. The Polk County Sheriff's Department did not receive any calls reporting the accident. At 6:56 a.m. the Polk County Sheriff's Department received a call from the Murray County 911 Center requesting two EMS ambulances to assist in the response.

CSXT. Earlier, while the train was coming to a stop, the conductor had called "Tone 9,"[13] and according to train dispatcher radio transcripts, the dispatcher answered the emergency call from train S-213-25 at 6:43 a.m. After confirming the location and identity of the train, the dispatcher called the CSXT Police Communications Center at 6:44 a.m. and informed the police communications specialist of the emergency. At 6:47 a.m., the Murray County Sheriff's Office received a phone call from the CSXT Police Communications Center in Jacksonville, Florida, reporting the nature and location of the accident. About 2 minutes later, the Murray County Sheriff's Office 911 operator called the CSXT Police Communications Center and confirmed information about the location of the accident.

On-Scene Activities. At 6:50 a.m. the first fire command officer and engine arrived at the scene and requested additional assistance, as well as a medical evacuation helicopter. The first helicopter departed Erlanger Medical Center in Chattanooga, Tennessee, at 6:59 a.m. and arrived at the Rostex airstrip landing zone established near the accident scene at 7:17 a.m. Another helicopter departed Knoxville, Tennessee, at 7:08 a.m. and arrived at the landing zone at 8:03 a.m. By 7:06 a.m., all passengers had been extricated from the vehicle. At 7:17 a.m., the 911 center was advised that no additional EMS units were needed.

In all, 17 firefighters from Murray County responded, and 5 ambulances were sent to the scene (3 from Murray County and 2 from Polk County). The ambulances transported four passengers to the Rostex airstrip to be airlifted to Erlanger Medical Center. Two passengers were taken by ground transportation to Murray County Hospital and stabilized until they could be airlifted to Erlanger Medical Center. A formal disaster plan was not initiated. The Murray County Fire Services Director reported to investigators that no problems occurred during the response.

Survivability

The school bus driver, who sustained minor injuries, was wearing the three-point lap/shoulder belt available at the driver's seat. The belt webbing failed during the accident sequence and the driver was ejected. The passenger[14] seated in the second row on the driver side was wearing the available lap belt and sustained minor injuries.

[13] "Tone 9" is a radio tone specified as the method for contacting the train dispatcher in an emergency.

[14] This passenger was 4 feet 5 inches tall and weighed 117 pounds.

Two of the fatally injured passengers were seated in the impact area. The third fatally injured passenger was seated in the last row of the school bus and was ejected. Two of the seriously injured passengers were seated in the first row of the bus and were not using the available lap belts. Both of these passengers were ejected and one was found under the front right corner of the bus body. The third seriously injured passenger was seated on the driver side, across from the impact area.

Personnel Information

School Bus Driver

The Murray County School District hired the 34-year-old school bus driver as a full-time substitute busdriver[15] on May 11, 1999. She became a full-time busdriver at the beginning of the 1999-2000 school year. Between September 16, 1997, and September 16, 1998, she was a school bus driver at Olympic Truck Lease, which had a contract with the Dalton City, Georgia, schools for pupil transportation. The busdriver had a valid Georgia commercial driver's license (CDL) with a passenger endorsement, which expired on May 3, 2001. A corrective lens restriction was noted on the license, but it could not be determined whether the busdriver was wearing glasses or contact lenses at the time of the accident. Her driving record included a single conviction for speeding (61 mph in a 45 mph zone) while driving her personal vehicle on September 21, 1991.

Pupil transportation officials with the Dalton City Public Schools stated that the busdriver attended a 4-hour training class on January 20, 1998, which covered operational and driving procedures, including procedures at railroad/highway grade crossings. According to the officials, the busdriver was verbally reprimanded during the session for talking during class, and her response to the reprimand was that she did not understand why she had to attend the training because she already knew the material.

All drivers in Murray County are required to attend an 8-hour mandatory training session annually with a State Department of Education consultant and a State patrol officer for recertification as school bus drivers. The training includes information on the proper procedures to follow at grade crossings. The accident busdriver had received her training and annual recertification on August 12, 1999. The principal stated that he had not received any complaints about the busdriver and noted that teachers, parents, and students liked her. Except during summer vacation, the driver had been driving the same route since May 1999.

The busdriver tested negative for drugs and alcohol in a preemployment drug screen on May 9, 1999; no random drug tests had been performed on the driver since that time. She received her annual physical examination on July 14, 1999, and was found medically qualified to drive a school bus. Medical records obtained from the driver's

[15] Full-time substitute busdrivers drive every day but not necessarily the same route.

personal physician revealed that she was diagnosed with diabetes mellitus type II[16] on November 5, 1999, but insulin was not required for treatment. She had episodes of high blood pressure in October and December 1999; no repeated levels of high blood pressure were indicated thereafter and her blood pressure was normal in January, February, and March 2000. Neither of these conditions disqualified her from holding a CDL.

The busdriver took her bus home nightly because of the convenient location of her residence to the bus route. She usually departed her home in Chatsworth, Georgia, about 6:10 a.m.; drove to the Liberty Church Road area and picked up the first passengers about 6:35 a.m.; and arrived at Northwest Elementary School in Chatsworth, Georgia, between 7:30 and 7:40 a.m. She departed Northwest Elementary School about 2:00 p.m. on her afternoon route.

Train Crew

The conductor and engineer had been called on duty at Etowah, Tennessee, at 2:20 a.m. on the day of the accident. The engineer had been off duty for the required 10-hour period, and the conductor had been off longer than 10 hours. Both men indicated that they had slept well the evening before the accident. The engineer and conductor reported to the yard office, received documentation, and departed by taxi at 3:45 a.m. to the Ocoee siding, where the train was located, 19 miles south of Etowah.

The 50-year-old engineer had been a railroad employee on the Etowah subdivision since 1972 and became a conductor in 1975. He entered the CSXT engineer training program in 1995 and was promoted to engineer in 1996. CSXT employee records listed the engineer as medically qualified without restrictions. The engineer last took the CSXT operating rules class[17] on January 6, 2000, and had last passed an engineer certification class[18] on December 31, 1998.

The 51-year-old conductor had been a railroad employee since 1977 and was promoted to conductor in 1984. The conductor said he had worked most of his career on the Etowah subdivision and that he was familiar with the territory. CSXT employee records listed the conductor as medically qualified without restrictions. The conductor had last attended a CSXT operating rules class on January 23, 2000.

School Bus and Wreckage Information

School Bus

The 1999 Blue Bird Corporation 72-passenger school bus had an International Truck and Engine Corporation chassis, diesel engine, power steering, automatic

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[16] Generally, type II diabetes can be controlled through oral medication, weight loss, and diet.

[17] Periodic rules instruction is required by 49 CFR Part 217.11.

[18] Title 49 CFR Part 240.

transmission, and antilock brakes. The electronic control module was not capable of recording vehicle operational data but did provide system fault and diagnostic information. The data indicated no fault codes or abnormalities upon inspection after the accident. The odometer reading was 24,219 miles. The school bus was approximately 452 inches long and had a gross vehicle weight rating of 26,384 pounds.

The school bus had 12 rows of three-passenger bench seats on both sides of the bus and modesty panels in front of the first row. The first two rows were equipped with lap belts[19] in all designated seating positions. The bus was equipped with seven emergency exits: two roof vent hatches, four side window exits (two on each side), and one rear emergency door.

The driver's seat was equipped with a lap/shoulder belt. The latch plate receiver was mounted to the seatframe on the passenger side and tethered to floor anchorages below the driver's seat. The continuous loop strap with free-sliding latch plate was seat-mounted and floor-tethered on the left side of the driver's seat in the same manner as the receiver. The continuous loop passed through the D-ring and terminated at an emergency locking retractor, which was mounted to the bus body sidewall panel at the roofline to the rear and above the driver's left shoulder position, 16 inches behind the seat. The driver's seat and lap belt anchorages were mounted to the school bus body.

The bus body was secured to the chassis using bolts and body-to-chassis mounting clips, in accordance with design specifications of the *National School Transportation Specifications and Procedures*[20] manual and current industry practices. The front section of the bus body (below the driver's seat) was attached to the chassis with tie down brackets secured by four grade 8 bolts (higher grade than the rest of the bolts).[21] The body cowl panels were secured to the chassis by 25 bolts and locknuts.

The school bus was equipped with an AM/FM cassette radio with an integrated public address system and four overhead speakers. One speaker was located above and just to the rear of the driver's seat, and the remaining speakers were in roof panels above rows 4, 7, and 11. After the accident, investigators found the toggle switch for the speakers in the "INT" position, indicating that all four speakers were active. The two interior roof panels located above the driver were lined with sound attenuation materials.

The bus was equipped with a "Silent Witness" in-vehicle video camera, mounted midline approximately 71 inches above the floor at the front of the bus. The video recorder was on at the time of the accident (see Bus Video Recorder section).

The bus was equipped with two 291-inch-long open-style overhead storage racks mounted above the windows on both sides of the body (see figure 6). Angled padding

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[19] Lap-only belt.

[20] *National School Transportation Specifications and Procedures, 2000 Revised Edition* (Warrensburg, MO : Missouri Safety Center, 2000).

[21] Society of Automotive Engineers standard; grade 8 bolts have the highest tensile strength of commercially available bolts.

protected the aisle side of the rack. Five metal bars formed the rack along the length of the bus. According to Blue Bird Corporation, the racks were 61.13 inches above the floor. They were located outside the head protection zone, as defined by Federal Motor Vehicle Safety Standard (FMVSS) 222 (49 CFR 571.222.5.3.1.1),[22] and thus were not required to comply with head protection requirements.

Figure 6. Roof rack.

Maintenance records indicated no recurring maintenance problems or recent repairs to the vehicle. Safety Board investigators conducted a postaccident inspection of the vehicle and found no mechanical defects.

School Bus Damage

The school bus body separated from the chassis at the engine compartment cowling[23] and the forward roof panel above the windshield. The driver's seat, windshield, engine cowling, entrance stairwell, firewall, and dash controls remained attached to the part of the bus body still attached to the chassis. The chassis' main frame rails were deformed rightward from the drive axle rearward; maximum deformation was 44.63 inches. The drive axle was displaced leftward 7.8 inches. Frame rail cross members and rear bumper supports were also damaged (see figure 7).

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[22] The upper limit of the head protection zone is 40 inches above the seating reference point. This is about 58.62 inches above the floor in this bus, according to Blue Bird Corporation.

[23] Metal cover for the engine.

Damage to the bus body was extensive in the immediate area of impact; maximum intrusion was 44.85 inches (figure 8). In addition, induced damage, in the form of bowing of the body structure, was substantial. The right rear corner of the bus was skewed rightward 42.67 inches and forward 40.85 inches (see figures 9 and 10).

Figure 7. Bus chassis.

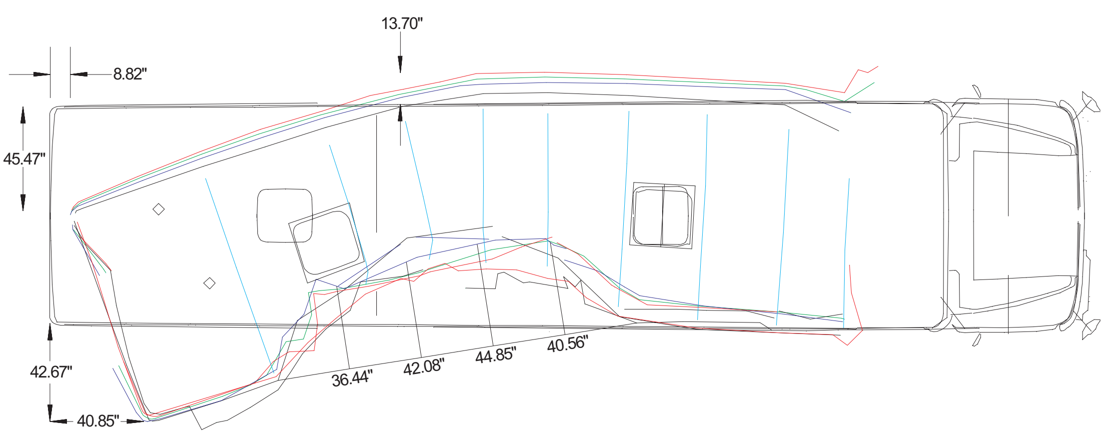

Figure 8. Bus body deformation.

Figure 9. School bus exterior body damage.

Postaccident inspection showed the driver's seat tilted toward the passenger side of the bus (see figure 11). The left lap belt segment extended from the edge of the seat cushion to the floor of the bus and was taut, while the right lap belt segment extended from the edge of the seat cushion to the floor of the bus and was slack. The driver's seat and the floor anchorages remained attached to the body flooring, which was in turn attached to the chassis. The shoulder belt passed through the D-ring, and the D-ring and the emergency retractor were located on the sidewall of the bus body (see figure 12). The shoulder belt webbing was torn, some of it remained with the driver's seat, and the rest remained with the sidewall-mounted retractor.

Figure 10. School bus interior body damage.

Figure 11. Driver's seat.

Figure 12. Portion of driver's shoulder belt attached to bus body.

Except in the area of maximum intrusion, the seat cushions remained fixed to the seatframes. Damage was noted to the seatframe attachments in the area of maximum intrusion; the seatframes were not dislocated from the floor. The modesty panels remained intact.

Severe damage to the roof rack was noted on the passenger side of the bus. Damage to the sidewall and roof of the bus caused the rack to rotate approximately 90 degrees, with the opening into the rack facing the top of the roof. Although twisted and bent after the accident, the racks remained securely attached to the bus body. The rack on the driver side of the bus was almost completely intact, except near seats 6 and 7, where induced deformation was present. This deformation was near the area of maximum intrusion.

Train and Wreckage Information

Train

Train S-213-25 consisted of 1 locomotive and 33 loaded auto-rack cars. The train was 3,173 feet long and had a gross weight of 2,465 tons. The locomotive was a six-axle General Electric C40-8 powered by a 16-cylinder engine rated at 4,000 horsepower. The locomotive weighed 395,000 pounds. The locomotive had received its required annual brake servicing on March 26, 2000.

Locomotive warning devices included an air-operated bell, a five-chime Nathan “Airchime” horn mounted on the top of the locomotive body, a standard two-bulb headlight, and two ditch lights on the leading edge of the front walkway. When the horn was sounded, the ditch lights oscillated in an alternating on-off pattern. Audiometer testing revealed that the horn exceeded the Federal requirement in 49 CFR 229.129 of 96 decibels when measured 100 feet ahead of the locomotive.

