Motorcoach Override of Elevated Exit Ramp
Interstate 75
Atlanta, Georgia
March 2, 2007

ACCIDENT REPORT

NTSB/HAR-08/01
PB2008-916201

National Transportation Safety Board

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Notation 8021A
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Highway Accident Report

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

National Transportation Safety Board. 2008. ***Motorcoach Override of Elevated Exit Ramp, Interstate 75, Atlanta, Georgia, March 2, 2007.*** **Highway Accident Report NTSB/HAR-08/01. Washington, DC.**

Abstract: About 5:38 a.m. eastern standard time on Friday, March 2, 2007, a 2000 VanHool T2145 57-passenger motorcoach operated by Executive Coach Luxury Travel, Inc., transporting 33 members of the Bluffton University baseball team, the driver, and his wife, was traveling south on Interstate 75 in Atlanta, Georgia. According to witnesses, the motorcoach was in the southbound high occupancy vehicle (HOV) lane at milepost 250 when it departed the interstate, traveling at highway speed, onto the HOV-only left exit ramp to Northside Drive. The exit ramp came to an end at the stop sign-controlled T-intersection with Northside Drive. As the motorcoach entered the intersection at an estimated speed of 50 to 60 mph, the driver steered to the right and collided with the reinforced portland cement concrete bridge wall and chain-link security fence located along the southern edge of the eastbound lanes of the overpass. The motorcoach then overrode the bridge rail, rotated clockwise, and fell 19 feet onto the southbound lanes of the interstate. The motorcoach came to rest on its left side (driver's side), perpendicular to the southbound lanes of Interstate 75. Two southbound passenger vehicles received minor damage from debris as the motorcoach fell onto Interstate 75; none of the passenger vehicle occupants were injured. Seven motorcoach occupants were killed: the driver, the driver's wife, and five passengers. Seven other passengers received serious injuries, and 21 passengers received minor injuries.

Major safety issues identified in this accident include inadequate HOV traffic control devices, inadequate motor carrier driver oversight, lack of event data recorders on motorcoaches, and lack of motorcoach occupant protection. As a result of its investigation, the Safety Board makes recommendations to the Federal Highway Administration and to the Georgia Department of Transportation. The Safety Board also reiterates four previous recommendations to the National Highway Traffic Safety Administration.

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Contents

Acronyms and Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
CAMI	Civil Aerospace Medical Institute
CDL	commercial driver's license
CFR	*Code of Federal Regulations*
CSA 2010	Comprehensive Safety Analysis 2010
CVSA	Commercial Vehicle Safety Alliance
ECE	Economic Commission for Europe
EDR	event data recorder
EU	European Union
Executive Coach	Executive Coach Luxury Travel, Inc.
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FMVSS	Federal Motor Vehicle Safety Standard
GAO	Government Accountability Office
GDOT	Georgia Department of Transportation
HOV	high occupancy vehicle
I-75	Interstate 75
I-85	Interstate 85
IEEE	Institute of Electrical and Electronics Engineers, Inc.
MCMIS	Motor Carrier Management Information System
MUTCD	*Manual on Uniform Traffic Control Devices*
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NPA	notice of proposed amendments
SAE	SAE International
SAFER	Safety and Fitness Electronic Records
TRB	Transportation Research Board

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Executive Summary

About 5:38 a.m. eastern standard time on Friday, March 2, 2007, a 2000 VanHool T2145 57-passenger motorcoach operated by Executive Coach Luxury Travel, Inc., transporting 33 members of the Bluffton University baseball team, the driver, and his wife, was traveling south on Interstate 75 in Atlanta, Georgia. The motorcoach had departed from the university, about 60 miles southwest of Toledo, Ohio, about 7:00 p.m. the previous day and was en route to a competition in Sarasota, Florida. When the original driver had stopped in Adairsville, Georgia, approximately halfway through the 18-hour trip, the 65-year-old relief driver, accompanied by his wife, boarded the motorcoach and began driving at 4:30 a.m. to complete the trip to Florida. The relief driver had driven approximately 54 miles and, according to witnesses, was in the southbound high occupancy vehicle (HOV) lane at milepost 250 when the motorcoach departed the interstate, traveling at highway speed, onto the HOV-only left exit ramp to Northside Drive.

The exit ramp came to an end at the stop sign-controlled T-intersection with Northside Drive. As the motorcoach entered the intersection at an estimated speed of 50 to 60 mph, the driver steered to the right and collided with the reinforced portland cement concrete bridge wall and chain-link security fence located along the southern edge of the eastbound lanes of the overpass. The motorcoach then overrode the bridge rail, rotated clockwise, and fell 19 feet onto the southbound lanes of the interstate. The motorcoach came to rest on its left side (driver's side), perpendicular to the southbound lanes of Interstate 75. Two southbound passenger vehicles received minor damage from debris as the motorcoach fell onto Interstate 75; none of the passenger vehicle occupants were injured. Seven motorcoach occupants were killed: the driver, the driver's wife, and five passengers. Seven other passengers received serious injuries, and 21 passengers received minor injuries.

The National Transportation Safety Board determines that the probable cause of this accident was the motorcoach driver's mistaking the HOV-only left exit ramp to Northside Drive for the southbound Interstate 75 HOV through lane. Contributing to the accident driver's route mistake was the failure of the Georgia Department of Transportation to install adequate traffic control devices to identify the separation and divergence of the Northside Drive HOV-only left exit ramp from the southbound Interstate 75 HOV through lane. Contributing to the severity of the accident was the motorcoach's lack of an adequate occupant protection system.

Major safety issues identified in this accident include inadequate HOV traffic control devices, inadequate motor carrier driver oversight, lack of event

data recorders on motorcoaches, and lack of motorcoach occupant protection. As a result of its investigation, the Safety Board makes recommendations to the Federal Highway Administration and to the Georgia Department of Transportation. The Safety Board also reiterates four recommendations to the National Highway Traffic Safety Administration.

Factual Information

Accident Narrative

About 5:38 a.m. eastern standard time on Friday, March 2, 2007, a 2000 VanHool T2145 57-passenger motorcoach operated by Executive Coach Luxury Travel, Inc. (Executive Coach), transporting 33 members of the Bluffton University baseball team, the driver, and his wife, was traveling south on Interstate 75 (I-75) in Atlanta, Georgia. The motorcoach had departed from the university, near Toledo, Ohio, about 7:00 p.m. the previous day and was en route to a competition in Sarasota, Florida. When the original driver had stopped in Adairsville, Georgia, approximately halfway through the 18-hour trip, the 65-year-old relief driver, accompanied by his wife, boarded the motorcoach and began driving at 4:30 a.m. to complete the trip to Florida. The relief driver had driven approximately 54 miles and, according to witnesses, was in the southbound high occupancy vehicle (HOV) lane at milepost 250 when the motorcoach departed the interstate, traveling at highway speed, onto the HOV-only left exit ramp to Northside Drive. (See figures 1 and 2.)

The exit ramp came to an end at the stop sign-controlled T-intersection with Northside Drive. As the motorcoach entered the intersection at an estimated speed of 50 to 60 mph, the driver steered to the right and then collided with the reinforced portland cement concrete bridge wall and chain-link security fence located along the southern edge of the eastbound lanes of the overpass. The vehicle overrode the bridge rail, rotated clockwise, and fell 19 feet onto the southbound lanes of the interstate. The motorcoach came to rest on its left side (driver's side), perpendicular to the southbound lanes of I-75. Two southbound passenger vehicles received minor damage from debris as the motorcoach fell onto I-75; none of the passenger vehicle occupants were injured. Seven motorcoach occupants were killed: the driver, the driver's wife, and five passengers. Seven other motorcoach passengers received serious injuries, and 21 passengers received minor injuries.

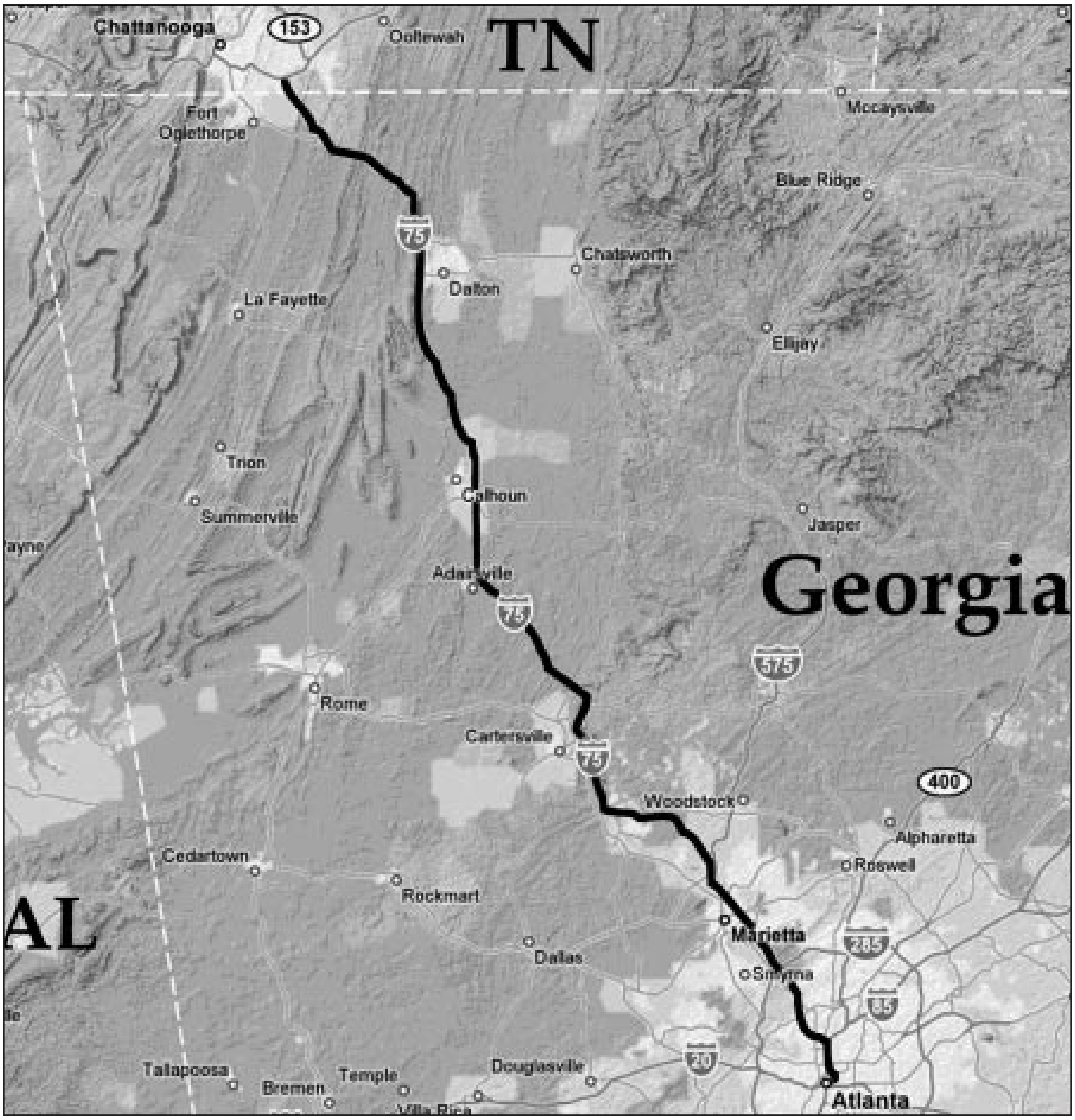

Figure 1. Regional view of motorcoach route.

