# National Transportation Safety Board

Washington, D.C. 20594

## Highway Accident Brief

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| **Accident No.:** | HWY-07-MH-007 |
| **Accident Type:** | School bus bridge override following collision with passenger vehicle |
| **Location:** | Interstate Highway 565 transition exit ramp 19A, Huntsville, Alabama |
| **Date and Time:** | November 20, 2006; 10:10 a.m., central standard time |
| | |
| **Vehicle One:** | 1990 Toyota Celica 2-door |
| **Operator:** | Driver |
| **Occupants:** | 2 |
| **Injuries:** | None |
| | |
| **Vehicle Two:** | 2006 Integrated Conventional Corporation 71-passenger school bus |
| **Operator:** | Laidlaw Transportation Company |
| **Occupants:** | 40 students, 1 driver |
| **Fatalities/Injuries:** | 4 fatalities<br>34 injuries<br>3 (none) |

## Accident Description

On Monday, November 20, 2006, about 10:10 a.m. central standard time, a 2006 Integrated Conventional Corporation (IC)[1] 71-passenger school bus, transporting 40 students from Lee High School to the Huntsville Center for Technology, was traveling westbound in the left lane of an elevated two-lane Interstate Highway 565 (I-565) transition ramp, in Huntsville, Alabama. (See figure 1.) A 1990 Toyota Celica, also traveling from Lee High School to the Huntsville Center for Technology, was in the left lane behind the school bus. According to witnesses, the Toyota moved to the right lane and accelerated in an attempt to pass the school bus. The driver of the Toyota stated that as he came alongside the school bus, his vehicle began "fishtailing" and became impossible to control. The Toyota veered to the left, striking the right front tire of the school bus. The vehicles remained in contact as they swerved to the left, and both vehicles struck a 32-inch-high cement bridge rail on the left side of the ramp.

Physical evidence indicated that the school bus climbed and overrode the bridge rail. The school bus driver, who was not wearing his seat belt, was ejected from the bus onto the roadway. The bus continued along the top of the bridge rail for about 117 feet before rolling and falling

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[1] IC is a fully owned subsidiary of the International Truck and Engine Company.

30 feet to a dirt and grass area beneath the ramp. The school bus landed on its front end, rotated clockwise, and came to rest upright on its wheels. (See figures 2 and 3.) Four students in the school bus were killed. The bus driver was seriously injured, and 33 students received minor-to-serious injuries. Three students were not injured.

After striking the bridge rail, the Toyota continued along the ramp. It curved to the right and came to rest against the north bridge rail. The driver and his passenger were not injured.

At the time of the accident, the roadway was dry, the visibility was 10 miles, the temperature was 39° F, and the wind was blowing from the north at 14 mph.