Train Damage

The steps on the front left side of the locomotive, CSX 7580, were displaced rearward about 4 inches. There was yellow paint transfer on the snowplow and coupler. Both ditch lights were broken and the light brackets were bent back about 2 inches. The hand railings on the front walkway were bent back toward the body. CSXT estimated damage to the locomotive at $1,500. The first car behind the locomotive was an 89-foot flatcar equipped with a trilevel auto rack. The side panel of this car was damaged; CSXT estimated repair costs at $200. The track was not damaged.

Crossing Information

Highway

Liberty Church Road is an 18-foot wide, two-lane road without a centerline that winds about 1.8 miles in a "U" shape from Route 411 in Georgia back to Route 411 in Tennessee. No street name signs identify it as Liberty Church Road, nor do street signs mark any other roads in Polk County, Tennessee. At the time of the accident, two advisory signs were present as vehicles approached the crossing. One was a round railroad advance warning sign[24] 314 feet east of the nearest rail, and the other was a diamond-shaped warning sign[25] 200 feet east of the nearest rail that stated "LIMITED SIGHT DISTANCE," below which was a supplemental advisory speed sign[26] that stated "10 MPH." At the crossing was a railroad crossing sign (crossbucks) on the right side of the roadway (see figure 13). According to the Polk County Superintendent of Highways, an engineering study regarding the selection and placement of the advance warning signs and placards for the Liberty Church Road grade crossing had not been conducted.

Figure 13. Driver's view of Liberty Church Road approaching the crossing.

[24] W10-1.

[25] W11.

[26] W13-1.

The road approaching the tracks from the west was 18.1 feet wide and narrowed to 15 feet wide just before the crossing. At the center of the crossing, the road was 14.5 feet wide. It had a downhill grade of 12.9 percent prior to and 10 percent at the railroad advance warning sign. Adjacent to the "limited sight distance" sign the grade was 5 percent. Just before the crossing, the roadway had a 2-percent downgrade that transitioned to a flat surface across the rails. The roadway surface was asphalt on the approach and between the rails; rubber transition treatments were on each side of the rails. The roadway had been resurfaced in fall 1999.

Records showed no previous accidents at the grade crossing. After this accident and the subsequent upgrade of the crossing to active devices consisting of lights and gates, all signs were removed. New round railroad warning signs (W10-1) were installed in advance of the crossing, and two signs (W10-3s, one in each direction) were placed on Route 411, indicating a grade crossing on Liberty Church Road.

Railroad

The accident occurred at milepost 362.82 on the north-south track of the Etowah subdivision at crossing 347 942 N. A toll-free number is posted on the crossbuck posts at the crossing for reporting stalled vehicles or an emergency to CSXT. Daily track inspection reports for the 6 months before the collision indicated no track problems near the grade crossing.

Operations Information

School Bus Operations

The Murray County School District owned and operated the accident bus. The school district comprises five elementary schools, two middle schools, one high school, and one alternative school in a 344-square mile area. In the 1999-2000 school year, the student population was 6,559, of whom 3,930 were transported daily on school buses. The school district had a fleet of 74 buses and employed 54 full-time busdrivers and 7 substitute drivers. Vehicles were maintained by a shop foreman, three full-time mechanics and one part-time mechanic, who was also a busdriver.

Training. Murray County provides annual mandatory training, as required by the State, to its busdrivers for recertification. During this training, information on railroad/highway grade crossings is provided. On February 3, 2000, Operation Lifesaver[27] presented a training class in Murray County attended by eight busdrivers. School officials reported that because of a lack of funding, busdrivers could not be paid to attend and were not required to be present. The accident busdriver did not attend the session. Since this

[27] Operation Lifesaver is a nonprofit nationwide effort to educate the public and increase public awareness of the hazards at railroad-highway grade crossings and to develop proper driver behavior patterns at grade crossings. Operation Lifesaver participants include State and local officials, civic groups, safety organizations, transportation industry groups, labor groups, public information media, and private citizens.

accident, Murray County School District has been working with Operation Lifesaver to provide mandatory, in-depth driver training for railroad/highway grade crossings. Drivers are now paid to attend this training.

Routing. According to Murray County School District officials, the school district has 18 railroad crossings, 15 of which were crossed by school buses at the time of the accident. These figures do not include the Liberty Church Road crossing, which is not in Murray County. School bus routes were established several years ago and change periodically depending on population and location of the students. The school district's transportation director stated that grade crossings are considered in routing and that some routes have been changed to utilize active rather than passive crossings. In rural areas, roadways sometimes only enter and exit an area one way and must cross the tracks. According to the transportation director, the Liberty Church Road school bus route crosses the railroad tracks because the intersection of Liberty Church Road and Route 411 in Georgia is such that, if the bus turned around and exited in Georgia (eliminating the need to cross the tracks), the bus would have to go into the opposing lane of traffic to turn onto Route 411. The accident vehicle was the only Murray County school bus that traversed the Liberty Church Road crossing. A Polk County school bus also crossed the tracks.

Safety Board investigators reviewed several Murray County school district route maps during the investigation and noted that none documented any road hazards. Following this accident, the school district revised some routes, so that currently, only one route crosses a passive crossing because that neighborhood has no other way out. The intersection of Liberty Church Road and Route 411 was redesigned so that a school bus can now turn around on Liberty Church Road and enter Route 411 without encroaching on the opposing lane.

Busdriver Procedures. Title 40-6-142 of Georgia State law, which governs the procedures of school bus drivers at railroad/highway grade crossings, states:

> The driver of any motor vehicle carrying passengers for hire or of any school bus, whether carrying school children or empty before crossing any railroad tracks shall stop such vehicle within 50 feet but not less than 15 feet from the nearest rail, look and listen for a train and not proceed until safe to do so.

Tennessee law is the same, except that drivers are not required to stop if there are no children on the bus.

In the district's *Bus Drivers Manual: Procedures and Rules*, under the section entitled "State Law and Policy," the Murray County schools list seven steps to be followed at railroad crossings:[28]

a. Always come to a complete stop.

b. Stop not closer than 15 feet, but not farther than 50 feet, from the nearest rail.

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[28] These steps are adapted from the *National School Transportation Specifications and Procedures*.

c. Open service door and left front window. Cut off radio, fans and heaters.

d. Look both ways – Listen!!

e. A school bus driver does not activate warning lights while approaching or stopped for a railroad crossing.

f. When tracks are clear and safe, proceed forward. Do not shift gears while crossing.

g. Close door and continue route.

One question on the Georgia CDL test, which a school bus driver must pass, addressed the effect of minimum and maximum stopping distances to the nearest rail on a driver's ability to see down the track.

Railroad

Each day, 30 to 35 trains travel on the Etowah subdivision, which runs from Etowah, Tennessee, to Junta, Georgia, a distance of 87.6 miles. No revenue passenger trains operate in the subdivision. According to CSXT, the Etowah subdivision is often congested due to bottlenecks in the Atlanta area and scheduled track maintenance. Rail freight volume for the subdivision increased from 48.6 million annual gross tons in 1998 to almost 49.9 million tons in 1999. The subdivision is a single-track main line with numerous passing sidings. In the area in which the accident occurred, *CSXT Atlanta division timetable No. 1*, dated October 1, 1999, indicates that the maximum track speed is 60 mph for intermodal trains and for trains comprising solid blocks of auto racks, such as the accident train; all other trains are limited to 50 mph.

Train times and directions of travel do not follow a fixed schedule; wayside signal indicators govern train movement. Before the accident, the most recent train to pass the Liberty Church Road crossing was headed northbound about 6:10 a.m. Signal records indicate that 26 trains had passed over the accident site between 6:00 a.m. and 7:00 a.m. in the 25 days preceding the accident.

Management Information

Murray County Oversight

Under "Performance Appraisal/Evaluation," the Murray County School District's *Bus Drivers Manual: Procedures and Rules* states: "Each employee is appraised on common factors according to the contents of the job description. An employee is rated on unique factors if contained in the job description." Neither the accident busdriver's personnel file nor those of other busdrivers contained documentation indicating that their performance behind the wheel had been evaluated or rated.

State Oversight

The Georgia Department of Education's (DOE's) Office of Learning and Achievement, Student Transportation Services, includes five full-time consultants, located throughout the State, who assist the school districts. All consultants are State-certified school transportation trainers who have advanced degrees in education. The consultants, coordinating through the DOE, conduct the annual recertification training for school bus drivers. According to the director of pupil transportation, the agency's mission is to provide service rather than serve a regulatory function; its area of expertise is pupil transportation systems. The DOE allocates funds for pupil transportation operations; about 40 percent of the funds cover the purchase of new buses.

Georgia's director of pupil transportation is a member of the National Association of State Directors of Pupil Transportation Services (NASDPTS). Local school district transportation directors in Georgia primarily receive information provided by the NASDPTS through mandatory annual in-service training.

According to the State pupil transportation director's office, busdriver evaluation programs are not mandatory and depend upon the size of the school district; smaller school districts often lack the manpower to conduct them.

School Transportation Standards

National. The National Highway Traffic Safety Administration (NHTSA) has published National Highway Safety Program Guideline No. 17, which establishes minimum recommendations for pupil transportation safety; it includes recommendations on the identification, operation, and maintenance of buses used to transport students. Georgia is among the States that have adopted guideline No. 17.

Section C-2b of the guideline, which sets forth recommended practices for the routing of school buses, states:

> Each State should develop plans for minimizing highway use hazards to school bus and school-chartered bus passengers, other highway users, pedestrians, bicycle riders, and property. They should include, but not be limited to: (1) Careful planning and annual review of routes for safety hazards; (2) Planning routes to ensure maximum use of school buses and school-chartered buses, and to ensure that passengers are not standing while these vehicles are in operation.

Association. The National Conference on School Transportation (NCST) takes place every 5 years for the purpose of developing the publication *National School Transportation Specifications and Procedures.* The May 2000 conference attendees included NASDPTS members from 48 States, as well as industry representatives.[29] They met to address and make recommendations concerning issues that had arisen since the previous conference in 1995.

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[29] Hawaii and North Dakota were not represented.

The resulting document was the *2000 National School Transportation Specifications and Procedures* published by the NASDPTS. The publication contains guidelines, not requirements, and includes recommendations on public address systems in school buses. It states that buses may be equipped with interior and exterior speakers, but interior speakers should not be installed within 4 feet of the driver's seatback in its rearmost upright position. No States opposed this specification. Georgia adopted the guidelines for school bus construction contained in the 2000 *National School Transportation Specifications and Procedures* but has not provided guidance on radio speaker placement and operation to local school districts, which have the option of developing specifications on this issue.

The NASDPTS, through a grant from NHTSA,[30] recently developed a document for the "Identification and Evaluation of School Bus Route and Hazard Marking Systems," which was incorporated in the *2000 National School Transportation Specifications and Procedures*. NHTSA made the grant as a result of the Safety Board's investigation of the 1995 Fox River Grove, Illinois, school bus accident[31] and resulting recommendations[32] to the NASDPTS to:

> H-96-52
>
> Encourage your members to develop and implement a program for the identification of school bus route hazards and to routinely monitor and evaluate all regular and substitute school busdrivers.
>
> H-96-53
>
> Advise your members to consider railroad/highway grade crossing accident histories or unusual roadway characteristics when establishing school bus routes.

The purpose of the grant was to research the issue of school bus route hazards and marking systems, develop guidelines to identify the hazards, suggest ways to inform school bus drivers of the hazards and how to deal with the hazards, and propose methods to disseminate information to the community. Among the hazards identified were railroad/highway grade crossings.

The *2000 National School Transportation Specifications and Procedures* also recommends a regular review of busdrivers for compliance with regulations and of bus routes for accuracy and the presence of hazardous road conditions. At the most recent

[30] NHTSA grant DTNH22-97-G-05155.

[31] National Transportation Safety Board, *Collision of Northeast Illinois Regional Commuter Railroad Corporation (METRA) Train and Transportation Joint Agreement School District 47/155 School Bus at Railroad/Highway Grade Crossing in Fox River Grove, Illinois, on October 25, 1995,* Highway/Railroad Accident Report NTSB/HAR-96/02 (Washington, DC: NTSB, 1996).

[32] Safety Recommendations H-96-52 and -53 were classified "Closed—Acceptable Action" (November 11, 1997) because the NASDPTS had provided the information requested by the Safety Board to its members.

NCST to update the practices, the committee recommended mandatory reviews but did not specify the intervals.

Meteorological Information

At Lovell Field Airport in Chattanooga, Tennessee, approximately 30 miles from the accident site, between 6:00 a.m. and 7:00 a.m. on March 28, 2000, the weather was clear with light winds out of the south-southeast. The temperature was 46 degrees, dew point was 39 degrees, and sunrise was at 6:33 a.m. The bus was traveling west and the train, south; therefore, the sun did not obstruct the driver's view.

Tests and Research

Lap and Lap/Shoulder Belts and Seat Coverings

The driver's lap/shoulder belt webbing was severed near where it passed through the free-sliding latch plate, which remained secured in the latch plate receiver on the chassis. Loading marks[33] were noted on the latch plate of the lap/shoulder belt and were visible on the D-ring. Striations in the plastic cover where the webbing passed through the latch were present along the length of the plastic.

The center lap belt[34] in row two on the driver side of the bus had visible indentation marks on the latch side of the webbing. No other belts showed marks. This location corresponds to the seating position of the passenger who reported she was wearing her lap belt.

The seatback of row 11 on the passenger side had blue fiber scuff marks, most likely transferred to the seat cover from the passenger's (12A) clothing. More pronounced fiber transfer occurred over creases created by the folded-over seat cover material. The curvature of the creases and the severity of heat damage indicate that at impact the passenger's (12A) body was moving toward the right and upward.

Locomotive Event Recorder

The event recorder[35] on the CSXT locomotive was downloaded after the accident and the data were taken to Safety Board headquarters for examination. The data showed that the locomotive was in maximum throttle position prior to the collision and that the

[33] Marks indicating that a force was exerted on the belt when it was in use.

[34] The latch plate of the center lap belt overlapped with the left lap belts and could be latched to the left seat buckle without the passenger being out of position.