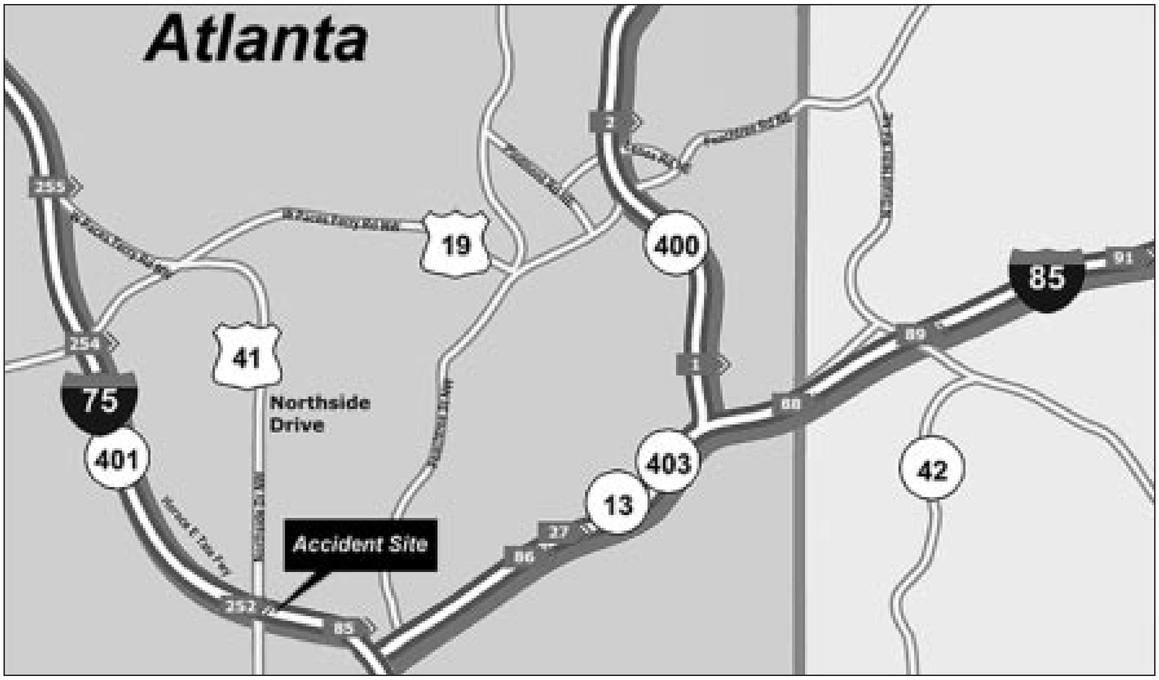

Figure 2. Local route of accident motorcoach through Atlanta.

Once inside the Atlanta beltway (Interstate 285), the driver used the HOV lane,[1] which was to the left of the four southbound traffic lanes and separated from them by a double white line. Figure 3 shows the motorcoach's travel route as it approached the Northside Drive exit (lower-right corner). The HOV-only left exit at Northside Drive is the first left exit encountered in the Atlanta area on southbound I-75, and it precedes the next left exit, the interstate merge, by 1 mile. The motorcoach's intended route of travel just past the accident location would have followed I-75 as it merged with Interstate 85 (I-85) through downtown Atlanta.

[1] HOV lanes are one of several types of managed lanes, often called preferential lanes, that restrict access based on vehicle class, limited access locations, number of vehicle occupants, or price (toll lanes). The I-75 HOV route used by the accident motorcoach was restricted to buses and two-person carpools.

Figure 3. Path of the motorcoach as it approached the Northside Drive exit.

Figure 4 shows the sequence of collisions in this accident. The motorcoach traveled up the 1,120-foot HOV-only left exit ramp at Northside Drive, through the elevated T-intersection, and collided with the reinforced portland cement concrete bridge wall and security fence located along the southern edge of the eastbound lanes of the overpass. While crossing the intersection at an estimated speed of 50 to 60 mph, the driver steered to the right. The left-front corner of the motorcoach impacted the concrete bridge wall, and four passengers were ejected onto Northside Drive. The motorcoach overrode the bridge wall, rotated clockwise (270 degrees), and fell onto the interstate below, ejecting six passengers and partially ejecting two additional passengers onto I-75.

Figure 4. Photo illustration of the motorcoach accident sequence.

The motorcoach came to rest on the driver's side in a 90-degree rollover orientation, pointing east, and blocking the southbound lanes of I-75, as shown in figure 5. Two southbound passenger vehicles, a 2005 Chevrolet Equinox and a 2003 Ford F150 pickup truck, received minor damage after being hit by debris from the motorcoach as it fell from the overpass onto I-75; no passenger vehicle occupants were injured.

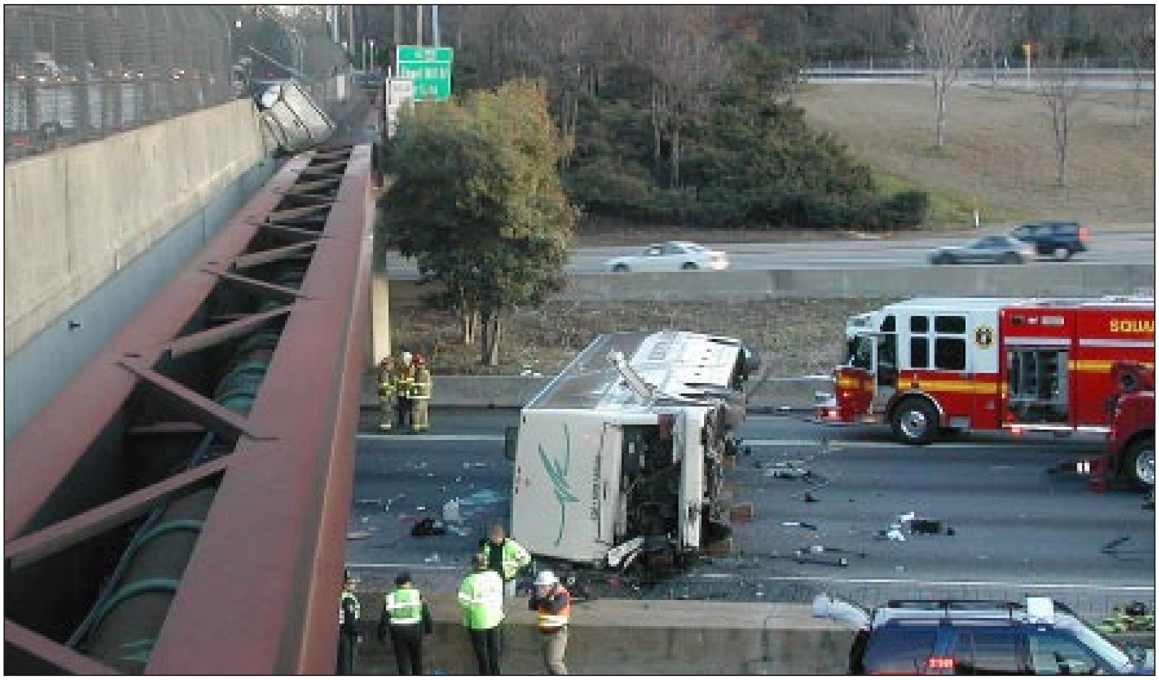

Figure 5. Accident scene with Northside Drive in the upper-left corner and the motorcoach at rest on I-75.

Injuries

The accident motorcoach had 35 occupants: the driver, his wife, 28 university students, and 5 university personnel. The motorcoach driver, his wife, and five passengers seated at the front of the motorcoach sustained fatal injuries. (See table 1.)

Table 1. Injuries.

Injury type	Motorcoach driver	Motorcoach passengers	Others	Total
Fatal	1	6	0	7
Serious	0	7	0	7
Minor	0	21	0	21
None	0	0	0	0
Total	1	34	0	35

Title 49 *Code of Federal Regulations* (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 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, 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.

The driver's wife was seated in the jump seat[2] to the right of the driver's seat; both the driver and his wife were wearing two-point lap belt restraints. The five fatally injured passengers were in seats 3B, 4C, 6A, 6D, and 7B (see figure 6 on the next page) and were not restrained. Of the 33 passengers (not counting the driver and his wife), 11 were asleep on the center aisle floor or on the floor between seats.

Twelve occupants were ejected from the motorcoach. Eleven of those passengers were seated in seats 1C, 2B, 2C, 3B, 3C, 4C, 6A, 6D, 7B, 7D, and 9A; the twelfth passenger was lying in the aisle between rows 3 and 4. Four passengers seated in the front of the motorcoach (seats 1C, 2B, 2C, and 3C) were ejected through the windshield[3] or the left-front side windows onto Northside Drive before the motorcoach departed that roadway and fell onto I-75, landing on the driver's side. Six passengers were ejected from left-side windows as the motorcoach impacted I-75. Two passengers were partially ejected and trapped between the motorcoach and the I-75 roadway (seats 7D and 9A).

The general nature of the injuries sustained by the motorcoach occupants was blunt force trauma. With the exception of the driver and his wife, the fatally injured passengers were propelled from their seats, causing them to sustain severe head, upper torso, and internal trauma. The driver and his wife, who were lap-belted, sustained fatal blunt force trauma injuries.