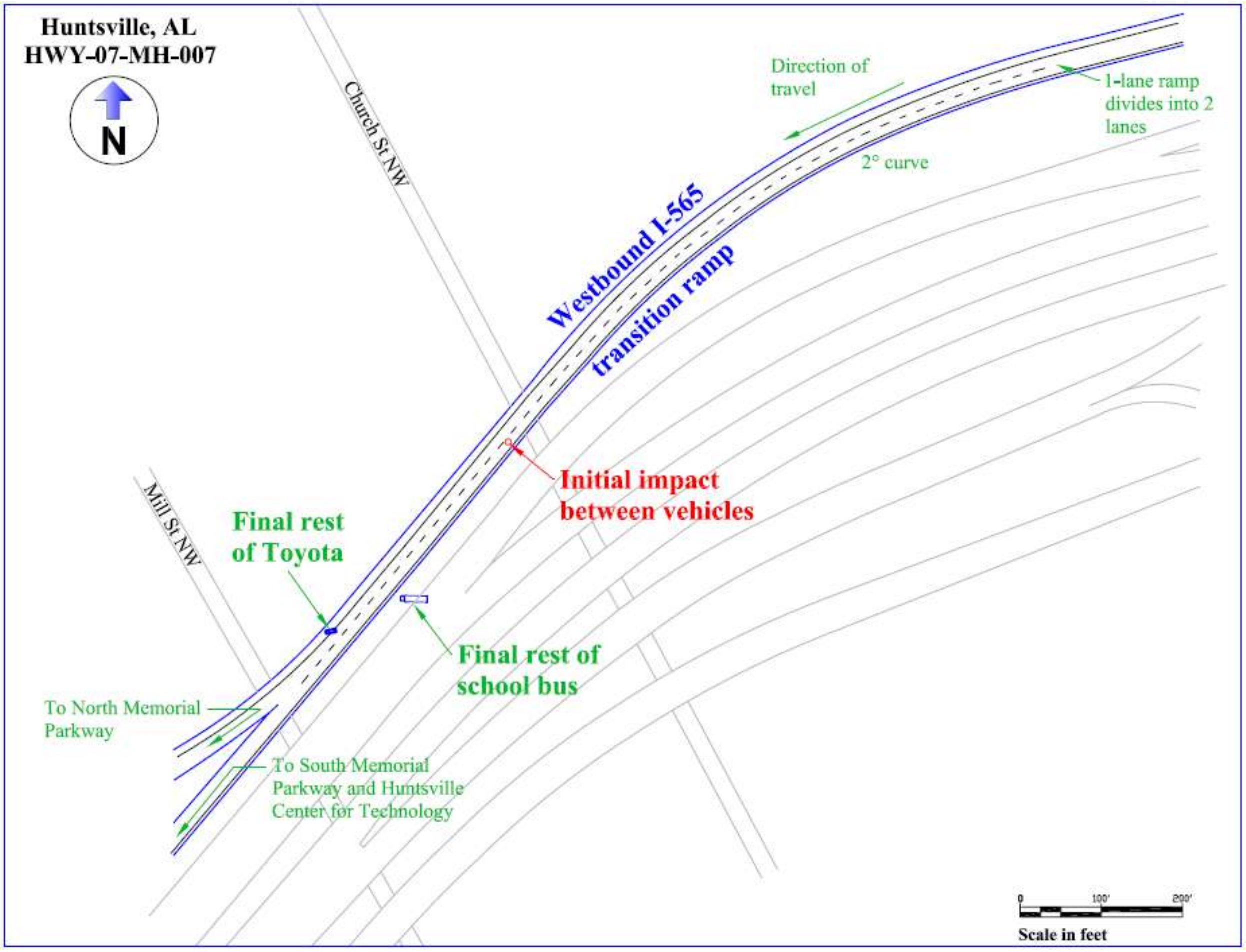

**Figure 1.** Diagram of westbound I-565 transition ramp, showing point of initial impact between the two accident vehicles, as well as their final rest locations.

**Figure 2.** Impact damage caused by school bus, westbound I-565 transition ramp bridge rail.

**Figure 3.** School bus at final rest position.

## Survival Factors

The school bus sustained significant exterior damage to its front end, undercarriage, and roof during its collisions with the Toyota, the bridge rail, and the ground. The damage due to impact with the Toyota extended from the front right corner of the school bus bumper to the right front wheel rim. The damage from the bridge rail ran along the undercarriage and extended almost the entire length of the school bus. The ground impact crushed the front end of the school bus, as well as the front portion of its roof. (See figure 4.) The impact twisted the frame and chassis and caused wrinkled body panels extending to the rear roof area. The twisting of the frame around the rear emergency exit door caused the lower half of the doorframe to be torn away from the body of the bus and caused the top of the rear exit door to bend, allowing the door to spring open. (See figure 5.) The door was bowed inward, and the bottom hinge pin was bowed outward; the top hinge pin was sheared off.

The damage to the interior of the school bus was primarily to the driver seating area and the front loading door. The steering wheel and steering column were crushed downward into the driver seat cushion. The roof crush extended approximately 36 inches into the driver seating area and loading door. The roof also intruded into the first row passenger seating area, though the maximum extent of intrusion could not be determined due to the extensive use of extrication tools and other lifesaving devices within the school bus after the accident.

The driver’s seat was equipped with a three-point lap and shoulder belt. Postaccident inspection of the seat belt revealed that it was in the stored and locked position and showed only evidence of normal wear. The floor and wall anchors for the 12 rows of two-person bench seats on the left side of the school bus remained securely attached. Two seat cushions on the left side were detached from their mountings in seat rows 2 and 11. Of the 12 rows of seats on the right side, all anchors remained secure except for the wall anchors that secured the courtesy panel and the first row seat, which were torn away during postaccident passenger extrication. Numerous seatbacks on both sides were deformed forward because of the effect of passengers being thrown into them from behind.