[35] The event recorder records data related to speed, time, and distance and to systems such as the horn, throttle, and bell at 1-second intervals. The times and distances stated here are estimates based on the 1-second intervals recorded.

speed immediately before brake application and collision was 51 mph. The locomotive bell had been activated after passing the last crossing, about 1.8 miles before Liberty Church Road. The locomotive passed the whistle post about 14 seconds before impact and at least 7 seconds before the horn was sounded. The horn was sounded for 3 seconds (about 952 feet from the crossing), released for 2 seconds, and then sounded for about 9 seconds before impact (beginning about 574 feet from the crossing). The locomotive was placed in emergency braking less than 2 seconds (about 122 feet) before the crossing. The train came to a stop 50 seconds after the emergency brake application (about 1,990 feet beyond the crossing).

Bus Video Recorder

All Murray County School District buses are equipped with a video monitoring system consisting of a videocassette recorder (VCR) and color video camera. The system on the accident bus was a Silent Witness brand (model SW210). The camera was mounted at the front and center of the bus and pointed down the length of the passenger compartment. The driver and the first two rows of seats were not within the camera's line of sight. The camera's field of view included the remaining seats and windows at the rear and on the driver and passenger sides of the bus.

School district policy is that each bus have a separate videocassette for each day of the week stored on the bus. Each morning the driver is to remove the previous day's videocassette from the VCR and insert the current day's videocassette. Once a videocassette is inserted, the VCR automatically begins recording about 6 seconds after electric power is supplied (by turning on bus's the ignition switch). When the bus is turned off, the VCR stops recording. According to school district officials, the VCR and camera are used to record passenger behavior and are reviewed only if problems are reported.

The VCR from the accident bus and the videocassette in it were recovered at the accident scene. Police also removed 1 other intact videocassette, 14 videocassette reels that had separated from their cassette housings during the accident sequence, and 7 segments of loose magnetic videotape. Safety Board personnel examined the videocassette removed from the VCR, as well as the reassembled videocassettes (made from the reels found on scene).

Investigators were able to identify passengers and landmarks on the videotapes, confirming that most of the videotapes had been recorded on the accident bus route. Using sound recordings, they were also able to identify the driver on the videotapes. Staff determined that the bus had crossed the railroad tracks 12 times in the videotapes, and in each instance the accident driver was driving. The bus did not stop before crossing the railroad tracks on nine occasions, including the accident, eight of which were in the 2 weeks preceding the accident; stopped twice (both times when another vehicle was present behind the bus); and in one instance too much glare was present to make a determination. Safety Board personnel identified 11 crossings on the videotape as the one on Liberty Church Road and were unable to identify the 12th crossing.

The videotape on the day of the accident revealed that the bus did not stop, that the radio was playing, and that the train horn was not audible on the video recording.

Vehicle Speed

Using landmarks identified on the video, Safety Board personnel were able to determine the speed of the bus as it approached the grade crossing on the day of the accident. The calculated speed, as the bus traveled downhill toward the crossing, was 25 to 30 mph. The bus slowed as it approached the crossing to a calculated speed of 15 mph at the driveway about 71 feet before the grade crossing. On the videotape, the train's light can be seen moving across the side window bars immediately prior to impact, which helped staff calculate the bus's speed.

An exemplar bus was used to determine a likely speed for the accident bus as it traveled over the crossing. A volunteer busdriver, who was instructed to drive at a constant speed over the crossing, reported that he was most comfortable driving between 10 and 15 mph, which corresponds to the speed calculated from the video.

Audibility Tests

Audibility tests[36] were conducted inside an exemplar bus to determine whether the driver should have been able to hear the train horn when stopped at the crossing.[37] A baseline reading, established using a sound level meter located near the driver's head, indicated an ambient sound level within the bus of 68.2 decibels[38] with the engine idling, radio off, and door closed. With the radio on,[39] the sound level inside the bus increased to the 71.5- to 72.4-decibel range. When traveling downhill on Liberty Church Road approaching the crossing, the interior sound level was 73 to 74 decibels with the radio off and 76.2 decibels with the radio on. When the train was stopped 1,268 feet from the crossing (at which point the test busdriver first could see the train) and the bus was stopped at 15 feet, with the radio on and door closed, the train horn was sounded and the sound level increased to 77 decibels; the volunteer driver inside the bus said he could barely hear the horn. With the radio on and the door open, the train horn was sounded and the sound level inside the bus increased to 81 decibels, and the driver stated that the train horn was discernible over the ambient noise of the bus. With the radio off and the door open, the sound level from the horn increased to 98 decibels.

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[36] A Bruel and Kjaer precision sound level meter, type 2232, serial number 1129820, with a wind boot was used. The sound level meter was calibrated using a Bruel and Kjaer sound level calibrator type 4230, serial number 1140357.

[37] In performing these tests, the Safety Board coordinated with CSXT to ensure that no trains were approaching the crossing.

[38] Decibel is the degree of loudness on a scale of 0 (least perceptible sound) to 130 (average pain level). It is a logarithmic scale, that is, an increase of 3 decibels is equivalent to doubling the sound pressure.

[39] The radio volume was set at the same approximate knob location that was found on the accident bus during postaccident inspection.

Auditory Warnings

Research has shown that detecting the presence of a sound will not lead to appropriate action unless the sound is identified[40] or has reached the alerting level.[41] If a sound is to be identified, the warning signal must be 3 to 8 decibels above the threshold of detection;[42] if a sound is to reach the alerting level, the warning signal must be approximately 10 decibels above the ambient noise.[43]

Safety Board testing during the Fox River Grove accident investigation[44] showed that at 100 feet from impact, the train horn was only 3 to 5 decibels above the ambient noise level within the school bus. Investigators also found that the crossing bell was not audible above either the ambient noise level of the school bus or that of passing traffic.

Sight Distance

Safety Board investigators conducted visibility testing at the accident scene. When the bus was stopped 15 feet from the nearest rail, the train crew would have been able to observe the bus when the train was 1,349 feet from the crossing. The school bus driver could see the train when it was 1,268 feet from the crossing.

Geometric Design of Highways and Streets, published by the American Association of State Highway and Transportation Officials (AASHTO), states that sight distance is a primary consideration at crossings without train-activated warning devices, such as the accident crossing. AASHTO recommends that the required design sight distance along the railroad track from a crossing, for a combination of highway and train speeds, be based on a 65-foot truck crossing a single set of tracks at 90 degrees. Given a train speed of 60 mph and a vehicle departing from a stop, AASHTO recommends that the sight distance along the track from the crossing be 1,439 feet so that the truck can safely cross the tracks if a train is not seen. Using the same methodology and incorporating the accident bus length and acceleration, the school bus would have required approximately 960 feet of sight distance along the tracks when stopped 15 feet from the nearest rail to safely cross the tracks from a stop.

According to CSXT officials, the railroad right of way at the Liberty Church Road grade crossing is 100 feet wide, 50 feet on each side of the track centerline. The officials stated that CSXT brush-clearing activities call for a sight distance quadrant to be clear of brush at highway grade crossings. This quadrant at the accident site is 60 feet wide—30 feet on each side of the track centerline—and extends for 200 feet on either side of the roadway. Each year, CSXT sprays this 400- by 60-foot quadrant to a distance of 12 feet on each side of the track for weed control. Every 3 years, the brush is cut 30 feet from the

[40] David M. Lipscomb, "Audibility and the Law," *Forensic Audiology.*

[41] The "alerting level" is the sound level at which a person is aware of a sound and recognizes the source.

[42] The "threshold of detection" is the sound level at which a person is aware of a sound.

[43] Skeiber, Mason, and Potter, "Effectiveness of Audible Warning Devices on Emergency Vehicles," *Sound and Vibration,* 1978.

[44] NTSB/HAR-96/02.

centerline, which is the distance the brush-cutting machine can reach while positioned on the track. The brush at Liberty Church Road had last been cut in July or August 1998. The 400- by 60-foot quadrant contained no obstructions at the time of the accident.

Accident Simulation

Using a human vehicle environment system developed by Engineering Dynamics Corporation[45] and Mathematical Dynamical Models (MADYMO),[46] Safety Board staff conducted vehicle dynamics and occupant kinematics simulations for this investigation. Although a simulation does not replicate the actual accident, it is designed to evaluate specific mechanical and biomechanical issues for similar types of accident scenarios.

Results of the vehicle dynamics simulation verified that the train was traveling about 51 mph and the bus was traveling about 15 mph at impact. The resultant peak accelerations experienced by the bus during the initial lateral impact between the train and the bus were 30 Gs[47] at the center of gravity, 39 Gs at the last row of seats, and 31 Gs at the first row of seats. The peak angular acceleration at the center of gravity was approximately 2,500 deg/sec/sec. The angular accelerations were higher at the last row due to the school bus's clockwise rotation away from the impact point, the pivoting of the bus about the front axle, and the distance of the last row of seats from the impact location. During the initial lateral impact, the velocity of the train changed by 1 to 2 mph due to emergency braking, while the lateral velocity of the bus increased to the velocity of the striking train. Because the train was much larger and heavier than the school bus, the severity of the collision was more extreme for the bus.

Other Information

School Bus Transportation Safety

According to NHTSA, approximately 450,000 school buses are used to transport 23.5 million students to and from school over 4.2 billion miles annually throughout the United States.[48] About 54 percent of the student population, kindergarten through 12th grade, ride a school bus daily to and from school. Between 1989 and 1999, NHTSA's statistics indicate that 96 crashes occurred in which at least one passenger of a school bus

[45] Staff used the Engineering Dynamics Vehicle Simulation model to determine the speed and approach direction of the bus and the Engineering Dynamics Corporation Simulation Model of Automobile Collisions to examine the lateral impact between the train and the bus, as well as the movement of the train and the bus body and chassis separately after collision.

[46] For further information on MADYMO, see *MADYMO User's Manual 3D Version 5.3,* TNO Road-Vehicles Research Institute, November 1997. The MADYMO simulation for this investigation was conducted in conjunction with NHTSA and Information Systems and Services, Inc., a NHTSA contractor.

[47] Acceleration of gravity.

[48] U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1999: School Buses,* DOT HS 809 095 (Washington, DC: NHTSA, 1999).

died. Three of those crashes were railroad/highway grade crossing accidents involving school buses and resulted in 11 fatalities.[49]

In Georgia, about 12,600 school buses are used to transport over one million passengers annually.[50] For the 1998-1999 school year, Georgia reported 790 school bus-related accidents. In those accidents, 12 busdrivers, 162 passengers, and 60 passengers of other vehicles were injured.[51] No fatal injuries to busdrivers or passengers were recorded; one driver of another vehicle died as a result of fatal injuries. The last fatal accident in Georgia that involved a school bus and train occurred on October 23, 1974; it resulted in 7 fatalities and 71 injuries.[52]

Reporting Near Misses at Grade Crossings

After the accident in Conasauga, another locomotive engineer reported to investigators that 11 days earlier, he had seen a school bus cross the tracks at Liberty Church Road without stopping. This engineer stated that on March 17, 2000, between 3:00 p.m. and 3:30 p.m., "The school bus never attempted to stop, just like there were no railroad tracks there. It never slowed down." The school bus passed over the crossing about 500 feet ahead of the train. The engineer said he noticed the driver was a woman but that he did not look for any numbers on the bus until after it was over the crossing and going up the hill. He reported that he was unable to see any numbers on the back of the bus and was more concerned about what he had to do for the upcoming crossing.

The engineer told investigators that he did not report the occurrence because he could not see the numbers on the bus. He stated that if he had been able to properly identify the bus, he would have reported the incident.

According to company officials, CSXT locomotives commonly contain a placard that depicts a school bus stopped at a grade crossing while a train is approaching and instructs crews to report near misses. CSXT operation rule 100-F instructs crews to report the occurrence of a near miss, including the failure of school bus drivers to stop at crossings or to observe reasonable precautions at crossings when trains are approaching. The crew is to make such reports, detailing full information, to the CSXT Police Communications Center. If mobile access is not available, the train dispatcher may relay the information.

Railroad/Highway Grade Crossing Safety

The Safety Board investigated 60 accidents at passive grade crossings that occurred between December 1995 and August 1996 and, based on analysis of the findings,

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[49] These crashes occurred in Miltona, Minnesota, on November 16, 1989; Fox River Grove, Illinois, on October 25, 1995; and Buffalo, Montana on March 10, 1998.

[50] <www.doe.klz.ga.us>.

[51] Data provided by Georgia Department of Education, School Transportation Services.

[52] Aragon, Georgia, NTSB/RHR-75/01.

issued a study[53] on safety at passive grade crossings. Driver error was cited as the primary accident cause in 49 of the 60 cases. The study also noted that drivers at a passive grade crossing are not provided warnings from train-activated devices; consequently, they must rely on a system of grade crossing signs and pavement markings and on passive devices, such as crossbucks, that are designed to warn drivers only of the presence of a crossing. No element of this passive system changes to alert drivers to the presence of an oncoming train.

Some conclusions reached by the safety study are:

> Consolidation (the separation and closure) of passive crossings is the most effective means to eliminate accidents between highway vehicles and trains. The next most desirable method to improve safety at passive crossings is to equip these crossings with active devices that warn the motorist of an oncoming train.
>
> Installation and enforcement of stop signs at passive crossings would provide for consistent information, instruction, and regulation to the motoring public and would improve the safety of the Nation's passive grade crossings.

Stop Signs At Passive Grade Crossings. The 1998 Safety Board study[54] made 19 recommendations to improve safety at passive grade crossings, including one to the U.S. Department of Transportation (DOT) to:

> <u>H-98-28</u>
>
> Provide full funding within 3 years for the installation of stop and stop ahead signs at passive grade crossings.

The DOT responded on December 23, 1998, that funding is provided through 23 *United States Code* 130[55] and 133[56] and that the DOT would inform the States of the availability of such funding. The Safety Board replied on March 29, 2001, that it did not believe this action alone would meet the intent of the recommendation because it did not provide full funding. The Safety Board is awaiting further response from the DOT.

[53] National Transportation Safety Board, *Safety at Passive Grade Crossings,* Volume 1: Analysis, Safety Study NTSB/SS-98/02 (Washington, DC: NTSB, 1998).

[54] NTSB/SS-98/02.

[55] Railroad-Highway Crossings Program.

[56] Surface Transportation Program.

The 1998 safety study also made several recommendations to the States, including:

H-98-34

Install, within 2 years of receiving Federal funding, stop signs at all passive grade crossings unless a traffic engineering analysis determines that installation of stop signs would reduce the level of safety at a crossing. Crossings where conditions are such that the installation of stop signs would reduce the level of safety should be upgraded with active warning devices or should be eliminated.