Once the motorcoach came to rest, 25 occupants remained within or partially within the motorcoach. Of these occupants, 12 passengers exited the motorcoach through the windshield opening, 6 passengers used the emergency roof hatch adjacent to row 11, and 3 passengers were assisted by first responders. The four remaining occupants—the motorcoach driver, his wife, and the two partially ejected passengers (seats 7D and 9A)—were extricated by Atlanta firefighters.

[2] The jump seat is also referred to as the tour operator's seat, but there was no tour operator on this trip.

[3] In a postaccident interview, the passenger seated in seat 2B said that he was ejected through the windshield opening. No evidence exists to determine whether the three other passengers ejected onto Northside Drive went through the windshield or through the left-front side windows.

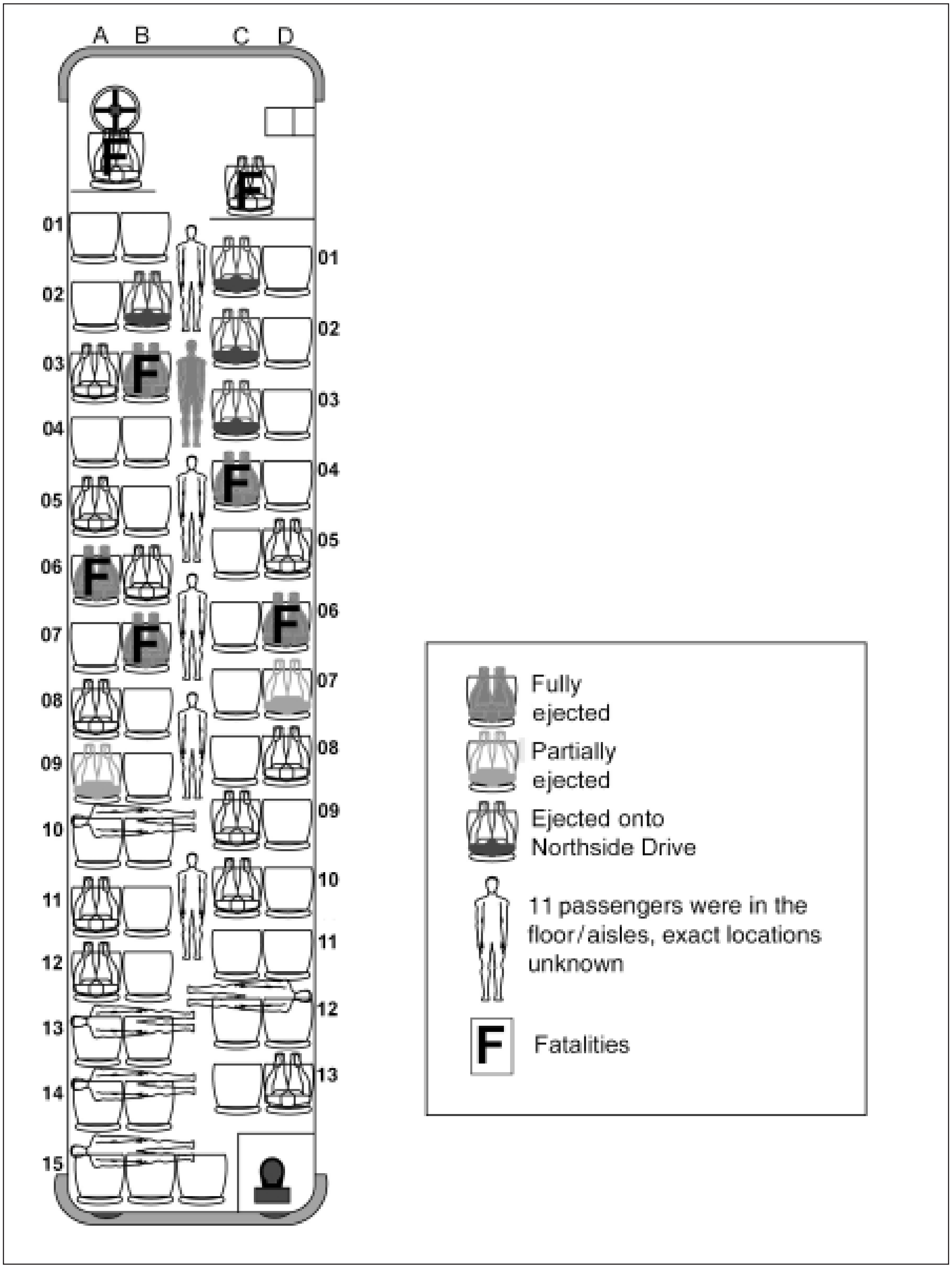

Figure 6. Seating diagram.

Emergency Response

At 5:38 a.m., city of Atlanta Communication Center dispatchers were notified of the accident through 9-1-1 and initiated emergency response by local public safety agencies. Emergency response was provided by the Atlanta–Fulton County Emergency Management Agency, the Atlanta Police Department Incident Command Center, and the Atlanta Fire Department. First responders arrived at 5:43 a.m., 5 minutes after the accident occurred, followed by emergency medical service support from Grady Health Care Systems, Piedmont Hospital, and the Atlanta Medical Center.

The Grady Health Care Level 1 Trauma Center received 19 injured persons, Piedmont Hospital received 3 persons, and the Atlanta Medical Center received 7 persons. These medical facilities were located within 5 miles of the accident site. The driver and five fatally injured passengers (including the driver's wife) were taken to the Fulton County Medical Examiner's Office. Another injured passenger died while at the Grady Health Care Trauma Center and was subsequently transported to the Medical Examiner's Office.

Driver Information

Experience and Work History

The 65-year-old motorcoach driver possessed an Ohio Class B commercial driver's license (CDL) with both passenger and school bus endorsements that was issued on November 30, 2004, to expire December 6, 2008. The driver's medical certification, as required by 49 CFR 391.45, was issued on March 1, 2005, and had expired at midnight on March 1, 2007. At the time of the accident, the driver had not been medically certified within 24 months, as required by 49 CFR 391.45 (a).

The driver had 6 years of experience driving motorcoaches for Executive Coach part-time beginning in March 2001. He did not hold another job at the time of the accident. The driver had worked as a substitute school bus driver in Ohio for 4 1/2 years between September 2000 and February 2005. The school district provided an "excellent" preemployment reference to the motor carrier in March 2001. The driver had no traffic violations in the prior 6-year period of motorcoach driving. He had been involved in an injury accident while operating an Executive Coach motorcoach on January 19, 2002, for which he was found not at fault. The accident occurred when the driver of a van turned left into the path of the motorcoach.

The driver had driven the same charter trip as the accident trip between Ohio and Florida on two previous occasions, in 2005 and 2006, both times transporting the Bluffton University athletes to a baseball tournament in Sarasota. According to interviews with the motor carrier, Executive Coach planned the trip itinerary with the customer and each driver planned the route of travel, often using maps, Web-based sites, or travel club services.

Work/Rest Schedule

The motorcoach driver's log indicated that he had been off duty for the 12 days preceding the accident. On March 1, 2007, the day before the accident, the driver left Executive Coach's business location in Ottawa, Ohio, driving a 15-passenger company van to pre-position himself as the relief driver for the next day's trip. He and his wife departed at 9:00 a.m., traveled approximately 550 miles and, according to hotel records, arrived in Adairsville, Georgia, at 7:37 p.m. on March 1. The motorcoach driver's logbook recorded an entry of "off duty" for the approximately 9 hours of driving time that day. The driver began the March 2 trip at 4:30 a.m. Table 2 shows the driver's known activities 72 hours before the accident. Figure 7 shows the driver's rest schedule.

Table 2. Driver's preaccident activities.

Wednesday, February 28	Driver's logs indicated he had been off duty for the 12-day period from February 17 through 28.
Thursday, March 1	Depart Ottawa, Ohio, at 9:00 a.m. in a company van.
	Refuel van in Mt. Vernon, Kentucky, at 2:08 p.m. and again in Dalton, Georgia, at 6:18 p.m.
	Check into hotel in Adairsville, Georgia, at 7:37 p.m.
Friday, March 2	Depart Adairsville, Georgia, about 4:30 a.m. Refuel motorcoach at 4:40 a.m.
	Accident occurred at 5:38 a.m.

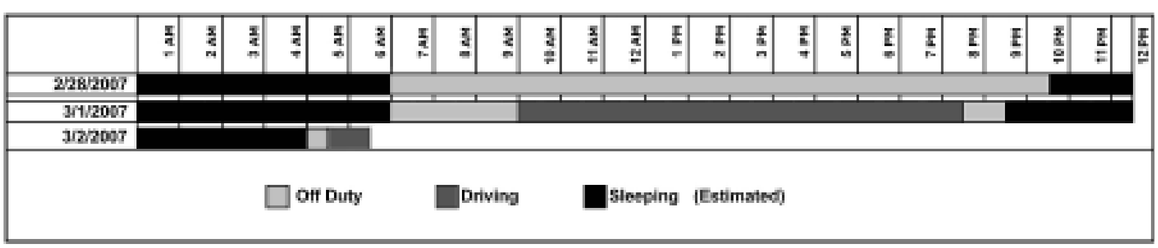

Figure 7. Driver's work/rest schedule.

At the time of the accident, the driver was assigned a company cellular telephone owned by the motor carrier. The motorcoach also had a citizens band radio. The telephone was not recovered, but a passenger seated near the front reported that the driver was not using a telephone or the citizens band radio at the time of the accident. Based on cellular telephone records, Safety Board investigators confirmed that the company telephone had not been used for several days before the accident.

Medical and Pathological Information

The driver had a CDL medical certificate, issued on March 1, 2005,[4] which was valid for 2 years; it expired the day before the accident. This certificate, *Medical Examination Report for Commercial Driver Fitness,* was signed by a chiropractor, and the two previous medical examination reports were signed by two different physicians.

According to the March 1, 2005, medical examination report, the driver was 6 feet tall and weighed 225 pounds. His uncorrected vision was noted as 20/40, corrected to 20/13, requiring the use of corrective lenses. The medical examination report further stated that the driver was taking three medications (amlodipine, benazepril, and atenolol) to control high blood pressure; his blood pressure was reported as 146/82. The driver was also noted to be taking sertraline for the treatment of "nervousness." Previous medical examination reports stated that the sertraline was being used for "depression" (March 9, 2003) and that the driver had also reported "loud snoring" (April 9, 2001). According to the driver's medical records, he had been seen in October 2006 by a physical medicine and rehabilitation specialist, who noted that the driver complained of low back pain but indicated that the pain was not aggravated by driving. The specialist prescribed clonazepam, a drug sometimes used to treat anxiety.