Based on interviews with first responders and school bus passengers, at least five ejections and one partial ejection occurred during the accident. The driver was ejected onto the pavement via the loading door while the bus was still on the roadway above. All other ejections occurred after the bus left the roadway and fell 30 feet to the ground below.

The loading door was an electropneumatic bifolding door that opened outward. The door was normally opened by pushing a steering-wheel-mounted switch. After the accident, investigators attempted to open the loading door on an exemplar bus by using the steering wheel switch, but the door would not open with the vehicle in motion. In testing done by IC, the loading door required 52 pounds of manual push force to begin opening and over 100 pounds of force to open all the way. Because the loading door also served as an emergency exit, the force needed to push the door open could not be so excessive as to prohibit egress by children. The unbelted school bus driver, who was 6 feet 2 inches tall and weighed approximately 340 pounds, would have exerted sufficient force to open the loading door as he fell into it during the accident sequence.

**Figure 4.** Extent of damage to front of accident school bus, compared with exemplar school bus.

**Figure 5.** Twisted bus frame and open rear emergency exit door resulting from impact with ground.

Table 1 summarizes the injuries resulting from the accident, and figure 6 shows the seating positions, ejection status, and injury severity of the school bus passengers. Three of the four fatalities occurred among the front row passengers, and one fatality occurred among the second row passengers. Had the school bus been equipped with lap/shoulder belts, some serious injuries might have been mitigated among occupants seated away from the area of intrusion, such as the fatally injured passenger in the second row and the seriously injured passengers in the rear of the bus, because the belts would have kept these students within their seating compartments during the accident sequence.[2] However, because it could not be determined whether—at its point of maximum penetration—the school bus roof impinged upon the survivable space of the first row passengers, uncertainty exists as to whether lap/shoulder belts might have prevented the fatalities among the first row passengers.

**Table 1.** Injuries.

| Injury Type[a] | School Bus | Toyota |
|---|---|---|
| Fatal | 4 | 0 |
| Serious | 17 | 0 |
| Minor | 17 | 0 |
| None | 3 | 2 |
| Total | 41 | 2 |

[a] Title 49 CFR 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 an injury that requires hospitalization for more than 48 hours, commencing within 7 days of the date of injury; results in a fracture of any bone (except simple fractures of the fingers, toes, or nose); causes severe hemorrhages, or 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.

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[2] Frontal crash simulations conducted by the National Highway Traffic Safety Administration (NHTSA) using dummies secured to a test sled suggest that, when worn properly, lap/shoulder belts could substantially reduce head and neck injuries, compared to the effects of lap belts or compartmentalization alone. See 49 *Code of Federal Regulations* (CFR) Part 571, *Federal Motor Vehicle Safety Standards*: Seating Systems, Occupant Crash Protection, Seat Belt Assembly Anchorages, School Bus Passenger Seating and Crash Protection, Final Rule. *Federal Register*, vol. 73, no. 204 (October 21, 2008), p. 62744.