Of the 11 passive crossings in Polk County and the 8 passive crossings in Murray County that were examined by Safety Board investigators, only 3 in Murray County were equipped with stop signs. No stop signs were installed at any crossings in Polk County.

In discussions with the Chairman of the Safety Board on October 25, 2000, Tennessee officials indicated that they intended to install stop signs at all passive crossings but were awaiting funding; consequently, in a January 5, 2001, letter, the Safety Board classified Safety Recommendation H-98-34 "Open—Acceptable Response" for Tennessee. The Safety Board has not received a response to this recommendation from Georgia, nor from 19 other States. Of the remaining States, the recommendation has been classified "Open—Acceptable Response" for 16 States, "Open—Unacceptable Response" for 7 States, "Closed—Unacceptable Action" for 4 States, and "Closed—Acceptable Action" for 2 States (Idaho and Hawaii). The Safety Board closed the recommendation for Idaho and Hawaii because Idaho already requires installation of stop signs at passive grade crossings unless an engineering study dictates otherwise (the only State with this requirement) and because Hawaii only has two passive grade crossings, for which stop signs have already been installed.

The *Manual on Uniform Traffic Control Devices,* published by the Federal Highway Administration (FHWA), establishes national standards for traffic control devices and all States are required to be in substantial conformance with the manual.[57] Concerning the use of stop signs at grade crossings, it states:

At the discretion of the responsible State or local highway authority, STOP (R1-1) or YIELD (R1-2) signs may be used at highway-rail grade crossings that have two or more trains per day and are without automatic traffic control devices.[58]

Installation of Active Warning Devices. According to the FRA's grade crossing inventory, Tennessee has about 2,145 passive grade crossings. The State receives Federal funds for the installation of active warning devices at railroad/highway grade crossings and installs 35 to 45 such devices each year.[59] Tennessee uses the Federal Railroad Administration's (FRA's) hazard index to help determine which grade crossings should

[57] U.S. Department of Transportation, Federal Highway Administration, *MUTCD 2000: Manual on Uniform Traffic Control Devices, Millennium Edition* (Washington, DC: FHWA, 2000).

[58] Page 8B-7.

[59] In 1999, the State installed 15 active warning devices.

receive an active warning device or an upgrade of an existing device. The index includes data such as the amount of railroad traffic, the amount of highway traffic, the speeds involved, and grade crossing accident history. Because of the widely varying conditions and circumstances at grade crossings (for example, types of vehicles using the crossing, sight distance, and location), Tennessee uses a diagnostic team comprising employees of the State department of transportation and the railroads to make the final selections.

Tennessee law requires that a railroad install an active warning device at a grade crossing where a collision between a motor vehicle or pedestrian and a train results in a fatality. Installation of the warning device is funded by the railroad, the State, and the county or local municipality at a cost of about $150,000 for lights and gates.[60] Before this collision, the Liberty Church Road crossing had not been designated for improvement. Following the accident, on September 9, 2000, it was upgraded to an active crossing with gates and lights.

DOT Highway Rail Crossing Inventory and Hazard Index. The FRA compiles and maintains the DOT's Highway Rail Crossing Inventory[61] to assist the States in conducting their own grade crossing safety programs. In examining the database, the Safety Board found discrepancies between information contained in the database and existing conditions at the accident crossing and other crossings in the area. Investigators looked at 10 crossings in the Liberty Church Road vicinity and found that the inventory listed the track speed as 10 mph less than the actual speed in seven instances and did not list the track speed at all in one instance. The inventory listed 13 trains per day for five crossings, 16 trains per day for four crossings, and did not list the number of trains for one crossing. CSXT reported 30 to 35 trains traveling over each crossing daily.

States often use information from the inventory to develop a hazard index for railroad/highway grade crossings. The FRA itself developed a Web-based Accident Prediction System (WBAPS) that is based, in part, on information from the inventory, and on data such as the type of warning device at the grade crossing, the exposure index,[62] and the number of accidents at the location in the past 5 years. A private company, under contract to the FRA, completed an analysis of the WBAPS in June 1999, comparing the performance of the FRA model to other models used to predict accidents. The study found that differences were minimal and that no model retained a substantial edge over another.[63] The public can use the WBAPS to help determine where best to direct highway grade crossing resources.[64] Law enforcement personnel can use the system to target unsafe crossings for monitoring.

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[60] NTSB/SS-98/02.

[61] Database intended to document every grade crossing in the United States <http://safetydata.fra.dot.gov/officeofsafety/Crossing/Default.asp>.

[62] The exposure index includes the number of trains per day, the number of cars traversing the grade crossing, and the fastest train speed on the track.

[63] May 8, 2000, letter from the Secretary of Transportation to the Chairman of the National Transportation Safety Board.

[64] U.S. Department of Transportation, Federal Railroad Administration, "Using Data Produced by WBAPS Disclaimer."

According to an FRA official, about half the States have devised their own hazard indexes for evaluating grade crossings. Tennessee uses the DOT's *Rail Highway Crossing Resource Allocation Procedure User's Guide*[65] to prioritize crossings for upgrade. To determine the hazard index of crossings, the guide applies the FRA accident prediction formula, which is similar to the WBAPS. Under 23 CFR 924, States are required to incorporate the relative hazard of railroad/highway grade crossings into their highway safety improvement program based on a hazard index formula.

Initiatives Related to Passive Grade Crossings and School Buses. On October 16, 2000, as a result of this accident, the Chairman suggested four safety initiatives in a letter[66] to the Governor of Tennessee that could be implemented to enhance the safety of citizens at passive grade crossings. These four initiatives were:

Install warning devices at passive grade crossings

The Safety Board has recommended (Safety Recommendation H-98-34) that stop signs be installed at all grade crossings that do not have active devices such as gates and lights. The Chairman urged the Governor of Tennessee to consider immediately installing warning devices at all passive crossings traversed daily by school buses.

Strengthen criteria for the installation of active warning devices

The Chairman encouraged the Governor to include the number and frequency with which school buses cross passive grade crossings as a factor in determining whether to install stop signs or active warning devices at those crossings.

Strengthen Tennessee's CDL manual and exam to include questions related to passive grade crossings

The Safety Board has recommended (Safety Recommendation H-98-37)[67] that the States include questions on safety at passive grade crossings in every version of the States' written commercial driver license examinations to reinforce the actions that commercial drivers, including school bus drivers, should take when encountering grade crossings.

Install noise reducing switches

In order to better hear the train horn at grade crossings, Florida and Kentucky are in the process of installing manual "option kill switches" in their school buses so that

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[65] DOT/FRA/OS-87/10.

[66] See appendix B for the letter in its entirety.

[67] Safety Recommendation H-98-37 requests that the States "ensure that questions on safety at passive grade crossings are included in every version of the State's written drivers examination." This recommendation has been classified "Closed—Acceptable Action" for 3 States, "Closed—Acceptable Alternate Action" for 10 States, "Open—Acceptable Response" for 12 States, and "Open—Unacceptable Response" for 1 State. The Safety Board has yet to receive a response from 24 States, including Georgia and Tennessee.

drivers can turn off noise-producing devices, including fans and radios, when they come to a grade crossing.

In-Vehicle Warning Systems

In-vehicle warning and advisory systems transmit alerts to highway vehicles to warn of the presence of approaching trains. A two-point system consists of train-to-vehicle communication, that is, a signal is broadcast by a transmitter on the locomotive to a receiver on the approaching highway vehicle. A three-point system uses a roadside device to detect a train and transmit the information to a vehicle-based receiver.[68] The addition of global positioning system (GPS) technology to either the two- or three-point system can improve accuracy by providing the train's estimated arrival time. Current systems are designed to alert drivers no more than 20 seconds before a train's arrival, the same amount of time as drivers are alerted at active grade crossings.

In 1997, the Minnesota Department of Transportation tested a three-point system in a school district in which 30 system-equipped buses each crossed two to five grade crossings per day.[69] School bus drivers were surveyed to determine their perception of the system, and 80 percent of them thought that the system provided valuable warning information; 15 percent reported that the system affected their driving behavior. One survey respondent stated that the system helped her avoid a crash.[70]

In 2000, the Intelligent Transportation Systems Program Office of the Illinois Department of Transportation conducted a pilot study of a three-point system at grade crossings near Chicago. The 300 test vehicles included school buses, emergency service vehicles, and commercial vehicles that regularly traversed five active grade crossings where train detection devices were already in place. This study used off-the-shelf technology and evaluated driver perceptions of on-board warning system effectiveness, including the in-vehicle receiver position, warning display methods, and overall system reliability.[71]

Final results from the Illinois study are due in spring 2002. According to the system evaluator, preliminary results indicate that drivers liked getting the additional warnings, although they would have preferred an earlier warning, before the lights and gates were activated.[72] One school bus driver said she liked the reassurance that the systems gave her when she approached a grade crossing. Overall, the drivers' impressions

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[68] Hoy A. Richards and Richard T. Bartoskewitz, *The Intelligent Highway-Rail Intersection Integrating ITS and ATCS for Improved Grade Crossing Operation and Safety* (College Station, TX: Richards & Associates and Texas Transportation Institute, April 1995).

[69] Amy Polk, *An In-Vehicle Signing System for School Buses at Rail-Highway Grade Crossings*, Minnesota Department of Transportation, 1996.

[70] Amy Ellen Polk, "The Use of ITS to Improve Safety and Mobility at Highway-Rail Grade Crossings," <http://www.nawgits.com/icdn/its_hri.html>.

[71] Pilot Study of Advisory On-Board Vehicle Warning Systems at Railroad Grade Crossings, Executive Summary, Illinois Department of Transportation, 1997.

[72] Dr. Ray Benekohol, Associate Professor of Civil Engineering, University of Illinois, July 18, 2001, telephone conversation.

were positive and they believed the device would be effective at passive grade crossings. The in-vehicle device is projected to cost about $100. The transmitters used in the test cost about $20,000 to $30,000, but the system evaluator believes the cost is likely to drop if more are produced.

Automatic Crash Notification Systems

Automatic crash notification (ACN) systems are vehicle-based systems that detect when a crash has occurred and then automatically notify the local 911 center. They can reduce the time that elapses between the accident and the arrival of emergency response personnel on scene.[73] Some research indicates that reducing notification time from the current average of 9 minutes after a crash to 1 minute would save an estimated 3,000 lives per year.[74]

ACN systems can differ in both the way in which a crash is detected and the way in which information is transmitted to an emergency response center. Some ACN systems activate when the driver's airbag deploys (the driver's airbag does not deploy in certain types of crashes, such as side impacts and rollovers). Other ACN systems use orthogonal accelerometers, which activate the system when a certain deceleration threshold is reached and can also provide an estimate of crash severity (such systems would detect accidents in all types of crashes). Information can be transmitted either directly to local police or to a customer service center (CSC), which functions as an intermediary between the vehicle and a 911 center. If transmittal is through a CSC, the center can help determine the severity of the crash and relay that information to the emergency responders. Direct transmittal to the emergency responders can decrease response time.

Publicly sponsored tests using ACN systems have been conducted in Colorado, Washington, Minnesota, and New York.[75] Based on test results, researchers have identified several areas that need improvement. First, ACN systems are heavily reliant on cellular telephone coverage to open a communication line and to transmit data. In rural areas, where ACN can have great impact, cellular coverage may be sparse, although even in rural areas coverage is growing rapidly. Second, the interface between CSCs and 911 centers can pose a challenge. If a call goes to a CSC, the CSC must determine the closest 911 center to the accident and then place a 10-digit telephone call to that center. The CSC itself cannot dial 911 because the call would go to the 911 center closest to the CSC, not necessarily the one closest to the crash. Third, GPS accuracy has been an issue. When the tests were conducted, nonmilitary GPS receivers could only provide geolocation information within about 120 meters because of deliberate errors embedded in the signal. These errors have since been removed, thereby increasing the accuracy of the systems.

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[73] <http://www.nhtsa.dot.gov/cars/problems/studies/acns/champion.htm>.

[74] W. Evanco, "Reducing Accident Fatalities with Rural Mayday Systems," Mitretek Systems, Inc., WN96W0000048, in U.S. Department of Transportation, Federal Highway Administration, *Review of ITS Benefits: Emerging Successes*, FHWA-JPO-97-001, HVH 1/10-96(1M0) E (Washington, DC: FHWA, 1996) 19.

[75] A. Blatt, E. Bellis, B. Donnelly, D. Funke, R. McClellan, and G. Wilson, *Automated Collision Notification, Final Report* (Washington, DC: NHTSA, October 31, 2000).

Cellular providers were required to provide geolocation ability for all calls by October 2001.[76] The Federal Communications Commission extended this date (the new deadline varies by carrier)[77] when none of the carriers met the October 2001 deadline.

In March 1997, as part of the ACN system used in the New York operational test, a software program, URGENCY,[78] was developed to improve computer-assisted dispatch of rescue resources. With the input of several parameters from crash data recorders, such as crash force, type of crash, and passenger data, the software determines the likelihood of a serious injury. This feature can help emergency responders determine the appropriate level of response prior to arrival on scene.

The costs of ACN systems vary from $200 to $1,000 per vehicle, depending on available options, including nonemergency services such as directions. ACN systems are already available on some passenger cars and open a communication line with a CSC if the airbag is deployed or the driver presses an emergency button. These systems incorporate the vehicle-equipped GPS locating function.

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[76] <http://www.fcc.gov/e911/factsheet_requirements 012001.txt>.

[77] <http://www.fcc.gov/bureaus/wireless/news_releases/2001/nw10127a.txt>.

[78] <http://www.nhtsa.dot.gov/cars/problesm/studies/acns/champion.htm>.

Analysis

General

During the past 30 years, Safety Board recommendations have led to significant improvements in the transportation of school bus passengers. Statistically, school buses are among the Nation's safest modes of transportation. Yet, as this accident demonstrates, certain issues pertaining to school bus safety, although previously addressed by the Board, continue to require attention.

In the following analysis, the Safety Board will first exclude factors that neither caused nor contributed to the accident and then examine those factors that led to or had a role in the accident. The discussion will focus on the school bus driver's performance; school district oversight, including busdriver monitoring and evaluation procedures and bus routing; passive grade crossing safety, including previous initiatives related to passive grade crossing and school bus safety; school bus crashworthiness and survival factors, including occupant kinematics; and emergency response.

Exclusions

The weather was clear and dry at the time of the accident and, although the sun had just risen, neither the school bus driver nor the locomotive engineer identified the sun as an impairment to visibility.