On February 20, 2007, 10 days before his CDL medical certificate was due to expire, the driver had a preventative physical examination for Medicare with his primary care physician but did not get a CDL physical examination. The driver's medications at that time included: sertraline, 100 mg; amlodipine, 5 mg; benazepril, 20 mg; atenolol, 50 mg; clonazepam, 0.5 mg (at bedtime); and hydrocodone, 5 mg (at bedtime as needed). His depression was noted to be controlled on sertraline. According to the driver's 2007 physical examination, he was 73 inches tall,[5] weighed 224 pounds, and had a blood pressure of 140/82.

An autopsy performed by the Fulton County Medical Examiner noted evidence of hypertensive cardiovascular disease, cardiomegaly (enlarged heart), and hepatomegaly (enlarged liver). The medical examiner determined the cause of death to be blunt force trauma of torso. Results from toxicology testing performed

[4] The most recent known past medical examination report dates were April 9, 2001; March 9, 2003; and March 1, 2005.

[5] This height differs from the driver's 2005 exam record of 6 feet, or 72 inches.

by the Federal Aviation Administration's Civil Aerospace Medical Institute (CAMI) laboratory identified only atenolol, sertraline (0.378 microgram/mL in blood), and ibuprofen in the driver's blood and urine.

Vehicle Information

The 2000 VanHool model T2145 57-passenger motorcoach measured 45 feet 5 inches long, 8 feet 6 inches wide, and 11 feet 10 1/2 inches tall. The wheelbase measured 23 feet 6 1/4 inches. Due to the condition of the motorcoach and the discharge of cargo during the accident, the total preaccident weight was estimated by calculation to be 43,826 pounds. According to the engine control module, the vehicle had traveled a total of 364,462 miles.

The accident motorcoach received an Ohio Public Utilities Commission Commercial Vehicle Safety Alliance (CVSA) "vehicle only" safety inspection on February 23, 2007, and no defects were noted. Maintenance documents dating from the time that the motorcoach was delivered new to Executive Coach on August 2, 2000, were reviewed, and no major repairs or recurring problems were documented.

The motorcoach was equipped with a six-wheel pneumatic disc braking system. In postaccident testing, the brake chambers activated the calipers on all brakes, with the exception of the left-front brake, which had a damaged brake chamber due to impact. Brake rotors were measured; the thickness for each of the six rotors was within minimum guidelines. The tires displayed no evidence of preaccident abnormalities. The motorcoach was also equipped with a Meritor/Wabco antilock braking system that included automatic traction control. According to VanHool documents, the minimum turning angle of the accident motorcoach was 51 degrees.

A Williams Controls, Inc., electronic accelerator pedal was found detached from its floor mounting in the driver's foot well area. The electrical connector remained attached to the pedal, and postaccident testing showed it to perform within specified ranges. The adjacent brake pedal was found in a full downward position, with the forward wall of the foot well pressed against it. Three tire marks, found on the roadway at the top of the exit ramp, were from the left-front tire, a left-rear tire, and a right-side tire as the motorcoach made a sharp turn to the right. There were no skid marks before impact.

The accident motorcoach had cruise control. The dual switch system was found with the on/off switch in the "on" position, indicating that the system was available to the driver, but investigators could not determine whether the cruise control was active at the time of the accident. Only one headlamp bulb remained intact, and Safety Board metallurgical testing was inconclusive as to whether the high beams were illuminated at the time of the accident.

The accident motorcoach was not equipped with a dedicated crash or event data recorder (EDR), though it was equipped with an electronically controlled Cummings diesel engine having a module capable of providing configuration and diagnostic information. The motorcoach was also equipped with an Intec backup camera system that did not have the capability to record video, images, or data. It also had a Scenic View forward-facing video camera that was mounted along the top of the windshield and connected to several video monitors. Postaccident examination determined that the forward-facing camera was part of a closed-circuit video system with no recording capabilities.

The motorcoach had a vertically divided lower windshield made of tinted safety glass that was laminated with an ultraviolet-ray blocking film and set in rubber. The upper windshield was laminated with ultraviolet-ray blocking bronze safety glass that was set in rubber. All side windows were made of tempered bronze safety glass;[6] each side had five emergency push-out windows hinged at the top with two red emergency handles at the bottom. There were two emergency escape roof hatches.[7]

Only the driver's seat, the jump seat, and the first row of the passenger seats were equipped with two-point lap belts; the other 53 seats were not equipped with seat belts. Further, the motorcoach was not equipped with airbags. Physical evidence showed that the driver and jump seat passenger were wearing their lap belts, but no evidence could be found showing that the available lap belts in the first row of passenger seats had been used. In the United States, motorcoaches are required to have an occupant protection system only for the driver, not for the passengers.[8]

Vehicle Damage

The motorcoach sustained the majority of damage to the left-front corner (driver's side), left side, and left-rear corner (see figures 8 and 9), and there was interior deformation in the area of the driver's station and front boarding door. The structural frame of the motorcoach was deformed, leaning toward the left. All of the windows along the left side were shattered; all of the windows along the right side remained intact, including the windows on and above the boarding door. Deformation of the motorcoach did not intrude into the passenger space.

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[6] Tempered glass has been processed by controlled thermal or chemical treatments to increase its strength. It breaks into small cube-shaped fragments instead of sharp glass shards.

[7] Transpec A503016 and Transpec A503017.

[8] Seat belts, required on passenger vehicles, are a common component of occupant protection systems. Another common design element of occupant protection, *compartmentalization*, is a passive system that requires no action on the part of the occupant. Compartmentalization on school buses is accomplished by having seats closely spaced in secure anchorage with cushions and seatbacks covered in energy-absorbing materials. The entire seat structure is designed to absorb energy and deform to dissipate the energy of the crash away from the passenger and into the surrounding environment.

Figure 8. Accident motorcoach, front view.

Figure 9. Accident motorcoach, rear view showing engine compartment.

The engine compartment in the rear of the motorcoach was partially crushed, more so on the left side than the right, as shown in figure 9. The engine and transmission were displaced right and upward with the engine partially knocked off the engine mounts. The left steer axle tire and the left outside drive axle tire were both damaged and deflated.

The motorcoach seats showed interior impact damage from passengers who struck the seatbacks and armrests. Even though the initial impact was to the front of the motorcoach as it struck the Northside Drive bridge wall, the final impact as the motorcoach landed on I-75 was to its rear. Twelve of the 57 passenger seats were deformed aft,[9] and there were broken or deformed armrests on 6 seats.

Accident Reconstruction

Using the physical evidence found by examining the vehicle and the roadway, the motorcoach's motions during the accident were reconstructed. Physical evidence on the roadway included several feet of tire marks that began just before the intersection of the exit ramp with Northside Drive and continued until the motorcoach initially struck the reinforced concrete bridge wall and security fencing located along the southern edge of the eastbound lanes of the overpass. Accident reconstruction determined that, based on the radius of travel and lateral acceleration, the motorcoach's speed

[9] The extent of seat deformation was as follows: seat 2B, 4 inches; seat 3C, 16 inches; seat 5A, 26 inches; seat 5B, 26 inches; seat 5D, 10 inches; seat 7A, 31 inches; seat 7B, 30 inches; seat 8D, 26 inches; seat 10D, 28 inches; seat 11B, 31 inches; seat 13A, 22 inches; and seat 13B, 22 inches.

as it entered the intersection was 50 to 60 mph,[10] which is consistent with the statement of a witness who indicated that the motorcoach driver did not decelerate as he traveled up the exit ramp.[11] This estimate is also consistent with the speed of 52 mph indicated on the speedometer of the motorcoach during postaccident examination.[12] Another witness traveling in the right southbound lane of I-75, who had observed the motorcoach in front of him and to his left traveling up the ramp, estimated the motorcoach's speed to be 65 mph.

The tire marks also confirm that just before entering the intersection, the driver steered to the right. Physical evidence at the accident site and from the vehicle showed that as the driver attempted to maneuver through the intersection, the left-front corner of the motorcoach struck the reinforced portland cement concrete bridge wall and security fencing. This collision caused the motorcoach to rotate clockwise, and as the vehicle moved forward, it struck the barrier again with its left-side/left-rear corner, mounted the barrier, and fell from the Northside Drive overpass onto the southbound lanes of the interstate below. The motorcoach landed with the left-rear corner leading, before coming to rest on its left side facing east.

Motor Carrier Operation

The accident motorcoach was owned and operated by Executive Coach Luxury Travel, Inc., headquartered in Ottawa, Ohio. The privately owned company, which had been in business since 1998, was sold following the accident and is no longer operating. According to its Federal Motor Carrier Safety Administration (FMCSA) registration, Executive Coach was an authorized, interstate for-hire passenger motor carrier. At the time of the accident, the company operated 6 motorcoaches in 10 States using 2 full-time drivers and 20 part-time drivers.

Bluffton University had taken about 13 to 18 trips per year with Executive Coach since 2000. During postaccident discussions with the Bluffton University official responsible for transportation, Safety Board investigators learned that the university employees who had originally selected Executive Coach as a

[10] This estimate is based on a radius of travel of 318 feet (calculated using the center of gravity of the motocoach as it traveled over the tire marks) and a maximum lateral acceleration of 0.7 g. The Georgia Department of Transportation (GDOT) measured the dry friction of a car tire at 0.86 g and that factor was adjusted because the maximum friction for a motorcoach tire is approximately 80 percent of car tire friction. This estimate provides the vehicle speed as it traveled over the path indicated by the tire marks. Because the motorcoach would have slowed as it produced the tire marks, the vehicle speed at the beginning of the tire marks would have been slightly higher and the speed at impact with the barrier would have been slightly lower. Additionally, there is evidence that the brakes engaged just before the collision with the barrier, which would have slowed the motorcoach even more.

[11] A motorist stopped on Northside Drive with an unobstructed view of the I-75 deceleration ramp estimated the speed to be 50 to 60 mph, noting that the motorcoach did not decelerate as it traveled up the ramp.

[12] The postaccident speed indicated on a speedometer is not always a good indicator of a vehicle's precollision speed. In this accident, the speed is corroborated by other physical evidence.

transportation vendor in 2000 had left the university and that the criteria for their selection of Executive Coach were unknown. According to the university official, the decision to contract with Executive Coach for the March 2007 trip was based on past service and accommodation of the university's transportation needs. Bluffton University officials were unaware that they could check the motor carrier's safety record using the FMCSA's Safety and Fitness Electronic Records (SAFER) system, which offers company safety data to industry and the public over the Internet. The SAFER system indicated that Executive Coach had a satisfactory rating.