HUNTSVILLE, ALABAMA
HWY-07-MH-007

ICAO* INJURY LEGEND

N = None
M = Minor
S = Serious
F = Fatal

F = FEMALE M = MALE # = AGE
*International Civil Aviation Organization

SAMPLE
INJURY LEVEL
AGE
GENDER
F - 14 : Minor

Source: NTSB

Bold **E** Indicates EJECTION

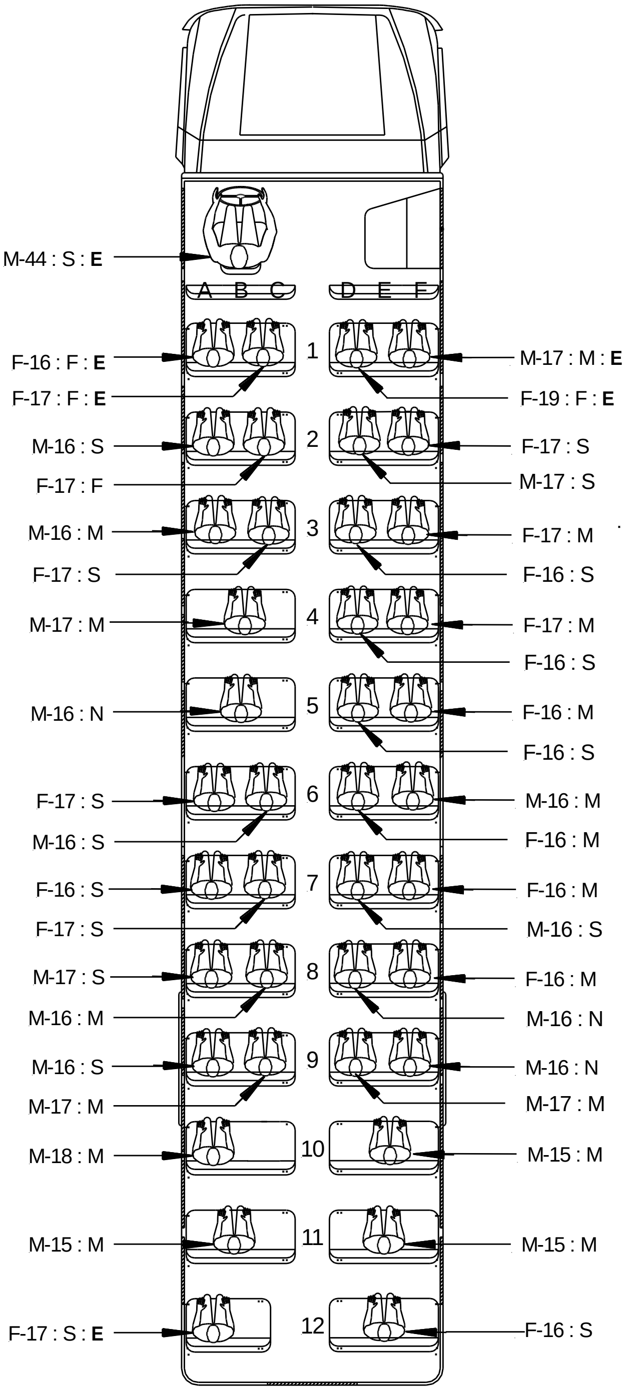

**Figure 6.** Seating chart listing gender, age, and injury severity of each bus occupant. Occupants further identified with an "E" were fully or partially ejected from the bus during the accident sequence.

The school bus experienced several side impacts and rolled over the bridge rail during the accident sequence. Compartmentalization[3] is designed primarily to mitigate injuries during a frontal or rear crash; it does not always offer protection during side impact crashes and rollovers. During these types of crashes, passengers often do not stay within their compartments and come into contact with other passengers, the sidewalls, the windows, the roof, or the edges of adjacent seats—objects that are not designed to absorb impact energy. In its 1999 special investigation report on bus crashworthiness,[4] the NTSB addressed the limitations of compartmentalization and issued Safety Recommendations H-99-45 and -46 to NHTSA:

> 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. (H-99-45)
>
> Once pertinent standards have been developed for school bus occupant protection systems, require newly manufactured school buses to have an occupant crash protection system that meets the newly developed performance standards and retains passengers, including those in child safety restraint systems, within the seating compartment throughout the accident sequence for all accident scenarios. (H-99-46)

In addition, in response to a collision between a CSX freight train and a Murray County, Georgia, school bus at a railroad/highway grade crossing near Conasauga, Tennessee,[5] the NTSB issued the following recommendation to NHTSA:

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

On October 21, 2008, NHTSA published a final rule addressing school bus seating and crash protection.[6] The rule mandates the installation of lap/shoulder belts on small school buses (those weighing less than 10,000 pounds), primarily because of the higher deceleration forces experienced by smaller buses. For large school buses, lap and lap/shoulder belts are optional. NHTSA acknowledged that, on large school buses, students belted with lap/shoulder belts could experience a lower risk of head and neck injury in a severe crash than unbelted students; however, the agency indicated that large school buses are already among the safest forms of transportation.[7] NHTSA pointed out that most school bus-related fatalities occur within the direct zone of intrusion by the impacting vehicle or during the loading and unloading of students, situations in which seat belts have minimal value.

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[3] In school buses, compartmentalization is used to protect passengers from crash impacts. This protection is accomplished by having the seats closely spaced together, with the seat cushions and high seatbacks covered in an energy-absorbing material. The entire seat structure is designed to absorb energy and to deform to dissipate the energy of the crash away from the passenger and into the surrounding compartment.

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

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

[6] Title 49 CFR Part 571.

[7] *Traffic Safety Facts 2005,* DOT HS 810 631 (Washington, DC: U.S. Department of Transportation, 2006).