Neither maintenance records for the 1-year-old school bus, nor postaccident inspection of the vehicle, indicated any mechanical problems that may have hampered operation of the vehicle.

A review of daily track inspection records in the 6 months prior to the collision showed no anomalies, and postaccident inspection of the track did not reveal any problems. A review of maintenance records and inspections both before and after the accident disclosed no mechanical problems with either the locomotive or the train.

The locomotive engineer and conductor were experienced in operating trains over the territory in which this accident occurred. They tested the brakes, as required, and complied with wayside signal indications and specified track speeds. Both the engineer and conductor had passed numerous efficiency tests in the previous year, exceeding Federal testing requirements. Data from the event recorder corroborated the engineer's and conductor's statements about what they did prior to impact.

A survey of the accident site did not reveal sight restrictions. Investigators calculated that the school bus driver had adequate distance to see the train had she stopped as required.

Toxicological tests performed on the blood and urine specimens taken from the train conductor, the engineer, and the busdriver were negative for alcohol and illicit drugs. Toxicological tests of the busdriver's blood and urine specimens did reveal the presence of phenylpropanolamine in the urine and the presence of pseudoephedrine and ephedrine in both specimens.

Pseudoephedrine, a common decongestant with the trade name Sudafed, is found in many over-the-counter cold and allergy preparations. It does not usually result in impairment and has been shown to have stimulant effects. Ephedrine is sold as an over-the-counter asthma medication (trade name Primatene). It too does not usually result in impairment and is a stimulant. Ephedrine and pseudoephedrine are often found together in the herbal supplement Ma Huang, also known as "ephedra," which is used as an "energy booster," stimulant, weight loss product, or decongestant in many nutritional supplements. Phenylpropanolamine, an over-the-counter decongestant, is also marketed as a weight loss product and is a metabolite of ephedrine and pseudoephedrine. The Food and Drug Administration requested that manufacturers withdraw it from the market in November 2000 due to a very small, but measurable, increased risk for stroke associated with its use, primarily in women taking it for weight loss. Nonetheless, phenylpropanolamine usually does not result in impairment and has stimulant effects.

Therefore, the Safety Board concludes that the weather, the mechanical condition of the school bus and train, and the condition of the track did not cause or contribute to the accident; the locomotive engineer and conductor were qualified and complied with Federal regulations; the sight distance along the tracks was adequate for the school bus driver to see an oncoming train; and neither alcohol nor drugs was a factor in the accident.

Accident Analysis

Georgia and Tennessee law require that school bus drivers stop the bus before crossing railroad tracks, open the door and window, turn off the radio, look both ways, and proceed when clear. An analysis of the videotape found on the bus showed that the school bus was traveling about 25 mph to 30 mph down Liberty Church Road and had reduced its speed to about 15 mph prior to the crossing. The videotape also recorded the driver's failure to stop. The window and door were not visible on the videotape, but no sounds associated with opening either one were audible. Had the busdriver stopped 15 feet from the crossing, as required, she would have been able to see 1,268 feet down the tracks and to observe the approaching train. Had the busdriver turned off the radio and opened the door and window, as required, she probably would have heard the train horn. The Safety Board therefore concludes that if the busdriver had followed the required procedures at the grade crossing, that is, if she had stopped at least 15 feet from the nearest rail, turned off her radio, and opened the door and window, she would have seen and heard the train and avoided the accident.

In a postaccident interview, the busdriver stated that she stopped, looked both ways, opened the door, looked in her rear view mirror to make sure the passengers were seated, then looked both ways down the track and proceeded. However, the school bus videotape contradicts this statement. Nor was the busdriver's behavior on this occasion an isolated incident; her actions were indicative of complacency at grade crossings. As recorded on the accident bus videotapes, the driver drove over the same railroad crossing, without stopping, eight other times. Another train engineer reported seeing a female school bus driver cross the railroad tracks in front of his train at the same location on a previous occasion, although he did not report the incident at the time that he witnessed it. The accident driver was the only female school bus driver to regularly traverse the Liberty Church Road crossing.

The Murray County School District provides annual recertification training for all busdrivers. This training, which the accident driver had received on August 12, 1999, includes information on what drivers are required to do at railroad/highway grade crossings. The driver also received training on the same subject from her previous employer and was reprimanded for talking during the lesson. The fact that the driver told police investigators that she stopped and opened the door shows that she knew the regulations for school buses crossing railroad tracks. The Safety Board concludes that although the driver had been educated on and knew the mandatory safety precautions at railroad/highway grade crossings, she disregarded the required procedures and crossed the railroad tracks without stopping on the day of the accident and at least eight other times before the accident.

The accident driver crossed the Liberty Church Road railroad tracks daily when operating over her regular route. In its 1998 study on safety at passive grade crossings,[79] the Safety Board concluded:

> A driver's decision to look for a train may be adversely affected by the driver's familiarity with and expectations at a specific passive grade crossing and the driver's experience with passive crossings in general.

The accident busdriver may have become complacent; she had not stopped at the crossing on at least eight other occasions and, therefore, even though trains passed this crossing daily between 6:00 a.m. and 7:00 a.m., may not have perceived the danger associated with railroad/highway grade crossings. The annual training she had received apparently was insufficient to reinforce to the driver the hazards associated with grade crossings.

[79] NTSB/SS-98/02, p. 61.

On January 25, 1985, the Safety Board issued a recommendation on monitoring school bus driver compliance at grade crossings to the state directors of pupil transportation of the 50 States and the District of Columbia:

> H-85-4
>
> Encourage local school jurisdictions to establish and enforce procedures to systematically monitor schoolbus driver compliance with railroad crossing stop requirements and routing requirements which include on-scene observations of driver performance.

Georgia responded that the superintendent or staff monitored each school bus route annually and that drivers were encouraged to report any unsafe crossings. The recommendation was classified "Closed—Acceptable Action" for Georgia on November 18, 1993.[80] The NASDPT's *National School Transportation Specifications and Procedures* recommends that pupil transportation directors monitor and evaluate school bus drivers in the performance of their duties.[81]

Based on a review of the Murray County School District files, neither the accident driver nor any other driver had been monitored or received a performance evaluation. Observing and evaluating drivers allows problems to be detected and addressed before an accident occurs. In this case, in which the driver had frequently ignored proper procedures at passive grade crossings by crossing the tracks without stopping, ample opportunity existed for the transportation director (or a representative) to have observed the driver's behavior, reviewed the videotapes, or both, and taken corrective action.

While the videotapes are intended to monitor passenger behavior, they can also be used to observe driver behavior and to educate drivers on proper actions, as necessary. Without an evaluation program in place, the school district had no proactive means of identifying drivers who were operating their buses in an unsafe manner. The Safety Board concludes that the Murray County School District did not monitor drivers nor identify and correct improper behavior, thus missing the opportunity to observe this driver's behavior at railroad/highway grade crossings. Since the accident, Murray County has implemented a program under which supervisors follow drivers who are operating school buses to evaluate their performance. The county has also been working more closely with Operation Lifesaver to provide mandatory driver training about grade crossing safety.

Grade Crossings

In its 1998 study on safety at passive grade crossings, the Safety Board recommended that all passive grade crossings be equipped with highway stop signs, at a

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[80] Safety Recommendation H-85-4 is classified "Closed—Acceptable Action" for 48 States and the District of Columbia and "Closed—No Longer Applicable" for 2 States.

[81] The NASDPTS recommendation was in response to Safety Recommendations H-96-52 and -53.

minimum. Only Idaho and Hawaii have taken the initiative to install stop signs at all passive grade crossings. In its September 8, 2000, response, the Tennessee Department of Transportation reported that the Tennessee Highway/Railroad Grade Crossing Task Force was studying the issue of placing stop signs at grade crossings and had already gathered considerable data, particularly for school bus routes. Tennessee has enhanced safety at the accident crossing by installing an active crossing warning device there; State law requires that Tennessee install active warning devices where a fatality has occurred.

While eliminating railroad/highway grade crossings or activating them with lights and gates is ideal, the Safety Board understands that activating crossings can be expensive; installing stop signs is a less costly solution. Had the accident driver stopped the school bus at the crossing and looked for the train, she would have been able to see it and probably would not have crossed in front of it. The sight distance along the tracks for a vehicle 15 feet from the crossing was sufficient to allow a stopped driver to see a train approaching. While State laws already require that school bus drivers stop at all grade crossings, drivers can benefit from being reminded about this requirement, and a stop sign provides that reinforcement. Moreover, passengers riding the bus are unlikely to know that all school buses are supposed to stop at grade crossings. If a stop sign is present, it is possible that passengers may question a driver if he or she does not stop or may tell their parents or teachers that the busdriver failed to stop, providing another means of oversight. The Safety Board therefore concludes that had a stop sign been present at the crossing, it would have reinforced to the driver the need to stop before crossing the tracks, likely prompting her to stop and not attempt to cross in front of the train.

Auditory Alerts

Locomotive event recorder data indicate that the train horn was activated for about 3 seconds when the train was 952 feet from the crossing and then continuously for 9 seconds (a minimum of 574 feet) before the collision. The busdriver had the radio and overhead speaker on. Additionally, the two panels above the driver's head were covered with sound attenuation material. To be identified, a sound must be 3 to 9 decibels above the threshold of detection;[82] to reach the alerting level, it must be at least 10 decibels above the ambient noise level.[83] With the door closed and the radio on (the conditions at the time of the accident), audibility testing revealed that the sound of the horn was only 5 decibels greater than the ambient noise when the train was 1,268 feet from the crossing and was barely detectable to the volunteer busdriver. Since the sound level increases by about 6 decibels when the distance is halved, at 574 feet, the sound of the horn would have been about 11 decibels above the threshold of detection. During the accident, with the radio on and the door and window closed, the audio portion of the videotape did not pick up the sound of the horn over the ambient noise. During testing, with the radio off and the door open, even at 1,268 feet, the sound level of the horn was 26 decibels above that of the

[82] The "threshold of detection" is the level at which a person is aware of a sound.

[83] Stanley C. Skeiber, Robert L. Mason, and R. C. Potter "Effectiveness of Audible Warning Devices on Emergency Vehicles, Sound and Vibration," February 1978, pp. 14-22.

ambient noise, and a driver would probably be able to detect the sound and be alerted to the approaching train. Therefore, the Safety Board concludes that the driver did not stop, had the radio on, and the door closed; thus she had difficulty detecting the train horn and was probably unaware of the presence of the train.

The Safety Board made two recommendations concerning bus speakers to the NASDPTS in the 1996 Fox River Grove highway accident report:

> H-96-50
>
> Develop guidelines for the appropriate placement of radio speakers and use of radios on school buses and disseminate these guidelines to your members.
>
> H-96-51
>
> Advise your members to check their school district buses and disable any radio speakers located immediately adjacent to the school bus drivers' heads.

The NASDPTS informed the Safety Board that it had surveyed the States and found that a majority of the States had prohibited, or had legislation pending that prohibited, radio speakers in the driver's compartment. The remaining States reviewed their policies on use of radios and radio speakers in school buses and stated that the policies were adequate to ensure that drivers can hear critical auditory information. Georgia informed its local school districts of the need to follow proper procedures, including turning off speakers, when crossing railroad tracks. The State did not require school districts to disconnect the speakers adjacent to the driver's head; Georgia left that decision to the local school districts. In October 1998, the National Safety Council revised its "Recommended Procedures for School Bus Drivers at Railroad Grade Crossings" to remind drivers of the importance of turning off radios at railroad/highway grade crossings; the revision was incorporated in the *2000 National School Transportation Specifications and Procedures*. Based on the NASDPTS survey and the association's efforts to inform its members of the hazards of not turning off the radio at grade crossings, Safety Recommendations H-96-50 and -51 were classified "Closed—Acceptable Alternate Action"[84] on February 19, 1999.

Despite the NASDPTS's efforts, the 1-year-old school bus involved in this accident was equipped with a radio speaker adjacent to the driver's head. In addition, the driver did not follow prescribed policy to turn down the volume at railroad/highway grade crossings. Consequently, the Safety Board believes that the Georgia Department of Education should require all school districts to disconnect radio speakers used for music or entertainment that are adjacent to school bus drivers' heads. The Safety Board understands from the NASDPTS's response to Safety Recommendations H-96-50 and -51 that the speakers are also used to transmit important information to the driver via two-way

[84] The recommendations received this classification because the actions taken met the intent of the recommendations, even though formal guidelines were not developed and school districts were reminded of the hazards of speaker use when approaching railroad tracks, but were not specifically told to disable the speakers.

radio from the school district dispatcher. While the Safety Board agrees that information from the dispatcher is important, use of the speakers for music or entertainment broadcasts is not critical and can hamper the driver's ability to hear external auditory alerts. Because of the urgent need that drivers receive auditory alerts while operating a school bus, the Safety Board believes that school bus manufacturers should discontinue the installation in school buses of radio speakers used for music or entertainment that are adjacent to the driver's head. The Safety Board further believes that NHTSA should implement rulemaking to prohibit radio speakers used for music or entertainment from being placed adjacent to drivers' heads in school buses.

Speakers adjacent to a school bus driver's head probably contribute the most to masking exterior sounds, such as train horns, but air conditioning, heaters, defrosters, wiper motors, and other sounds also help mask exterior sounds. Therefore, Florida and Kentucky have begun to install noise-canceling switches in school buses. The interrupt-type switches are spring-loaded to prevent drivers from permanently overriding normal operation of noise-producing equipment. When pressed, noise in the driver's area is reduced, improving the driver's ability to listen for audible warnings. The Safety Board concludes that if activated prior to a grade crossing, a switch that turns off all nonessential noise-making components, including, but not limited to, the radio, can help drivers hear train horns and stop as necessary.

In its Fox River Grove accident investigation report, the Safety Board recommended that NHTSA:

H-96-43

> Determine what effect school bus sound attenuation materials have on the ability of a busdriver to discern both interior and exterior audible warnings.

NHTSA responded on April 22, 1997, that it would survey bus manufacturers on the effect of sound attenuation materials, evaluate the data, and conduct testing, if necessary. The agency also discussed in-vehicle warning systems that were undergoing testing. Therefore, the Safety Board classified the recommendation "Open—Acceptable Response" on August 11, 1997.