The FMCSA's Motor Carrier Management Information System (MCMIS)[13] indicated that, in the 2 years from March 2005 to March 2007, Executive Coach had 17 inspections: 12 level V inspections, 1 level III inspection, 3 level II inspections, and 1 level I inspection.[14] The company received no out-of-service violations as a result of those inspections.

Federal commercial vehicle inspection regulations (49 CFR 396.17) require that commercial vehicles be inspected annually. The Ohio CVSA motorcoach inspection program qualifies as a substitute for the federally mandated program.[15] Ohio's February 23, 2007, inspection of the accident motorcoach found no defects. Further review of the FMCSA and Ohio records indicated that Executive Coach's motorcoaches had been inspected annually since 1998 and had not shown any out-of-service violations based on mechanical defects.

The FMCSA conducted a compliance review of Executive Coach on January 31, 2001, for which the company received a satisfactory compliance rating. The company also received a satisfactory rating following the FMCSA's postaccident compliance review on April 4, 2007. Operational deficiencies associated with nonrated regulations that did not affect the rating calculation were noted.[16] All of the violations to nonrated elements were associated with driver, not vehicle, infractions.[17]

[13] The MCMIS is a database of motor carrier census information, inspections, accidents, and enforcement history. Company profiles from MCMIS can be obtained by the general public for a fee.

[14] North American inspection level categories include standard inspection (level I), walk around driver/vehicle (level II), driver only (level III), special (level IV), and vehicle only (level V).

[15] Revised Ohio Code 4513.52 requires passenger-carrying vehicles to be inspected annually by May 31 every year.

[16] Violations to nonrated elements included the following: failure to ensure that random drug and alcohol tests are unannounced (382.305(k)(1)); using a driver not medically examined and certified during the preceding 24 months (391.45(b)(1)); failure to complete a record of duty status (395.8(e)); failure to require the driver to prepare a record of duty status in the prescribed form and manner (395.8 (f)); failure to obtain from a driver used for the first time or intermittently a signed statement providing total time on duty for the preceding 7 days and the time that driver was last relieved from duty (395.8(j)(2)); failure to ensure that driver vehicle inspection reports are complete and accurate (396.11(b)); and failure to ensure that the driver signs the vehicle inspection report when defects or deficiencies are noted (396.13(c)).

[17] As a result of its investigation of the Wilmer, Texas, accident that occurred during the 2005 evacuation preceding Hurricane Rita, the Safety Board reiterated Safety Recommendation H-99-6 and issued a new recommendation (H-07-3) asking that the FMCSA change the current rating review process so that all violations

Federal regulations (49 CFR 391.51) require motor carriers to keep current records of their drivers' qualifications to operate commercial vehicles. The investigation found no record of the accident driver's having completed a qualifying medical examination effective for the timeframe beginning March 2, 2007. The FMCSA's postaccident compliance review of Executive Coach identified a violation for using a driver not medically examined and certified during the preceding 24 months.

Federal regulations (49 CFR 395.8(f)) also require that drivers maintain a logbook during a trip and that the company maintain a file of the originals. A review of logbooks for the accident driver and the driver of the first leg of the accident trip contained no hours-of-service violations; however, the accident driver's hours for the pre-positioning trip on March 1, 2007, were logged as "off duty" when they should have been logged as "on duty." At the time of the accident, Executive Coach employed 22 drivers; all but two worked part-time. The company did not record work hours for drivers employed at other facilities, as required.

Executive Coach operated its own drug and alcohol testing program, administered by a health center in Ottawa, Ohio. In addition to preemployment testing, the company randomly tested 10 percent of drivers for alcohol and 50 percent of drivers for drug use annually, in accordance with 49 CFR 382.305. The accident driver tested negative for drugs and alcohol during his preemployment test and on four subsequent random drug tests. Postaccident review of Executive Coach's records determined that the company's random drug testing was not always unannounced, as required.

The company had no formal in-service training program, no written policies on driver procedures, and no driver requirement to conduct pretrip safety briefings for passengers. The company did have requirements for driver-vehicle inspections,[18] but recent compliance reviews indicated that post-trip inspections and inspection form sign-offs were not regularly completed. Drivers were invited, but not required, to attend quarterly company meetings. Drivers were generally given 30-day notice of assigned trips. Family members of drivers were permitted to ride with the driver on charter trips with the customer's prior permission, as was the case during the accident trip.

of regulations (driver and vehicle) are reflected in calculating a carrier's final rating. For further information, see National Transportation Safety Board, *Motorcoach Fire on Interstate 45 During Hurricane Rita Evacuation, Near Wilmer, Texas, September 23, 2005,* Highway Accident Report NTSB/HAR-07/01 (Washington, DC: NTSB: 2007).

[18] In accordance with 49 CFR 392.7, 396.11, and 396.13.

Meteorological Information

Data from the U.S. Naval Observatory indicated that on March 2, 2007, at 5:48 a.m. eastern standard time, the sun was 10 degrees below the horizon. It was dark and more than an hour before sunrise. Weather data, obtained from the Charley Brown Airport, 6 miles west of the accident site, indicated that the temperature was 47° F, with calm winds, 6 miles' visibility, and overcast conditions at 15,000 feet. The roadway was dry.

Speed Study

Following the accident, on March 8, 2007, between 5:00 and 6:00 a.m., GDOT performed a speed study of the southbound lanes of I-75 in the vicinity of the accident. The 85th percentile speed for all southbound vehicles was 75 mph and the 50th percentile speed was 71 mph, with an average running speed of 70.3 mph. The posted speed limit in this area is 55 mph, and the design speed is 60 mph.[19]

Traffic Volume

The most recent data from GDOT[20] showed the average daily southbound traffic count on I-75 near the accident location to be 95,920 vehicles per day. The southbound HOV lane carries an average of 6,800 vehicles per day, and the HOV exit ramp for Northside Drive carries an average of 500 vehicles per day.

Road Design

I-75 was originally constructed in the 1950s as a four-lane expressway with a raised median. In 1982, a widening and reconstruction project on I-75 from Northside Drive to Peachtree Creek[21] included construction of interchange exit ramps and provisions for HOV lanes.[22] Beginning in 1985, the exit ramps, designed as part of the HOV traffic plan, were operated as general purpose on- and off-exit ramps. In preparation for the 1996 Olympics, the I-75 HOV lanes were marked and activated.

[19] *Design speed* is the maximum safe speed that can be maintained over a specified section of highway when conditions are so favorable that the design features of the highway govern. In the accident area, I-75 is functionally classified as a principal urban arterial freeway with a design speed of 60 mph to match the rolling topography and frequent changes in horizontal alignment.

[20] The data cover 2006, the last full year before the accident.

[21] GDOT project I-75-3 (139) 09, Fulton County, project no. 710451.

[22] Applicable design guidelines included the following: 1967 American Association of State Highway and Transportation Officials (AASHTO) *Policy on Design Standards—Interstate System*; 1973 AASHTO *Policy on Design of Urban Highways and Arterial Streets*; 1979 FHWA *Safety Evaluation of Priority Techniques for High-Occupancy Vehicles*; and the 1978 *Manual on Uniform Traffic Control Devices* (MUTCD), revision 4.

Atlanta currently has 90 HOV-lane miles with plans for more along the northwest corridor of Interstates 75 and 575. To minimize the hazard of lane changes and cross-freeway merging, major interchanges on such routes may be equipped with HOV-only left exit ramps that are engineered into the existing urban infrastructure.

Left Exits

The I-75 exit for Northside Drive HOV traffic was on the left side of the roadway; the four general purpose traffic lanes had access to a right exit. HOV restrictions for this highway segment, which are full-time, limit lane use to vehicles with two or more passengers and buses. The HOV lane on this highway segment starts at Interstate 285 and continues approximately 7 miles south to the Northside Drive HOV exit, which is the first left exit encountered along the southbound I-75 route. HOV markings along that route include 48 diamond pavement markings and 34 HOV diamonds on median-mounted or overhead signs. There are eight left HOV exits in the Atlanta metropolitan area.[23]

Design consistency is defined as the conformance of a highway's geometric and operational features with driver expectancy.[24] According to National Cooperative Highway Research Program (NCHRP) Report 502,[25] driver expectancy relates to the observable, measurable features of the driving environment that increase a driver's readiness to perform a driving task in a particular manner. Geometric features of a roadway (such as curves, intersections, and shoulder widths) that are unexpected increase the risk of driver error. A lack of standardization in highway design violates driver expectancy.

Roadway Alignment

On the I-75 approach to Northside Drive, the road curves to the left for almost a half mile (2,268 feet), straightens for 750 feet, and then curves to the left again for 2,857 feet around a left-side retaining wall. The second curve begins 413 feet before the HOV-only left exit ramp. The total increase in elevation for the 1,120-foot-long southbound Northside Drive HOV exit ramp is 19 feet. The

[23] Left HOV exits in the Atlanta metropolitan area occur at I-75 southbound at Spring Street; I-75 southbound and northbound at C.W. Grant Parkway; I-75 northbound at Memorial Parkway; I-75 southbound at Piedmont Road; I-75 southbound at Akers Mill Road; I-85 northbound at Lindbergh Drive; and I-75 southbound at Northside Drive.

[24] Most highway research attributes the concept to G.J. Alexander and H. Lunenfeld, *Driver Expectancy in Highway Design and Traffic Operations* (1986), according to U.S. Department of Transportation, Federal Highway Administration, *Driver Expectancy in Highway Design and Traffic Operations*, FHWA-TO-86-1 (Washington, DC: FHWA, 1986).

[25] Transportation Research Board (TRB), National Cooperative Highway Research Program, *Geometric Design Consistency on High-Speed Rural Two Lane Roadways,* NCHRP Report 502 (Washington, DC: TRB, 2003) 1.

elevation of the ramp is shown in figure 10. The vertical curve[26] elevation of the roadway occurs approximately 475 feet past the exit gore,[27] or approximately 950 feet into the exit ramp. The exit ramp has no posted warning speed sign. According to GDOT engineers, a warning for a slower speed was unnecessary because interchange lighting mitigated the visibility limitation caused by the vertical curve.[28]

The Northside Drive exit ramp is a tapered departure lane (not a parallel lane), diverging gradually from the HOV interstate through lane and separated from it by a white dashed line. The distance from the beginning of the divergence to the area where the exit lane achieves its full width (12 feet) is 278 feet. The longitudinal distance of the lane split from the initial point of divergence to the beginning of the exit gore point is approximately 475 feet.