Based on its research findings, NHTSA did require a 4-inch increase in seatback heights for all new school buses to prevent occupants from overriding the seatbacks. However, because the final rule did not provide a uniform level of safety for all school bus occupants, the NTSB reclassified Safety Recommendation H-99-46 "Closed—Unacceptable Action." Safety Recommendation H-99-45 is currently classified "Open—Acceptable Response," pending further Board review. During discussions with NHTSA, the NTSB learned that the agency is currently testing methods to provide passenger protection for sidewalls, sidewall components, and seat frames. Safety Recommendation H-01-40 remains classified "Open—Acceptable Response."

In August 2007, in response to the Huntsville accident, the Alabama State Department of Education commissioned a study to examine whether installing seat belts on school buses improved passenger safety. The first year of data collection has been completed but results have not yet been publicized; a paper summarizing seat belt usage rates is expected at the Transportation Research Board's annual conference in January 2010.

## Driver Factors

***Toyota.*** The driver of the Toyota was a 17-year-old high school student who had obtained an unrestricted driver's license on August 31, 2005.[8] He told investigators that he was in excellent health and did not wear eyeglasses or contact lenses. He attended school daily and spent the third and fourth periods of the school day at the Huntsville Center for Technology. He also worked part-time at a fast-food restaurant. He described his sleep/wake cycle prior to the accident as normal; and neither he nor his parents were able to provide additional, specific details about his sleep/wake times. The driver had driven the accident vehicle for approximately 2.5 weeks. It was a preowned vehicle that his grandmother had purchased for his use.

Blood and urine specimens were collected from the Toyota driver and forwarded to the Alabama Department of Forensic Sciences for toxicological testing. The results were negative for alcohol and illicit drugs.

***School Bus.*** The 44-year-old school bus driver held a valid Alabama class "B" commercial driver's license (CDL),[9] with a "P" passenger endorsement. His CDL was issued on September 28, 2006, and expired on April 24, 2009. The CDL indicated that the driver was required to wear corrective lenses. He possessed a current medical certificate that was issued on April 4, 2005, and expired on April 4, 2007. The driver's record was free of motor vehicle violations for the 5 years prior to the accident. The driver had been involved in three "not-at-fault" accidents in the previous 5 years. The most recent accident had occurred on January 17, 2006, when a vehicle rear-ended the school bus that he was driving.

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[8] As part of Alabama's three-stage graduated licensing program, the driver held a learner's permit and then a provisional license, prior to obtaining an unrestricted license.

[9] One of three CDL license classifications, a class B license allows holders to drive any single vehicle with a gross vehicle weight rating (GVWR) of 26,001 or more pounds, or any such vehicle towing a vehicle not in excess of 10,000 pounds GVWR.

Blood and urine specimens were collected from the school bus driver and forwarded to the Federal Aviation Administration's Civil Aerospace Medical Institute (CAMI) for toxicological testing. The results were negative for alcohol. However, low levels of tetrahydrocannabinol carboxylic acid (THC-COOH),[10] a pharmacologically inactive metabolite of marijuana, were found in the blood and urine, which indicated only that the driver had used marijuana in the past week. The psychoactive ingredient in marijuana, tetrahydrocannabinol (THC), was not detected. Therefore, the driver was not under the influence of the drug at the time of the accident.

## Vehicle Factors

***Toyota.*** Investigators examined the Toyota at the Huntsville Police Department's evidence bay on November 24–25, 2006, to determine whether a mechanical problem might have caused the driver to lose control. The vehicle's brakes and steering mechanisms showed no preaccident wear or damage that might have triggered a loss of control. Investigators found several instances of poor maintenance, including mismatched front and rear tires, a loose right-front lower control arm ball joint, a leaking left-front shock absorber, and shock absorber components that were missing or incorrectly installed. However, after conducting inspections and field tests of the vehicle, party representatives and NTSB investigators concluded that it was unlikely that these defects caused or contributed to the loss of control. A nail was also found embedded in the right rear tire, causing a slow air leak. Investigators were unable to determine whether the nail penetrated the tire before or during the accident sequence.