Subsequently, on October 27, 2000, NHTSA wrote:

> The agency does not believe that the use of specifications for sound attenuation materials is the most effective approach for warning school bus drivers at railroad crossings. Another means of preventing these types of tragic train-motor vehicle collisions is by the use of in-vehicle warning systems. NHTSA believes that an alternate solution to warn drivers at railroad grade crossings that a train is approaching can be obtained by using intelligent transportation systems technology. We plan to determine the applicability of this technology to warn school bus drivers at railroad grade crossings that a train is approaching instead of testing sound attenuation materials.

The Safety Board responded that while the installation of vehicle warning systems is desirable for the future, the technology is still years away from implementation, and a more active approach is needed to protect passengers being transported in school buses over railroad crossings. Because of NHTSA's inaction in determining the effect of sound attenuation materials, and the 4 years that had elapsed in the interim, the Safety Board classified Safety Recommendation H-96-43 "Closed—Unacceptable Action" on April 18, 2001.

The accident school bus was equipped with sound attenuation material above the driver's head. While it is unclear how much this material contributed to the driver's inability to hear the train horn, it may have absorbed some of the horn sound. The Safety Board remains concerned about the effects of sound attenuation material on a driver's ability to hear an alerting signal. As explained in the Fox River Grove report,[85] sound attenuation material reduced the volume of both the train horn and the warnings shouted by bus passengers in that accident.

In-Vehicle Warning Systems

An in-vehicle warning system receives information about an approaching train either from the train itself or through the infrastructure and provides an auditory and visual warning inside the vehicle to the driver. In its response to Safety Recommendation H-96-43, NHTSA cited in-vehicle warning systems as a solution to the audibility problem that drivers encounter when a vehicle is equipped with sound attenuation materials. NHTSA stated that it would determine the applicability of such systems, which alert drivers to oncoming trains, to school buses. Yet to date, no further testing of in-vehicle warning systems for school buses has taken place, beyond the test completed in 2000 by the Minnesota Department of Transportation and one that will be completed in 2002 by the Illinois Department of Transportation that was not specific to school buses. This is the only progress that has been made in this area to date. The Safety Board is pleased that the DOT recognizes the importance of installing in-vehicle warning systems, but is concerned about the pace at which such systems are being tested and installed in school buses.

Had the accident school bus been equipped with an in-vehicle warning system, the driver may have realized that a train was approaching and may have stopped prior to the crossing. An alert would have been activated as the bus approached the crossing (the distance at which activation is triggered depends on the train's speed but allows enough time for a bus to stop prior to the crossing). The Safety Board concludes that an in-vehicle warning system to alert drivers of the presence of an oncoming train would have provided the busdriver with additional information, likely prompting her to stop before crossing the tracks.

In its 1998 study on safety at passive grade crossings, the Safety Board recommended that the DOT:

[85] NTSB/HAR-96/02, p. 47.

I-98-1

> Develop and implement a field test program for in-vehicle safety and advisory warning systems, variable message signs, and other active devices; then ensure that the private entities who are developing advanced technology applications modify those applications as appropriate for use at passive grade crossings. Following the modifications, take action to implement use of the advanced technology applications.

On February 10, 1999, the Safety Board classified Safety Recommendation I-98-1 "Open—Acceptable Response," based on the DOT's response that it is supporting railroad/highway grade crossing projects in several locations. However, the DOT did not specify how it planned to guide the implementation of such systems at passive grade crossings and has provided no further response concerning this recommendation.

In the Safety Board's opinion, the technologies described in the recommendation, particularly in-vehicle warning systems, can help enhance school bus safety at passive grade crossings. Therefore, the Safety Board is reiterating recommendation I-98-1 to the DOT.

Grade Crossing Inventory and Hazard Prediction

The FRA maintains the nationwide grade crossing inventory. As part of the 1998 passive grade crossing study, the Safety Board made the following recommendation concerning this system:

R-98-41

> Modify the grade crossing inventory system to include information on (1) the sight distances available to a motorist, and (2) the presence of curves on the roadway and on the tracks. Direct the States to include these data as a part of the regularly scheduled updates of the database.

Because the FRA updated the grade crossing inventory database to include recommended elements, on January 4, 2000, the Safety Board classified Safety Recommendation R-98-41 "Closed—Acceptable Action." However, as investigators discovered, some information in the inventory is still outdated and incorrect. Of 10 sites in the area of the accident crossing surveyed by Safety Board investigators, the inventory listed incorrect maximum train speeds for 8 and incorrect number of trains per day for all 10.

In its April 6, 1999, response to Safety Recommendation R-98-41, the FRA stated that such discrepancies occur because updating the information is voluntary and the FRA lacks the authority to require States or railroads to upgrade information in the inventory. The FRA has encouraged the States to provide up-to-date information for the inventory, but the States have not done so. The FHWA gives funds to the States annually for highway safety, including grade crossing safety and maintaining a survey of all grade crossings, and provision of these funds could be contingent on updating the inventory regularly.

Because the States and others rely on this inventory for determining hazards and predicting accidents at grade crossings, inaccurate information can lead to invalid assessments. For example, the inventory lists the Liberty Church Road crossing as having 13 trains per day at a speed of 50 mph, which underestimates the 30 to 35 trains per day passing through at a maximum of 60 mph. When these underestimates are factored into equations that help users determine relative hazards, the resulting hazard index is similarly understated and hazardous grade crossings may not be recognized as such. Therefore, the Safety Board concludes that though critical to assessing grade crossing hazards, the data in the Highway-Rail Grade Crossing Inventory are not always accurate and complete. The Safety Board believes that the FHWA should require States to update the Highway-Rail Crossing Inventory to accurately reflect current railroad operations.

About half the States use their own hazard index to determine priorities for upgrading passive grade crossings to active crossings. Some, such as North Carolina, plan to factor school buses into their formula. North Carolina has indicated that it will not only consider whether school buses use a crossing but will also rank passive crossings according to number of school bus trips over them and load data. Including such factors assigns higher priority to school bus crossings and results in upgrading the safety of these crossings more quickly than if the standard hazard index is used. At the time of the accident, two school buses used the Liberty Church Road crossing daily. The Safety Board concludes that had Tennessee factored school bus use into its grade crossing hazard index, the accident crossing may have had a higher priority for receiving funds to install active warning devices.

Although the WBAPS, the FRA's Web-based accident prediction system, is primarily a tool for States to use in determining funding authority, law enforcement agencies also use it to identify and monitor unsafe grade crossings. If the crossing inventory in the WBAPS were accurate, school districts could also find the WBAPS helpful in establishing school bus routes and identifying hazardous crossings. While the inventory is not up-to-date, it represents the most comprehensive source of data available and does permit hazard identification. Ideally, school bus routes should exclude passive grade crossings; when that is not possible, the WBAPS or the State's own grade crossing index could help school districts determine the least hazardous crossing. Such use further emphasizes the need for maximum accuracy in these inventories. The Safety Board concludes that the FRA's WBAPS or a State's grade crossing hazard index, as part of the school bus routing hazard identification program, could help school districts select the safest school bus routes. The Safety Board believes that the NASDPTS should encourage its members to use the FRA's Web-based accident prediction system or the States' hazard indexes for grade crossings when developing school bus routes.

School Bus Routing

In reviewing documents pertaining to Murray County school bus routes, investigators determined that route hazards, including grade crossings, apparently were not identified, nor were busdrivers told (other than through annual training) what actions to take in the area of potential hazards. In 1996, the Safety Board recommended to the NASDPTS:

> H-96-52
>
> Encourage your members to develop and implement a program for the identification of school bus route hazards and to routinely monitor and evaluate all regular and substitute school bus drivers.

In its response to the Safety Board, the NASDPTS stated:

> Where it is possible to re-route the school bus to avoid a potential hazard, that is the preferred action. Where it is not possible or feasible to change the school bus route to avoid a potential hazard, then those hazards should be clearly and prominently highlighted on the school bus route document that is provided to the operator of the school bus. Additionally, a full description of what action(s) the school bus driver should take in the area of the potential hazard should be provided to the driver…. Drivers should be evaluated on a routine basis to ensure that they remain knowledgeable on route hazard identification and action plans.

In June 1998, the NASDPTS, in cooperation with NHTSA, published guidance on school bus routing that reflects its position as stated above and distributed the guidance to States and localities. The Safety Board classified Safety Recommendation H-96-52 "Closed—Acceptable Action" on November 7, 1997. The guidance is also now part of the *National School Transportation Specifications and Procedures*.

The Murray County transportation director has stated that all routes have been reviewed since the accident and, as necessary, rerouted to use gated railroad crossings. The routes were also reviewed and, as appropriate, adjusted for other hazards, such as unsafe turns, curves, and pick-up and drop-off locations.

Safety Initiatives for Passive Grade Crossings and School Buses

Although the Safety Board has issued numerous recommendations, as previously cited, to improve school bus and grade crossing safety, needless accidents, such as this one at Conasauga, continue to occur. Following the accident, the Safety Board developed four initiatives, based on previous safety recommendations that, if implemented by the States, could reduce the number of grade crossing accidents involving school buses. Such a program would include upgrading passive crossings, improving school bus routing, monitoring driver performance, enhancing driver training and testing, and reducing the noise inside the bus.

The Safety Board believes that the States, in cooperation with the NASDPTS, should develop and implement a program of initiatives for passive grade crossings and school buses that includes (1) installation of stop signs at passive crossings that are traversed by school buses except where an engineering study shows their installation would create a greater hazard; (2) use of information about whether school buses routinely cross passive grade crossings as a factor in selecting crossings to upgrade with active warning devices; (3) a requirement that all newly purchased and in-service school buses be equipped with noise-reducing switches; (4) enhanced school bus driver training and evaluation, including periodic reviews of on-board videotapes where available, especially with regard to driver performance at grade crossings; and (5) incorporation of questions on passive grade crossings in the CDL manual and examination.

Survival Factors and Occupant Kinematics

The school bus was extensively damaged during the collision, and the bus body separated from the chassis behind the driver's seat. Within the passenger compartment, the rows of seats in the impact area sustained massive crush damage, which decreased longitudinally away from the impact area. The driver's seat separated from the body of the bus and remained with the chassis, while the passenger seats remained within the body. All window glazing on the passenger (impact) side of the bus was broken, while on the driver side the window glazing remained intact, except for the first window. Despite severe damage in the impact area of the bus, which is not unusual in a side impact collision with a train locomotive at 51 mph, the bus body otherwise remained intact.

The MADYMO simulation generally showed that during the impact, the simulated passengers rapidly traveled laterally and slightly forward toward the passenger side of the bus. Those already seated on the passenger side quickly struck the sidewall and windows of the bus, while those on the driver side typically struck the side of the adjacent seatback and then continued across the width of the bus. The remainder of this section will discuss both the evidence found on scene and the results of the occupant kinematics simulation.

During the accident, the lap-belted passenger received minor injuries, three passengers (two of whom were ejected) received serious injuries, and three passengers sustained fatal injuries (one of whom was ejected). The passenger seated behind the driver in row two (seat 2A) was restrained by a lap belt and remained within the bus body. This passenger sustained minor abdominal blunt force injuries along the line of the lap belt. In the simulation, this passenger's upper body pivoted laterally toward the right and slightly forward about the belt. Predicted injuries were low for this passenger when restrained by the lap belt. Bruising is the most common injury from a lap belt and results from force applied by either the diagonal or transverse lap strap.[86] The lap belt acts as a fulcrum for flailing of the upper body and lower extremities.[87]

[86] Bernard Knight, *Forensic Pathology* (New York: Oxford University Press, 1991) 260.

[87] J.K. Mason, *The Pathology of Violent Injury* (London: Edward Arnold, 1978) 28.

The availability of a lap belt restraint system and the size of this passenger (4 feet 5 inches tall and 117 pounds) enabled a properly fitted restraint system[88] and permitted ride-down[89] within the vehicle during this accident. In addition, this passenger remained within the seating compartment[90] and, unlike the two unbelted and ejected front-row passengers, was not exposed to injury-causing objects and surfaces inside and outside the vehicle. The Safety Board concludes that the lap belt-restrained passenger sustained minor abdominal injuries as a result of the severity of the accident and the pivoting of her body about the lap belt. Further, she was not ejected due to the use and proper fitting of the available restraint.

The two passengers ejected from the front row (seats 1A and 1F) sustained serious injuries, including closed head injuries, and were seated in the area that was exposed following separation of the bus body from the chassis. (The modesty panel in front of this row remained intact). They were not wearing the available lap belts, did not remain within the seating compartment, and, therefore, were ejected through the front opening of the bus body during its rotation and deceleration. In addition, one of the two passengers (in seat 1F) was pinned underneath the front right corner of the bus body after it came to rest. The simulation showed that during the initial collision, these passengers struck interior, non-energy absorbing surfaces, including the side of the modesty panel[91] (passenger in seat 1A) and the sidewall (passenger in seat 1F). The seats and the modesty panel conformed to FMVSS 222 criteria for absorbing impact and dissipating collision energy from a passenger striking the seat during a frontal impact. These standards were not developed for a passenger striking the side of the seat in a lateral impact.

The passengers in seats 1A and 1F were then ejected and struck the exterior surfaces at the same speed at which they were ejected from the vehicle. The full ride-down effect was not afforded to these unbelted front-row passengers, particularly the passenger in 1A, who was ejected shortly after separation. Although physical evidence was not found that would have permitted investigators to determine what objects the passengers struck to obtain their injuries, both passengers probably sustained serious injuries as a result of having struck interior and exterior surfaces. The simulations predicted injuries to these unrestrained front-row passengers as they contacted the side of the modesty panel (passenger in seat 1A) and the sidewall of the bus (passenger in seat 1F). When restrained

[88] Incorrectly adjusted or positioned straps can increase the danger of injury. Loose straps allow movement of the body prior to the point at which restraint occurs. If a person, such as a child, is too small for the lap belt, the body may slide from under the strap and sustain injury. See Bernard Knight, *Forensic Pathology* (New York: Oxford University Press, 1991) 260.

[89] Ride-down is the gradual deceleration experienced by passengers who remain within the compartment of a vehicle and attached to the vehicle during its movement before coming to rest. If a passenger is attached to the vehicle, he or she can take advantage of all the energy absorbed by the vehicle later in the crash.

[90] In school buses, compartmentalization protects passengers during frontal impacts. It affords this protection through closely spaced seats, covering of the seat cushions and high seatbacks with an energy-absorbing material, and deformation of the seatback when impacted. The entire seat structure is designed to absorb energy and to dissipate the energy of the crash away from the passenger and into the surrounding compartment.