Lighting and Sight Distance

Stopping sight distance values may exceed pavement visibility distances afforded by low-beam headlights, regardless of whether the roadway profile is level or vertically curving. Following this accident, investigators measured a daytime sight distance of 885 feet from the southbound I-75 lane at the point where the overhead HOV exit sign can first be seen behind the longitudinal median barrier and the light standards.[29] At the posted speed of 55 mph, this distance is traveled in 11 seconds. The sight distance for the exit gore point was 542 feet, a distance traveled in 6.7 seconds at 55 mph.

For nighttime driving, the I-75 HOV Northside Drive interchange has 100-foot-tall high-mast lighting (see figure 11). The traffic lanes of I-75 have luminaries erected on the median barrier at 200-foot intervals. These light supports have dual-mast lights with a 50-foot mounting height. Safety Board investigators confirmed that all of the lighting was functional at the time of the accident.

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[26] The vertical alignment of a road consists of straight segments (leveled or inclined) connected by sag (concave) or crest (convex) vertical curves. Combinations of these elements create various road profiles.

[27] The *gore* is defined as the area between the main roadway and the ramp, just beyond where the ramp branches from the main roadway.

[28] MUTCD guidance for the use of speed reduction signs is based on engineering judgment (section 2C.30).

[29] GDOT calculated the 885-foot sight distance by using a bus driver's eye height of 7.5 feet.

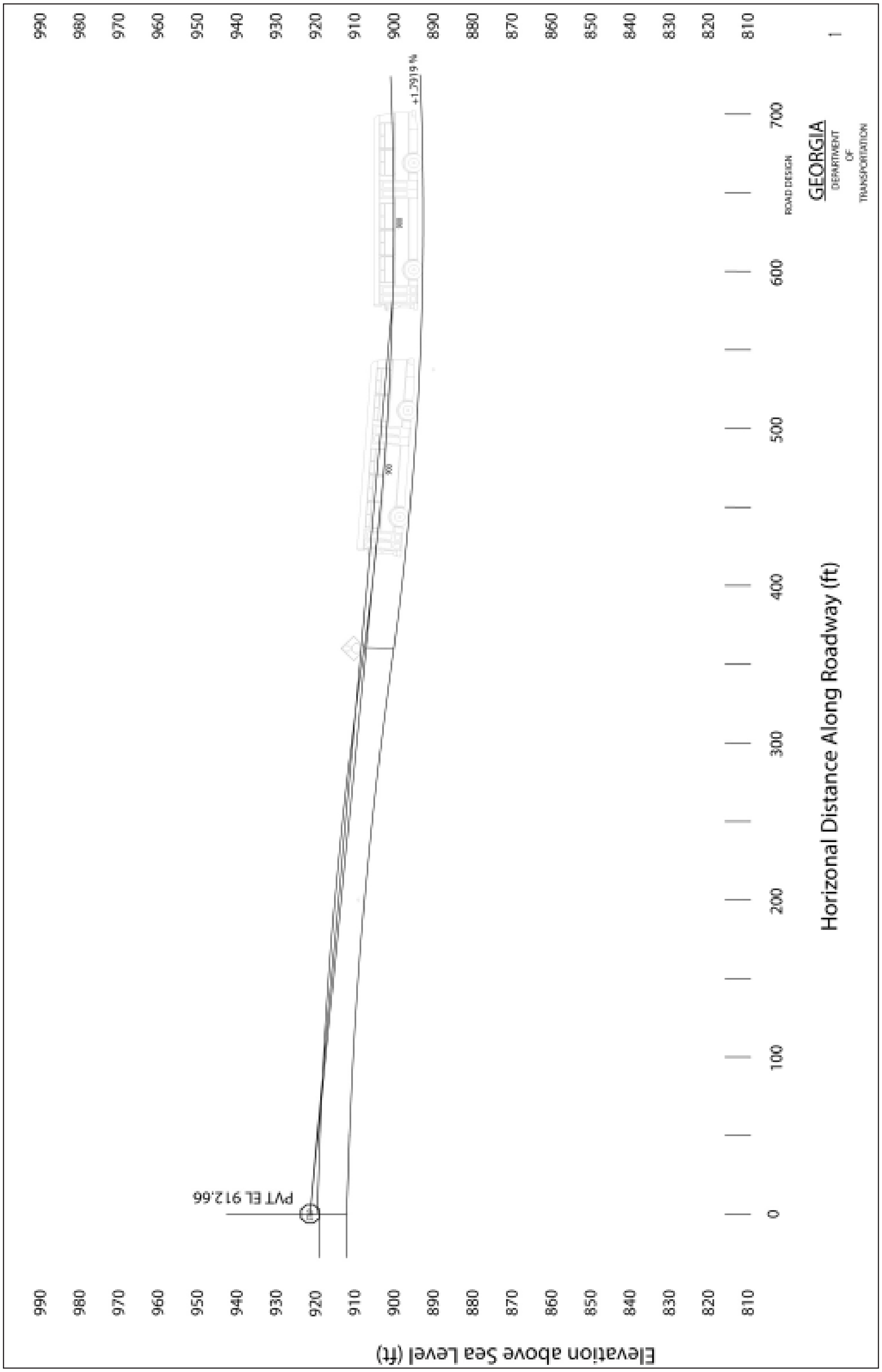

Figure 10. Exit ramp elevation.

Figure 11. Exit ramp showing high-mast lighting (circled).

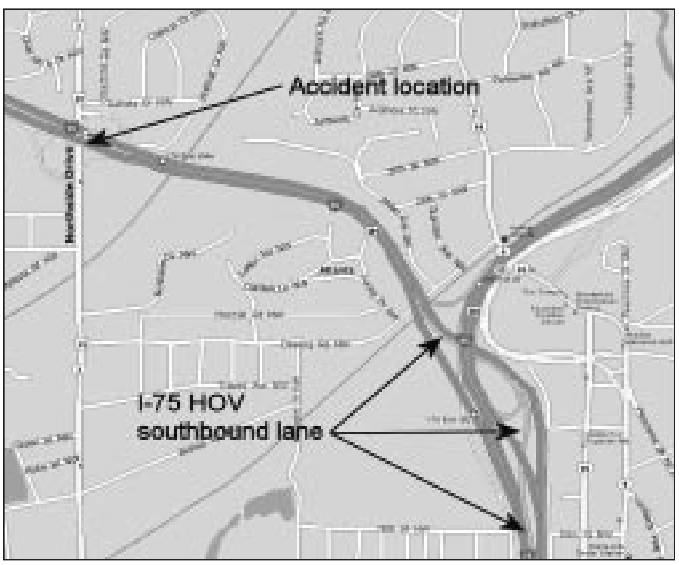

Figure 12. Southbound I-75 separation of HOV-only lane.

I-75 and I-85 HOV Merge

Less than 1 mile south of the Northside Drive exit, I-75 approaches Atlanta from the northwest and merges with I-85, which approaches Atlanta from the northeast. The traffic pattern for this merge separates the southbound I-75 HOV lane from the four southbound general purpose travel lanes. The single HOV lane diverges to the left to align with the northbound traffic lanes as they pass under I-85 in preparation for the merge. Figure 12 shows the route configuration for the interstate merge. Figure 13 shows the roadway view of the southbound I-75 HOV lane separation before the merge.

Accident Location History

During the course of this investigation, GDOT provided a 10-year history (1997 to 2007) of traffic accidents for the Northside Drive exit. (See appendix B.) GDOT was unable to provide an accident history for this exit from 1985 through 1996, when it was operated as an exit ramp for general traffic instead of an HOV-only left exit ramp.

Of the nine accidents that occurred from 1997 through 2007 (including this accident), seven involved injuries; of those seven accidents, three involved fatal injuries. Six of the nine accidents involved a single vehicle, and all but one of those six accidents occurred at night. The drivers ranged from 51 to 76 years old; none were residents of Atlanta, and only two were residents of Georgia. Seven of the nine accidents shown in appendix B involved drivers who had taken the exit ramp at interstate speeds and had failed to stop at the intersection stop sign and subsequently collided with the curb, the concrete bridge wall, or another vehicle.

Following this motorcoach accident, six other drivers who had reportedly driven the accident route contacted the Safety Board to express concern that the signage and pavement markings were confusing. Two of those drivers reported that they had inadvertently exited onto Northside Drive when it was their intention to follow I-75. One of those callers was a CDL driver of a motorcoach.

Figure 13. I-75 HOV lane diverging to the left in preparation for I-85 merge.

Traffic Control Devices and Guidance

Traffic control devices provide regulatory, warning, and route guidance information to drivers. These devices include traffic signal lights, signs, and roadway markings. The national standard for all traffic control devices is the *Manual on Uniform Traffic Control Devices*.[30]

Title 23 CFR Part 655 provides the States with a 2-year period from the effective date to adopt the MUTCD. By December 22, 2005, States were required

[30] The MUTCD was first published in 1935. Since then, there have been eight editions, some with extensive revisions. The most recent edition was published in November 2003 (U.S. Department of Transportation, Federal Highway Administration, *Manual on Uniform Traffic Control Devices for Streets and Highways*, [Washington, DC: FHWA, 2003]). An electronic version of the 2003 MUTCD, including revisions 1 and 2, is the most current version <http://mutcd.fhwa.dot.gov>.

to have adopted the 2003 edition of the MUTCD or to have a State MUTCD or supplement that is in substantial conformance with it.[31] One role of the Federal Highway Administration (FHWA) Division Offices is to review and approve any State MUTCD or supplement (23 CFR 655.603(b)). Georgia is one of 24 States that have adopted the 2003 MUTCD without a State supplement. The 2003 MUTCD is scheduled for revision in 2008, and a notice of proposed amendments (NPA) to the MUTCD was published in the *Federal Register* on January 2, 2008.[32]

The 1988 MUTCD would have been in effect when the Northside Drive exit was changed to an HOV-only exit before the 1996 Olympics. GDOT's conversion of existing I-75 traffic lanes to HOV lanes[33] involved signing, pavement marking, milling, and inlay work.[34] At that time, the MUTCD (section 2B-20) contained slightly more than a page of text on HOV signage and markings, including six exemplar signs. It contained no traffic control device guidance for the merge of two urban HOV interstate lanes.