***School Bus.*** The 2006 school bus had been driven less than 22,000 miles. The vehicle was equipped with air brakes and antilock braking at all wheel positions. The brakes were standard drum-type foundation brakes. The front brakes had type 20 long stroke (20LS) air chambers, and the rear brakes were standard type 30/30 air chambers with spring brakes for parking and emergency use. The brakes were equipped with automatic slack adjusters on all four wheels. The pushrod stroke lengths were all within Commercial Vehicle Safety Alliance (CVSA) specifications. The brake shoes were unremarkable. An inspection of the tires revealed that all tread depths were within CVSA specifications, and no preaccident defects were identified.

The Huntsville school bus was equipped with an electronic control module[11] that did not have the capability to record preimpact events (such as vehicle speed, braking, steering, and engine rpm). In 1999, the NTSB held a symposium on transportation recorders.[12] Later that year,

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[10] CAMI detected a concentration of 0.0165 µg/mL THC-COOH in the urine and an unspecified concentration (>0.001 µg/mL) in the blood. THC-COOH has a half-life of 6 days and is readily detected in the urine even after the intoxicating effects of marijuana have dissipated. See J. E. Manno and others, *Journal of Analytical Toxicology*, vol. 25, no. 7 (October 2001), pp. 538–549.

[11] An electronic control module is a semiconductor unit for controlling ignition timing, fuel delivery, speed, and other engine management system parameters. It is capable of logging data associated with critical diagnostic events. This feature, however, is not intended to capture crash data but rather to assist technicians in troubleshooting system fault conditions.

[12] *Proceedings: International Symposium on Transportation Recorders, May 3-5, 1999*, Report of Proceedings NTSB/RP-99/01 (Washington, DC: National Transportation Safety Board, 1999).

as a result of its special investigation on bus crashworthiness,[13] the NTSB made the following recommendations to NHTSA concerning event data recorders (EDR):

> Require that all school buses and motorcoaches manufactured after January 1, 2003, be equipped with on-board recording systems that record vehicle parameters, including, at a minimum, lateral acceleration, longitudinal acceleration, vertical acceleration, heading, vehicle speed, engine speed, driver's seat belt status, braking input, steering input, gear selection, turn signal status (left/right), brake light status (on/off), head/tail light status (on/off), passenger door status (open/closed), emergency door status (open/closed), hazard light status (on/off), brake system status (normal/warning), and flashing red light status (on/off) (school buses only). For those buses so equipped, the following should also be recorded: status of additional seat belts, airbag deployment criteria, airbag deployment time, and airbag deployment energy. The on-board recording system should record data at a sampling rate that is sufficient to define vehicle dynamics and should be capable of preserving data in the event of a vehicle crash or an electrical power loss. In addition, the on-board recording system should be mounted to the bus body, not the chassis, to ensure that the data necessary for defining bus body motion are recorded. (H-99-53)
>
> Develop and implement, in cooperation with other Government agencies and industry, standards for on-board recording of bus crash data that address, at a minimum, parameters to be recorded, data sampling rates, duration of recording, interface configurations, data storage format, incorporation of fleet management tools, fluid immersion survivability, impact shock survivability, crush and penetration survivability, fire survivability, independent power supply, and ability to accommodate future requirements and technological advances. (H-99-54)

NHTSA has yet to implement a requirement for the use of EDRs on school buses and motorcoaches. On September 1, 2009, the NTSB reiterated Safety Recommendations H-99-53 and -54 in its special investigation report on pedal misapplication in heavy vehicles[14] and reclassified them "Open—Unacceptable Response." Had the Huntsville school bus been equipped with an EDR, its preaccident speed would have been recorded. Data from the initial collision would have yielded information on the Toyota's speed, and EDR data would also have indicated whether the bus driver made any steering or braking inputs before hitting the bridge rail. Valuable information regarding the interaction of the bus with the bridge barrier and the vehicle's subsequent impact with the ground would also have been available to state and Federal investigators.

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[13] NTSB/SIR-99/04.

[14] *Pedal Misapplication in Heavy Vehicles*, Special Investigation Report NTSB/SIR-09/02 (Washington, DC: National Transportation Safety Board, 2009).

## Highway Design

The accident occurred on an elevated multifunction ramp that runs parallel to an elevated portion of I-565. The ramp provides exits to Pratt Avenue Northwest and Memorial Parkway North and South, as well as access to westbound I-565. The ramp originates as a single-lane roadway, which divides into two lanes after 1,375 feet. The lanes follow a 694-foot-long, 2-degree left horizontal curve before straightening and diverging, with the right lane exiting to Memorial Parkway North and the left lane exiting to Memorial Parkway South. The initial impact occurred approximately 430 feet before the split.