[91] The modesty panels and seatbacks are designed to absorb energy in a frontal or rear collision. Although the sides of the modesty panel and seatbacks are padded, there are no specifications for these to absorb energy when struck during the lateral motion of an passenger.

by a lap belt only or a lap/shoulder belt, the passengers were retained within the seating compartment, and the level of predicted injury was reduced for both passengers. The Safety Board concludes that had the available restraints in the first row been worn in this accident and had they fit properly, the two front-row passengers probably would not have been ejected during the accident sequence and the level of injury may have been reduced. The Safety Board also concludes that components within the passenger compartment that are not fitted with energy-absorbing materials can contribute to serious injuries when passengers strike them during an accident sequence.

Although the three passengers seated in the middle section of the bus remained within the bus body during the accident, they sustained serious and fatal injuries. The locomotive struck this section of the vehicle, resulting in major intrusion damage and interior compartment deformation, thereby reducing the amount of survivable space. The passenger seated on the driver side across from the impact area (seat 6A) was propelled out of his seating compartment toward the intruding locomotive. He sustained a closed head injury, right first rib fracture,[92] and facial lacerations. The two passengers seated on the passenger side of the bus (seats 6F and 8F) remained within their compartments; they sustained blunt force trauma injuries to the head, thorax, and upper abdominal regions. Although injuries were still predicted for the passenger across from the impact area (seat 6A), the simulation results indicated that the level of injury was reduced when a lap/shoulder belt restrained this passenger. Furthermore, this passenger was retained within the seating compartment and therefore not exposed to the interior deformation when restrained by both the lap only belt and the lap/shoulder belt. The Safety Board concludes that the seriously injured passenger across from the impact area (seat 6A) sustained his injuries due to incomplete lateral compartmentalization and that all three passengers (seats 6A, 6F, and 8F) in the impact area sustained injuries as a result of locomotive intrusion and exposure to high impact forces.

Fiber evidence indicated that the rearmost-seated passenger on the driver side of the bus (seat 12A) struck the side of the adjacent seatback and traveled laterally and upward to the right. Blood evidence in the vehicle indicated that he then struck the right sidewall and surface of the overhead storage rack support and frame. Postaccident examination of this passenger, who was fatally injured, revealed chest abrasions and linear contusions indicative of a contact injury; the pattern of these contusions matched the size and shape of the window frame screw housing. Internal examination showed a transected aorta[93] and lacerated right atrium, in addition to multiple fractures and internal lacerations. Although subsequently ejected from the bus, this passenger probably sustained his fatal lacerated aortic injury within the vehicle during the first moments of the accident sequence.

[92] First rib fractures are rare unless extreme force is applied to the upper torso. See David Viano, *Chest: Anatomy, Types and Mechanisms of Injury, Tolerance Criteria and Limits, and Injury Factors,* AAAM and IRCOBI Biomechanics of Trauma Course Book, October 1997, p. 9.

[93] The aorta is fixed and unyielding at the aortic ligament level, and this type of fatal injury is usually seen in intersection-type crashes in which the jarring effect on the chest organs shears the aorta. From: Werner U. Spitz, ed., *Spitz and Fisher's Medicolegal Investigation of Death: Guidelines for the Application of Pathology to Crime Investigation,* Third Edition (Springfield, IL: Charles C. Thomas, 1993) 549.

The simulation showed that this passenger moved out of the driver side seating compartment, struck the adjacent seatback, and continued laterally until the point of impact with the window structure and sidewall, resulting in a predicted injury that corresponded to the on-scene evidence. Simulation results indicated that the forces applied to this passenger upon impact with the sidewall components were greater than those applied to any other passenger away from the impact area in the bus, possibly due to the high lateral and rotational accelerations at this seating location. Although this passenger principally sustained blunt force trauma to the chest, the forces were sufficiently high that the simulation predicted head, neck, and chest injuries when the passenger struck the sidewall and window screw frame housing. A likely source of his fatal injury was the passenger's deceleration into the non-energy absorbing interior surfaces, including the interior right sidewall and the window frame screw housing, during the initial severe lateral impact from the locomotive. The passenger struck these surfaces due to incomplete compartmentalization in a lateral impact. Therefore, the Safety Board concludes that the rearmost-seated passenger sustained fatal injuries due to movement out of the seating compartment and subsequent impact with non-energy absorbing interior components.

Unlike the results from the passengers seated away from the impact area in the front and center of the bus, the simulation predicted high levels of injury for the passenger in seat 12A when restrained by a lap belt only and a lap/shoulder belt. The combination of large lateral and rotational accelerations in this region of the bus caused this passenger to decelerate rapidly, even when restrained, resulting in predicted injuries in all restraint conditions.

The following table (table 2) details the actual injuries sustained by the bus passengers and the injuries predicted by the simulation. Although the injuries are not identical, the trends are evident, especially for the passenger in seat 2A. This passenger sustained only minor injuries during the accident sequence. The simulation indicated that had this passenger not worn the available lap belt, the passenger would have been exposed to a similar level of injury as the two front-row passengers.

Table 2. Summary of predicted injuries to the simulated occupants based on the bus simulation.

Seating location	Segment	Actual injuries	Unrestrained	Lap belt only	Lap/shoulder belt
1A (E)	Head Thorax Neck	√ √	√ √ √		
1F (E)	Head Thorax Neck	√	√ √ √ √	√	 √
2A (+)	Head Thorax Neck		√ √ √		
6A	Head Thorax Neck	√ √	√ √ √	√ √	√ √
6F (*)	Head Thorax Neck	√ √	 √ √	√ √ √	√ √
8F (*)	Head Thorax Neck	√	√ √ √	√ √ √	√ √ √
12A (*E)	Head Thorax Neck	 √	√ √ √	√ √ √	√ √ √

√= predicted injury
* = fatally injured passenger
E = ejected passenger
\+ = passenger wearing available restraint device

On September 21, 1999, the Safety Board adopted a special investigation report on bus crashworthiness issues[94] in which the Board found that some passengers not seated in the intrusion area were seriously or fatally injured in school buses involved in lateral impacts with large vehicles. The Safety Board concluded:

> Current compartmentalization is incomplete in that it does not protect school bus passengers during lateral impacts with vehicles of large mass and in rollovers, because in such accidents, passengers do not always remain completely within the seating compartment.

[94] National Transportation Safety Board, *Bus Crashworthiness Issues.* Highway Special Investigation Report NTHSB/SIR-99/04 (Washington, DC: NTSB, 1999).

The Safety Board recommended that NHTSA:

H-99-45

In 2 years, develop performance standards for school bus occupant protection systems that account for frontal impact collisions, side impact collisions, rear impact collisions, and rollovers.

NHTSA is conducting a study to develop ways to enhance the safety of the interior environment for school bus passengers. The agency completed front and side impact full-scale crash testing in 2000 and is publishing the results. NHTSA expects to release its research on frontal impact testing this winter. The side impact testing and research report will not be completed until fall 2002. Safety Recommendation H-99-45 was classified "Open—Acceptable Response" on April 18, 2001. Preliminary results from the frontal impact test showed that three available options—no restraint, lap belt only, and lap/shoulder belts—offer varying degrees of benefit to the passenger and that passenger size, seat spacing, and proper usage affect the protection capabilities of the restraint system. Preliminary results from NHTSA's side impact crash test showed that crash test dummies away from the impact area do not travel across the width of the bus and strike the sidewall or other non-energy absorbing surfaces. Injury values were low for dummies away from the impact area.

In this accident, as well as other school bus accidents the Safety Board has investigated, passengers sustained serious or fatal injuries due to impact with sidewall components (differing from NHTSA's results). The unrestrained passengers on the driver side of the bus in this accident were propelled out of their seating compartment and received serious or fatal injuries as a result of such impacts. In several accidents discussed in the Safety Board's *Bus Crashworthiness Issues* report (Holmdel, New Jersey; Monticello, Minnesota; and Easton, Maryland), passengers away from the impact area were also propelled laterally out of their seating compartment and sustained serious and fatal injuries due to contacting non-energy absorbing surfaces.

Even passengers seated on the same side as, but not in, the area of impact (such as the passenger in seat 1F in this accident), have struck non-energy absorbing sidewalls and components during a collision. In the Fox River Grove accident, a passenger seated away from the impact area but on the same side of the bus as the impact sustained a fatal head injury and an abrasion across the forehead that matched the perforated sound attenuation panel pattern on the upper left side of the bus interior. The Safety Board concludes that even those passengers who are outside the area of impact and remain within their compartment can receive serious or fatal injuries due to impact with non-energy absorbing components within a school bus.

Sidewall components, such as window frames, screws and joints, and overhead storage rack supports are located throughout the interior of the passenger compartment, as are the sides of the seatframes,[95] yet are exempt from the *Federal Motor Vehicle Safety*

[95] Or in the case of the first row in this accident, the modesty panels.

Standards for passenger protection in school buses. Although energy-absorbing materials on the window frames, sidewall panels, roof racks, sides of seatframes and modesty panels might benefit passengers who impact these locations, school bus passengers are not afforded the benefit of energy-absorbing surfaces on these structures and components. If these components were included in the passenger protection requirements of FMVSS 222, "School Bus Passenger Seating and Crash Protection," passenger injuries would probably be mitigated. The Safety Board concludes that FMVSS 222 exempts sidewall components and sides of seatframes within the passenger compartment of school buses, thereby exposing passengers to these injury-producing components in lateral impact collisions. The Safety Board believes that NHTSA should develop and incorporate into the *Federal Motor Vehicle Safety Standards* performance standards for school buses that address passenger protection for sidewalls, sidewall components, and seatframes.

In this accident, the school bus body separated from the chassis. The separation and subsequent distance traveled by the bus body are likely to have provided further ride-down for passengers after the collision, although the separation resulted in an opening at the front of the body through which the two passengers and driver were ejected. In other accidents[96] the Safety Board has investigated, the body and chassis have also separated, providing similar ride-down benefits to passengers remaining within the bus body. What the Safety Board observed in this accident, but not in others, is the unique location in which the body and chassis separated. In the Conasauga accident vehicle, the school bus body separated behind the driver's seat; the engine cowling, front floor, and driver's seat remained attached to the chassis. In other school bus accidents, the complete body (including the driver's seat and flooring) and chassis have separated from one another. The location of the body separation in this accident probably occurred because of the bus's movement immediately following the collision. Tire marks on the inside of the rail indicated that the school bus wheels were temporarily hung up on the track as the bus rotated away from the striking train. The tire catching on the rails may have initially induced the separation between the body and chassis. The location of the separation, behind the driver's seat, may have resulted from the impact with the railroad cross buck near that location and from the fact that the body is attached to the chassis by more rigid bolts under the driver's seat than at other locations.

The Safety Board has investigated two other accidents[97] involving bus body-chassis separation in which the driver's seat was equipped with a lap/shoulder belt. In both, the body and chassis separated completely and the driver's seat and belt system remained with the bus body. In neither accident did the lap/shoulder belt become separated between the anchor points. Both the lap and shoulder belts remained intact and attached to the body of the bus.

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[96] Rehobeth, Massachusetts, January 10, 1984 (DCA-84-FH-005); Carrsville, Virginia, April 12, 1984 (DCA-84-AH-008); Palm Springs, California, July 31, 1991 (DCA-91-MH-005); Fox River Grove, Illinois, October 25, 1995 (CRH-96-MH-002); and Buffalo, Montana, March 10, 1998 (HWY-98-MH-022).

[97] Fox River Grove, Illinois (CRH-96-MH-002), and Buffalo, Montana (HWY-98-MH-022). Both involved AmTran school buses.

In this accident, the upper anchorage (D-ring) and emergency retractor of the driver's continuous lap/shoulder belt was mounted to the bus body side panel approximately 16 inches behind the driver's seat. The lower anchorages were mounted to the seat and attached to the floor with tethers directly under the driver's seat. When the body separated, the driver's seat, the seat-mounted lap belt components, and part of the lap/shoulder belt remained with the chassis, while the D-ring mounted on the sidewall and part of the shoulder belt remained with the bus body. The body separation resulted in high forces exerted on the belt webbing system, which tore, and the driver was ejected from the separating vehicle components. The driver sustained minor injuries.

Because the driver's lap/shoulder belt was attached to both the bus body floor and the sidewall, with one anchor point remaining with the body and the others with the chassis, great forces were exerted on the belt. When the distance between anchor points is broad and the body separates anywhere between these points, the webbing may cause injury to the driver because of forces exerted on the webbing as the two components separate. In this accident, the webbing failed, and the driver was ejected before the belt exerted serious or fatal forces on her. While the Safety Board has not seen body separations in this location before, it is concerned that drivers can sustain serious or fatal injuries if the lap/shoulder belt anchor points are sufficiently far apart that a vehicle separation between the points results in extreme forces exerted on the driver by the webbing during an accident. The Safety Board concludes that the driver's lap/shoulder belt webbing failed due to the high forces applied to the webbing as the two parts of the school bus separated and due to the large distance between the lap/shoulder belt anchor points.

Manufacturers should be aware of the potential consequences associated with lap/shoulder belt anchor points that are far apart. If the anchor points are closer together, the likelihood of a body separation occurring between them can be reduced, thereby lessening the risk of injury. The NASDPTS's School Bus Manufacturers Technical Council functions as an industry advisor to school bus manufacturers and the Safety Board believes that it should notify its members of how and why the driver's lap/shoulder belt tore in this accident and of the potential consequences of large longitudinal distances between lap/shoulder belt anchor points.

Emergency Response

Almost immediately after the accident, a passerby placed a 911 cellular telephone call and reported the accident. Even though the accident occurred in Polk County, Tennessee, the call was routed to the Murray County, Georgia, 911 Center because the cellular tower automatically relayed the cellular call to the closest 911 center. EMS units, located within 2 miles of the scene, were immediately dispatched and arrived on scene within minutes. The caller did not know the exact location of the accident because Polk County does not have street signs. Emergency response was not hindered because the caller was familiar with the area and described it in sufficient detail that emergency responders immediately identified where the accident occurred. The caller also called back 4 minutes later, after she went to St. Claire's gas station and learned the name of the street.

The CSXT Police Communications Center placed its emergency call to local police about 7 minutes after the accident. No other calls reporting the accident were recorded.

The accident occurred in a rural area where traffic is not heavy. An ACN system on the school bus would have detected the crash immediately and transmitted the crash information, as well as the precise location, obtained via GPS, to the local 911 center. Had such a system been in place, the school bus passengers would not have had to rely on a passerby to place the call or on the driver, who was incapacitated, to call 911. In this accident, the locomotive conductor notified CSXT of the accident, and CSXT then notified the 911 center; but not all accidents involve vehicles in which the driver (or in this case the train crew) is able to place an emergency call.