The current (2003) MUTCD provides additional information and requirements regarding preferential lane[35] signs. The MUTCD "standard"[36] requires that preferential lanes use signs and pavement markings to advise road users of their status and that specific signs be used exclusively with HOV lanes to indicate occupancy requirements and time restrictions (MUTCD, section 2B.26, figure 2B-7). The MUTCD requires that ground-mounted preferential lane signs, when used, be located adjacent to the preferential lane and that overhead signs be mounted directly over the lane. A related standard describes pavement markings, including the use of the diamond symbol. The only information specific to HOV sign placement is a guidance statement that notes sign placement "should be determined by engineering judgment based on prevailing speed, block length, distance from adjacent intersections, and other considerations."

The MUTCD organizes signs by purpose and uses a standard color scheme (section 1A.12 and table 2A-4). Regulatory signs, which have black, white, or

[31] Compliance dates are deadlines by which States must have brought their traffic control devices into conformance with specific provisions of the MUTCD. These compliance dates generally range from 5 to 15 years from the effective date of the MUTCD final rule.

[32] "National Standards for Traffic Control Devices; the Manual on Uniform Traffic Control Devices for Streets and Highways; Revision"; *Federal Register*, Vol. 73, No. 1 (January 2, 2008).

[33] GDOT project CM-OOMS (2) Ct.1; Clayton, Fulton, Cobb, and Dekalb counties; project no. 71297.

[34] Applicable design guidelines included the following: *1991 AASHTO Policy on Design Standards—Interstate System*; *1990 AASHTO Policy on Geometric Design of Highways and Streets*; and *1992 AASHTO Guide for the Design of High-Occupancy Vehicle Facilities*.

[35] Preferential lanes are designated for special traffic uses such as HOV, light rail, buses, taxis, or bicycles.

[36] MUTCD headings are used to classify the nature of the text. *Standards* are statements of required, mandatory, or specifically prohibitive practice regarding a traffic control device. *Guidance* is a statement of recommended, but not mandatory, practice in typical situations; deviations are allowed if engineering judgment or an engineering study indicates that the deviation would be appropriate. Standards and guidance are sometimes modified by *Options*, which serve as a statement of practice that is a permissive condition. *Support* provides supplemental information.

red legends on black, white, or red backgrounds (section 2A.11), inform drivers of selected traffic laws or regulations; examples include speed limit signs, stop signs, or preferential lane signs (MUTCD, chapter 2B). Guide signs show route destinations, directions, and distances (MUTCD chapter 2E, addresses guide signs for interstates). Guide sign color combinations depend on the type of route and sign function but generally have white legends on green backgrounds.

The other left exit ramps along southbound I-75 terminate at traffic-signalized intersections. In deciding whether traffic signals should be used at an intersection, the current MUTCD (chapter 4C, "Traffic Control Signal Needs Study") requires that traffic volume, flow patterns, pedestrian flow, school zones, sight distances, and accident rates be evaluated. According to MUTCD section 4C.08, an intersection can be identified as a high-accident location if, "five or more reported crashes, of types susceptible to correction by a traffic control signal, have occurred within a 12-month period." GDOT concluded that this location did not warrant a traffic control signal.

Signage and Pavement Markings Approaching Accident Location

Guide Signs for I-75 HOV Traffic

Interchange guide signs in proper sequence should provide the driver with the necessary information for route navigation. There are two overhead advance route guide signs[37] on I-75 for Northside Drive: *NORTHSIDE DRIVE, EXIT 1 MILE* at mile marker 252.6 and *NORTHSIDE DRIVE, EXIT 1/2 MILE* at mile marker 252.1. (See figures 14 and 15.) Both signs have black lettering on white backgrounds with a white-on-black HOV diamond to the left and a *BUSES/CARPOOLS ONLY* supplemental plaque on the bottom. Both signs are posted directly over the HOV lane and occur before the I-75 overpass for Howell Mill Road. In accordance with the 2003 MUTCD (sections 2E.33 and 2E.34), a third exit directional sign, *NORTHSIDE DRIVE*, with a left arrow, is mounted over the exit lane on a support post located on the median barrier;[38] and a fourth exit sign is posted to the right of the exit lane in the exit gore. (See figures 16 and 17.) The advance guide signs contained no indication of a left exit, and none of the signs included a LEFT plaque.

[37] Advance guide signs give notice well in advance of the exit point of the principal destinations served by the next interchange and the distance to that interchange (2003 MUTCD, section 2E.30).

[38] The MUTCD standard for this sign states that it should carry the exit number, if used; route number; cardinal direction; and destination, when appropriate. The overhead guide sign did not display the word "EXIT."

Figure 14. Advance guide sign (*EXIT 1 MILE*) for Northside Drive exit.

Figure 15. Advance guide sign (*EXIT 1/2 MILE*) for Northside Drive exit.

Figure 16. Overhead directional sign for Northside Drive.

Figure 17. Northside Drive exit sign in gore area.

GDOT's original (1985) signage and pavement marking plan[39] called for dual signs posted side by side: one for the Northside Drive HOV-only left exit (arrow sign) and one pull-through sign[40] guiding the HOV traffic on southbound I-75. According to section 2E.11 of the MUTCD,

> Pull-through signs should be used where the geometrics of a given interchange are such that it is not clear to the road user which is the through roadway, or where additional route guidance is desired. Pull-through signs with a down arrow should be used where the alignment of the through lane is curved.

The design for placement of the signs was changed in August 1995. Because of structural failures in the base plate bolts on type II cantilevered dual-sign structures, GDOT had adopted a policy to eliminate them. To support dual signs (both an exit sign and a pull-through sign), a sign support over the entire roadway would have been needed. GDOT indicated that a sign support over the entire roadway would limit sight distance to other signs ahead. GDOT's design change was partially documented in interdepartmental memorandums reviewed during the course of the Safety Board's investigation. GDOT's solution was to separate the two signs, placing the HOV-only left exit sign in its original location and moving the I-75 HOV South pull-through sign 0.2 mile north, mounted to the Howell Mill Road overpass. Figure 18 shows the Northside Drive exit sign separated from the I-75 pull-through sign, and figure 19 shows the original design plan positions for the signs mounted side-by-side.

Stop Signs at the Northside Drive Intersection

Closer to the accident location, approximately 300 feet from the intersection *STOP* sign, were two *STOP AHEAD* signs (MUTCD W3-1a), one on each side of the exit ramp. Both *STOP AHEAD* signs had supplemental plates indicating that the intersection stop sign was 300 feet ahead. Additional *STOP AHEAD* pavement markings were located on the roadway. Figure 17 shows the driver's view of both the pavement markings and the *STOP AHEAD* signs at the top of the exit ramp. The intersection *STOP* sign, which measured 36 by 36 inches, was posted on the right side of the road at Northside Drive.

The accident motorcoach traveled up the exit ramp at highway speeds (50 to 60 mph). When the motorcoach reached the *STOP AHEAD* signs, which are located 300 feet in advance of the intersection, it would have required 225 to 266 feet, assuming maximum braking, to stop. That distance would have been traveled in 1.0 to 1.5 seconds.

[39] GDOT project CM-OOMS (2) Ct. 1; Clayton, Fulton, Cobb, and Dekalb counties; project no. 712970. The signage and pavement marking plan was approved by the FHWA and was in compliance with the MUTCD guidance in effect at the time.

[40] A *pull-through* sign is an overhead lane-use sign intended for through traffic.

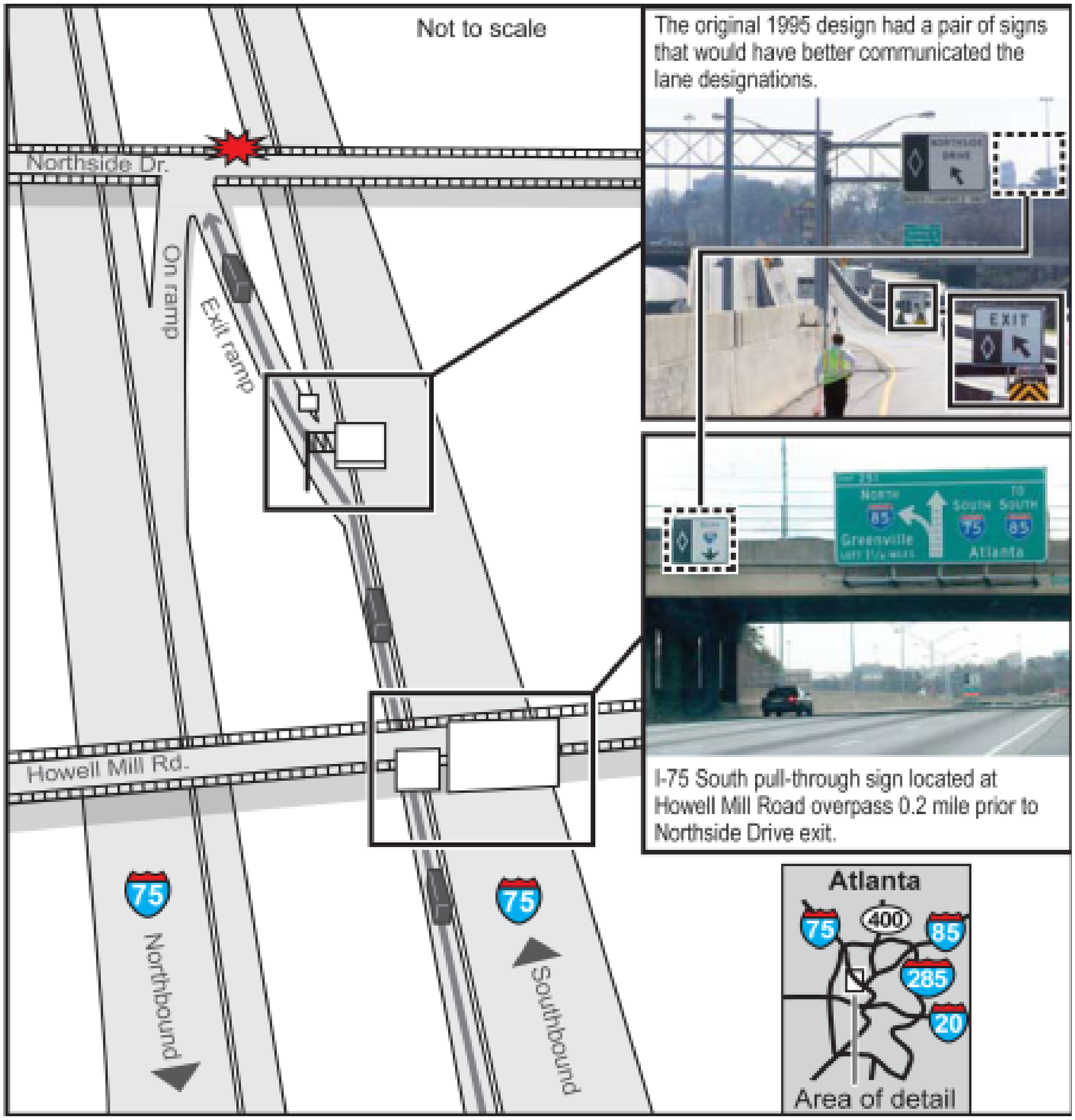

Figure 18. Pull-through sign for the I-75 HOV lane positioned at the Howell Mill Road overpass instead of mounted next to the Northside Drive exit sign.