Memorial Parkway South leads to the Huntsville Center for Technology, and several witnesses to the accident speculated that the Toyota driver was attempting to pass the school bus and reenter the left lane before the split. The Toyota driver stated that he entered the right lane because he thought he needed to be in that lane, though he actually needed to be in the left lane to exit to the Huntsville Center for Technology, where he attended classes every day. The Toyota driver stated that he was traveling 45–50 mph prior to the accident. A witness behind both accident vehicles estimated their speeds to be about 55 mph. The ramp had a speed limit of 65 mph, but the curve was posted with an advisory speed limit of 40 mph.

The ramp cross section near the scene of the accident consisted of a 10-foot-wide right shoulder, two 12-foot-wide lanes, and a 4-foot-wide left shoulder. Adjacent and integral to the roadway were 32-inch-high New Jersey-shape concrete bridge rails, designed to National Cooperative Highway Research Program (NCHRP) Report 350[15] Test Level 4[16] (TL-4) standards. This type of New Jersey-shape concrete bridge rail has been shown in tests to successfully redirect an 18,000-pound single-unit truck, impacting at a 15.5-degree angle, at a speed of 51.6 mph.[17]

There are some similarities between the impact of the school bus with the bridge rail and the NCHRP TL-4 parameters: the bus had a gross empty weight of 17,700 pounds, it was traveling no more than 55 mph, and it struck the bridge rail at a 9- to 10-degree angle. However, NCHRP test vehicles are provided with unrestricted trajectory before and after impact with a barrier. By contrast, the trajectory of the Huntsville school bus away from the bridge rail was restricted by the presence of the Toyota, which resulted in the school bus mounting and rolling over the bridge rail.

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[15] *Recommended Procedures for the Safety Performance Evaluation of Highway Features*, NCHRP Report 350 (Washington, DC: Transportation Research Board, 1993). This research was sponsored by the American Association of State Highway and Transportation Officials and the Federal Highway Administration.

[16] To meet the standards, TL-1, TL-2, and TL-3 barriers must be tested to show that they can successfully redirect an 1,800-pound car impacting the barrier at an angle of 20 degrees and a 4,400-pound pickup truck impacting the barrier at an angle of 25 degrees, at speeds of 30, 45, and 60 mph, respectively. To meet the standards, TL-4 barriers must successfully redirect a 17,600-pound single-unit truck at an impact angle of 15 degrees and a speed of 50 mph. TL-5 barriers substitute an 80,000-pound van tractor-trailer for the single-unit truck, and TL-6 barriers substitute an 80,000-pound tanker tractor-trailer.

[17] See ~~http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/barriers/bridgerailings/index.cfm~~> for a list of bridge railings that have been crash-tested; accessed November 4, 2009.

## Probable Cause

The National Transportation Safety Board determines that the probable cause of the November 20, 2006, accident in Huntsville, Alabama, was a vehicle loss of control during a passing maneuver around a curve by the Toyota driver attempting to overtake the school bus prior to an impending exit both drivers intended to take. Contributing to the severity of the accident was the restricted trajectory of the school bus away from the bridge rail due to the presence of the Toyota, which resulted in the bus overriding the rail and falling 30 feet from the elevated highway access ramp to the ground.

**Approved:** November 19, 2009

# ERRATA

**THE CORRECTIONS BELOW ARE *INCLUDED***
**IN THIS REVISED VERSION OF THE DOCUMENT**

HIGHWAY ACCIDENT BRIEF
NTSB/HAB-09/02

## SCHOOL BUS BRIDGE OVERRIDE FOLLOWING COLLISION WITH PASSENGER VEHICLE, INTERSTATE HIGHWAY 565 TRANSITION EXIT RAMP 19A, HUNTSVILLE, ALABAMA, NOVEMBER 20, 2006

On page 7, figure 6, seating chart, the following corrections are made: (1) the age of the student passenger in row 7, right side, window seat, is corrected to “16,” and the injury code is corrected to “M” for “minor”; and (2) the injury code for the student passenger in row 7, right side, aisle seat, is corrected to “S” for “serious.”

[For the passenger in the window seat, the document originally reported the incorrect age of “08” and the incorrect code of “S” for “serious”; for the passenger in the aisle seat, the document originally reported the incorrect code of “M” for “minor.”]