Because school buses often carry many children, quick and adequate emergency response is important if all children are to be treated expeditiously, particularly those with serious injuries. The more information provided to an emergency dispatch center, the better the response is likely to be. An ACN system can transmit information on the severity of the crash, the vehicle dynamics, and the location. Some systems include a voice communication line that automatically opens so that the emergency response center can communicate directly with the driver, if the driver is capable. If the school bus in this accident had been equipped with an ACN system, a call would have immediately been forwarded to the 911 center, either directly or through a relay center, and the 911 dispatcher would have known the exact location of the accident. A more advanced ACN system would have relayed information about the severity of the crash, indicating to the dispatcher a need to send multiple responders. The time lag would most likely have been less than 2 minutes from the time of the collision to the time when emergency response was dispatched.

Currently available ACN systems have helped reduce emergency response time, thereby leading to more lives saved.[98] In the operational test in New York, an emergency notification was sent to the sheriff's office within 2 minutes of the accidents that occurred.[99] Cellular telephone system coverage has expanded and geolocation systems have become more accurate; as a result, ACN system accuracy has improved. While the school bus passengers in this accident were fortunate in the actions of a quick-thinking passerby and a train crew that was able to place an emergency call, severe accidents, particularly in rural areas, do not always occur in such circumstances.

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[98] W. Evanco "Reducing Accident Fatalities with Rural Mayday Systems," Mitretek Systems, Inc. WN96W0000048, April 1996, in U.S. Department of Transportation, Federal Highway Administration, *Review of ITS Benefits: Emerging Successes*, FHWA-JPO-97-001, HVH 1/10-96(1M0) E (Washington, DC: FHWA) 19.

[99] B. Donnelly, D. Schabel, A.J. Blatt, and A. Carter, "The Automated Collision Notification System." *International Symposium on Transportation Recorders, May 3-5, 1999* (Washington, DC: NTSB and International Transportation Safety Association, 1999).

The Safety Board concludes that, in spite of a lack of street signs or a street address, emergency responders to this accident were able to efficiently coordinate their response operations and provided timely, appropriate medical services and rescue operations, in part because of the 911 caller's prompt action and familiarity with the accident area. However, in other accidents, passersby may not be present or callers contacting a 911 center may not be familiar with the local area. In such situations, ACN systems can help emergency call centers dispatch emergency responders to locations more expeditiously, particularly in rural areas or when drivers are incapacitated. The Safety Board concludes that, given the limited amount of traffic traversing Liberty Church Road, emergency response might have been delayed if the passerby had not noticed the accident or if the train crew had been incapacitated. While ACN systems are already available on cars, testing of such systems on school buses has yet to be done. While the cellular and GPS technology would be compatible with any vehicle, testing of ACN systems on school buses is needed to evaluate factors such as vehicle dynamics and crash severity. The Safety Board believes that NHTSA should evaluate the feasibility of incorporating ACN systems on school buses and, if feasible, proceed with system development.

Conclusions

Findings

1. The weather, the mechanical condition of the school bus and train, and the condition of the track did not cause or contribute to the accident; the locomotive engineer and conductor were qualified and complied with Federal regulations; the sight distance along the tracks was adequate for the school bus driver to see an oncoming train; and neither alcohol nor drugs was a factor in the accident.

2. If the busdriver had followed the required procedures at the grade crossing, that is, if she had stopped at least 15 feet from the nearest rail, turned off her radio, and opened the door and window, she would have seen and heard the train and avoided the accident.

3. The driver did not stop, had the radio on, and the door closed; thus she had difficulty detecting the train horn and was probably unaware of the presence of the train.

4. Although the driver had been educated on and knew the mandatory safety precautions at railroad/highway grade crossings, she disregarded the required procedures and crossed the railroad tracks without stopping on the day of the accident and at least eight other times before the accident.

5. The Murray County School District did not monitor drivers nor identify and correct improper behavior, thus missing the opportunity to observe this driver's behavior at railroad/highway grade crossings.

6. Had a stop sign been present at the crossing, it would have reinforced to the driver the need to stop before crossing the tracks, likely prompting her to stop and not attempt to cross in front of the train.

7. If activated prior to a grade crossing, a switch that turns off all nonessential noise-making components, including, but not limited to, the radio, can help drivers hear train horns and stop as necessary.

8. An in-vehicle warning system to alert drivers of the presence of an oncoming train would have provided the busdriver with additional information, likely prompting her to stop before crossing the tracks.

9. Though critical to assessing grade crossing hazards, the data in the Highway-Rail Grade Crossing Inventory are not always accurate and complete.

10. Had Tennessee factored school bus use into its grade crossing hazard index, the accident crossing may have had a higher priority for receiving funds to install active warning devices.

11. The Federal Railroad Administration's Web-based Accident Prediction System or a State's grade crossing hazard index, as part of the school bus routing hazard identification program, could help school districts select the safest school bus routes.

12. The lap belt-restrained passenger sustained minor abdominal injuries as a result of the severity of the accident and the pivoting of her body about the lap belt; she was not ejected due to the use and proper fitting of the available restraint.

13. Had the available restraints in the first row been appropriately worn in this accident and had they fit properly, the two front-row passengers probably would not have been ejected during the accident sequence and the level of injury may have been reduced.

14. Components within the passenger compartment that are not fitted with energy-absorbing materials can contribute to serious injuries when passengers strike them during an accident sequence.

15. The seriously injured passenger across from the impact area (seat 6A) sustained his injuries due to incomplete lateral compartmentalization, and all three passengers (seats 6A, 6F, and 8F) in the impact area sustained injuries as a result of locomotive intrusion and exposure to high impact forces.

16. The rearmost-seated passenger sustained fatal injuries due to movement out of the seating compartment and subsequent impact with non-energy absorbing interior components.

17. Even those passengers who are outside the area of impact and remain within their compartment can receive serious or fatal injuries due to impact with non-energy absorbing components within a school bus.

18. Federal Motor Vehicle Safety Standard 222 exempts sidewall components and sides of seatframes within the passenger compartment of school buses, thereby exposing passengers to these injury-producing components in lateral impact collisions.

19. The driver's lap/shoulder belt webbing failed due to the high forces applied to the webbing as the two parts of the school bus separated and due to the large distance between the lap/shoulder belt anchor points.

20. In spite of a lack of street name signs or a street address, emergency responders to this accident were able to efficiently coordinate their response operations and provided timely, appropriate medical services and rescue operations, in part because of the 911 caller's prompt action and familiarity with the accident area.

21. Given the limited amount of traffic traversing Liberty Church Road, emergency response might have been delayed if the passerby had not noticed the accident or if the train crew had been incapacitated.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the collision was the school bus driver's failure to stop before traversing the railroad/highway grade crossing. Contributing to the accident was the Murray County, Georgia, School District's failure to monitor busdriver performance and its lack of school bus route planning to identify hazards on school bus routes and to eliminate the necessity of crossing railroad tracks. Contributing to the injuries of the school bus passengers outside of the area of intrusion were incomplete compartmentalization and a lack of energy-absorbing material on interior surfaces.

Recommendations

To the States:

In cooperation with the National Association of State Directors of Pupil Transportation Services, develop and implement a program of initiatives for passive grade crossings and school buses that includes (1) installation of stop signs at passive crossings that are traversed by school buses except where an engineering study shows their installation would create a greater hazard; (2) use of information about whether school buses routinely cross passive grade crossings as a factor in selecting crossings to upgrade with active warning devices; (3) a requirement that all newly purchased and in-service school buses be equipped with noise-reducing switches; (4) enhanced school bus driver training and evaluation, including periodic reviews of on-board videotapes where available, especially with regard to driver performance at grade crossings; and (5) incorporation of questions on passive grade crossings in the commercial driver's license manual and examination. (H-01-38)

To the National Highway Traffic Safety Administration:

Implement rulemaking to prohibit radio speakers used for music or entertainment from being placed adjacent to drivers' heads in school buses. (H-01-39)

Develop and incorporate into the *Federal Motor Vehicle Safety Standards* performance standards for school buses that address passenger protection for sidewalls, sidewall components, and seatframes. (H-01-40)

Evaluate the feasibility of incorporating automatic crash notification systems on school buses and, if feasible, proceed with system development. (H-01-41)

To the Federal Highway Administration:

Require States to update the Highway-Rail Crossing Inventory to accurately reflect current railroad operations. (H-01-42)

To the Georgia Department of Education:

Require all school districts to disconnect radio speakers used for music or entertainment that are adjacent to school bus drivers' heads. (H-01-43)

To the National Association of State Directors of Pupil Transportation Services:

Encourage your members to use the Federal Railroad Administration's Web-based accident prediction system or the States' hazard indexes for grade crossings when developing school bus routes. (H-01-44)

In cooperation with the States, develop and implement a program of initiatives for passive grade crossings and school buses that includes (1) installation of stop signs at passive crossings that are traversed by school buses except where an engineering study shows their installation would create a greater hazard; (2) use of information about whether school buses routinely cross passive grade crossings as a factor in selecting crossings to upgrade with active warning devices; (3) a requirement that all newly purchased school buses and in-service school buses be equipped with noise-reducing switches; (4) enhanced school bus driver training and evaluation, including periodic reviews of on-board videotapes where available, especially with regard to driver performance at grade crossings; and (5) incorporation of questions on passive grade crossings in the commercial driver's license manual and examination. (H-01-45)

Notify your members of how and why the driver's lap/shoulder belt tore in this accident and of the potential consequences of large longitudinal distances between lap/shoulder belt anchor points. (H-01-46)

To the School Bus Manufacturers:

Discontinue the installation in school buses of radio speakers used for music or entertainment that are adjacent to the driver's head. (H-01-47)

The National Transportation Safety Board also reiterates the following recommendation:

To the U.S. Department of Transportation:

Develop and implement a field test program for in-vehicle safety and advisory warning systems, variable message signs, and other active devices; then ensure that the private entities who are developing advance technology applications modify those applications as appropriate for use at passive grade crossings. Following the modifications, take action to implement use of the advanced technology applications. (I-98-01)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

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Member

GEORGE W. BLACK, JR.
Member

Adopted: December 11, 2001

Appendix A

Investigation and Public Hearing

The National Transportation Safety Board was notified of the Conasauga, Tennessee, accident about 8:00 a.m. on March 28, 2000. An investigative team was dispatched with members from the Washington, D.C.; Atlanta, Georgia; Parsippany, New Jersey; and Fort Worth, Texas, offices. Groups were established to investigate human performance; motor carrier operations; highway, vehicle, and survival factors; and recorders and to document the scene.

Participating in the investigation were representatives of the National Highway Traffic Safety Administration; the Federal Motor Carrier Safety Administration; the Federal Railroad Administration; the Tennessee Highway Patrol; the Polk County, Tennessee, District Attorney; CSX Transportation, Inc.; and the Murray County, Georgia, School District.

No public hearing was held; no depositions were taken.

Appendix B

October 2000 Letter to the Governor of Tennessee From the Chairman, National Transportation Safety Board

National Transportation Safety Board
Washington, D.C. 20594

Office of the Chairman

October 16, 2000

Honorable Don Sundquist
Governor
State of Tennessee
State Capitol
Nashville, Tennessee 37243-0001

Dear Governor Sundquist:

It was a pleasure to talk to you recently about initiatives that can be implemented in Tennessee to enhance the safety of school children and all citizens in the Volunteer State at passive grade crossings. As we discussed, the National Transportation Safety Board has made a number of recommendations over the years to improve both school bus and grade crossing safety. Listed below are four actions Tennessee can take today to better protect its citizens.

Installation of warning devices at passive grade crossings

The Safety Board has recommended that until intelligent transportation systems are available to warn motorists of a train's approach, stop signs should be installed at all grade crossings that do not have active warning devices (i.e., gates and lights.) According to data the Safety Board received from Tennessee, there are 1,749 passive grade crossings in the State, 989 of these crossings are traversed daily by school buses.

Safety Board research indicates that it would cost about $400 for stop signs at each crossing; this is comparable to what you indicated when we spoke that the railroads are charging to install stop signs at the crossings. Therefore, installing stop signs at all passive crossings in Tennessee would cost about $787,050. Installing active warning devices at all of those crossings would cost a little more than $250 million (1,749 x $150,000/crossing).

I would suggest that to prevent another tragedy similar to the one at Conesauga, you might want to consider immediately installing warning devices at the 989 passive crossings traversed daily by school buses.

Criteria for the installation of active warning devices

You may also want to include the number and frequency with which school buses routinely cross passive grade crossings as a factor in determining whether to install stop signs or active warning devices. North Carolina recently amended its hazard safety index to include the number and times that school buses traverse railroad grade crossings. Tennessee should do the same. Thus, if school buses routinely cross the tracks, this would be a factor in determining whether the crossing should be targeted for active warning devices.

2

Strengthen the Tennessee commercial driver's license (CDL) manual and exam to include questions related to passive grade crossings

The Safety Board has also asked the States to include questions on safety at passive grade crossings in every version of the State's written commercial driver license examinations. The Safety Board believes that this will reinforce the actions that commercial drivers, which includes school bus drivers, should take when encountering grade crossings and will help ensure consistent behavior throughout the Nation.

Noise reducing switches

Finally, although the Safety Board does not have a recommendation to require noise reducing switches in all newly purchased school buses, I am aware that Florida and Kentucky are in the process of installing manual "option kill switches" in their school buses so that school bus drivers can turn off fans, radios, etc. when they come to a grade crossing. By using the kill switch, drivers can quickly and easily eliminate noise-producing devices in order to hear the train horn at grade crossings. Tennessee should consider installing these devices as well.

In fiscal year 2000, the Federal Government provided $1,633,692 to Tennessee specifically to be used for active crossing devices, and $1,633,692 specifically to be used to eliminate hazards; a total of $3.26 million specifically for grade crossing safety in Tennessee. Additionally, Tennessee received $8.47 million in funds that may be used optionally for highway hazards. Therefore, funds should be available to implement these suggestions.

I appreciate your commitment to improving the safety of railroad crossings used by school buses as well as your willingness to consider the National Transportation Safety Board's recommendations. I have enclosed a copy of my letter to you dated April 7, 2000, with suggestions on how you could develop a model child transportation safety program in Tennessee. I look forward to discussing all of these suggestions with you when we meet on October 25, 2000.

Sincerely,

Jim Hall
Acting Chairman

Enclosure