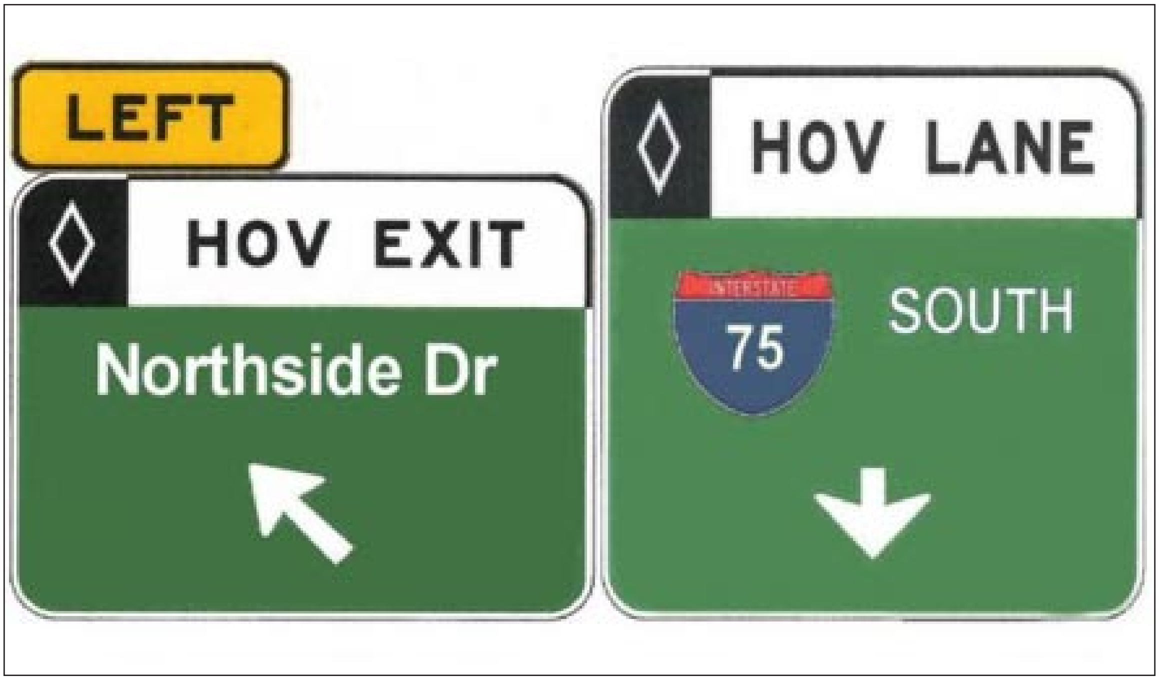

Figure 19. Northside Drive exit sign and pull-through sign for the I-75 HOV lane mounted side by side.

Pavement Markings

The 2003 MUTCD standard (section 3B.22) calls for preferential lanes to be marked with an appropriate diamond pavement symbol or message, such as the diamond symbol for an HOV lane, spaced at regular intervals based on the prevailing traffic speed. For the southbound I-75 HOV lane, these diamond markings occurred approximately every 1/6 mile. The FHWA recommended in an August 2007 information memorandum to Division Administrators,[41]

> in addition to the regular spacing interval, that the appropriate pavement marking be placed along preferential lanes at strategic locations, such as at major decision points, direct exit ramp departures, and along access openings with adjoining general-purpose lanes.

The Northside Drive HOV-only exit ramp contains the diamond symbol immediately past the exit gore point. A diamond symbol is also located in the HOV through lane immediately past the exit gore point.

Edge lines, which separate a travel lane from an adjacent shoulder, are always solid (MUTCD, section 3B.06). Along a one-way roadway that is one-half of a divided highway, such as I-75, yellow edge lines mark the left edge of the roadway and serve as a boundary between a travel lane and the left shoulder;

[41] FHWA information memorandum on traffic controls devices for preferential lane facilities, Associate Director for Operations, August 3, 2007, page 3.

white edge lines mark the right edge of the roadway and serve as a boundary between a travel lane and the right shoulder. The general purpose lanes for I-75 are separated by spaced white pavement stripes; the HOV lanes are delineated from the general purpose lanes by solid double white pavement markings.[42] At the time of the accident, the Northside Drive exit was marked with a white dashed line marking the tapered exit deceleration lane, as shown in figure 20, to distinguish the HOV-only left exit ramp from the through lane.[43] The exit gore area was striped with 10-inch white lane edge marking lines. It was not marked with channelizing lines to define the neutral area or to direct exiting traffic in accordance with the 2003 MUTCD (section 3B.05).

Figure 20. Exit roadway markings at Northside Drive.

The FHWA advised in its August 2007 information memorandum to Division Administrators that when extra emphasis is needed to differentiate between exit and travel lanes, a legend pavement marking *EXIT* or *EXIT ONLY* should be considered for use in the parallel or tapered deceleration lane for the direct exit and/or on the direct exit ramp itself just beyond the exit gore. At the time of the accident, the Northside Drive exit ramp was not marked with *EXIT* pavement markings.

[42] Solid double lines become dashed double lines at periodic intervals to allow for conventional traffic to transition to HOV lanes.

[43] The MUTCD, section 3B-11, provides for the optional extension of the pavement line with dotted pavement marking at exit ramps.

Postaccident Traffic Control Device Changes

Following this accident, GDOT enhanced the signage at the intersection by increasing the *STOP* sign dimensions from 36 to 48 inches. A second STOP sign was added to the left of the exit ramp terminus, and a flashing beacon was mounted to the top of the STOP sign located on the right side of the exit ramp terminus. A raised concrete traffic island with reflective pavement markers was added to the exit ramp terminus. A Large Double Arrow warning sign (MUTCD W1-7), measuring 60 by 30 inches, was placed across Northside Drive on the concrete bridge wall across from the end of the ramp to provide additional warning that the ramp ended. A second set of *STOP AHEAD* reflective pavement markings was added midway up the exit ramp, and the *STOP AHEAD* sign's size was increased to 60 inches. Roadway pavement markings were repainted to 10 inches wide, a dashed yellow line was used to replace the white dashed pavement marking across the exit split,[44] and a reflective pavement marking *EXIT* was added after the HOV diamond at the beginning of the ramp.

In its August 2007 information memorandum to Division Administrators, the FHWA acknowledged the significant variation in the application of design principles for traffic control devices when applied to preferential lane facilities. The memorandum stated that the FHWA wished to "encourage uniformity among such devices by expediting conformance with the requirements of the MUTCD." With regard to HOV left exits, the FHWA recommended that an additional plaque with the legend *LEFT* in black on a yellow background be placed at the top left edge of any guide sign calling for a left direct exit maneuver. The FHWA also recommended the use of dotted white pavement line markings across a direct exit taper to separate an exit lane from a continuing through lane.

[44] The MUTCD standard for longitudinal markings of preferential lanes (section 3B.23) calls for yellow lines to delineate the left edge of the roadway. To separate concurrent flow traffic, such as at an exit, a single broken white line indicates that crossing is permitted.

Analysis

This analysis first discusses the factors and conditions that the Safety Board has excluded as neither causing nor contributing to the accident. It then provides a brief overview of accident events and discusses the safety issues relevant to the accident: inadequate HOV traffic control devices, inadequate motor carrier driver oversight, lack of EDRs on motorcoaches, and lack of motorcoach occupant protection.

Exclusions

The weather was clear and dry at the time of the accident. Motor carrier and motorcoach records indicated that the vehicle was well maintained and in proper working condition; it had passed a Federal commercial vehicle inspection conducted by Ohio CVSA inspectors just 1 week before the accident. Postaccident inspection of the motorcoach showed no defects or anomalies. The Safety Board concludes that neither the weather nor the mechanical condition of the vehicle caused or contributed to the accident.

The driver had been a part-time motorcoach driver for 6 years and, before that, had been a school bus driver. During his employment with Executive Coach, he had no traffic violations, although he had been involved in one accident in which he was found not at fault. The Safety Board therefore concludes that the driver's qualifications and driving record were not factors in this accident.

Postaccident testing of the driver's blood and urine was negative for alcohol and illicit drugs. At the time of a physician's visit 10 days before the accident, the driver's medical records indicated that he had a prescription for hydrocodone, a narcotic pain reliever. However, the substance was not detected in the postaccident toxicology evaluation, indicating that it had not been used in the previous 24 hours. The Safety Board concludes that the driver was not impaired by alcohol, illicit drugs, or narcotic pain medication.

Appropriate resources were dispatched, and first responders were at the accident scene within 5 minutes of the accident. Medical services from three local area hospitals were coordinated to handle the treatment of the injured. The Safety Board therefore concludes that the emergency response was timely and effective.

Accident Discussion

The accident motorcoach was traveling from Bluffton University in Bluffton, Ohio, to Sarasota, Florida, a trip of approximately 1,120 miles. Except for local travel at each end, the trip followed I-75 South through the States of Ohio, Kentucky, Tennessee, Georgia, and Florida. As it approaches Atlanta from the northwest, I-75 merges with I-85 from the northeast; both interstates have HOV traffic lanes that merge through the metropolitan Atlanta area. Upon entering the metropolitan area southbound on I-75, drivers encounter the first HOV-only left exit, Northside Drive. One mile past the Northside Drive HOV exit, the merge of I-75 with I-85 is constructed such that the southbound I-75 HOV lane diverges to the left, separating from the general purpose travel lanes, and curves around to connect with the southbound I-85 HOV traffic lane much like an exit ramp. This merge of the HOV lanes and the general purpose traffic lanes is handled separately. The accident driver intended to take I-75 and merge with I-85 to continue south. The I-75 HOV route for that merge diverged from the HOV lane to the left at an angle similar to the Northside Drive left HOV exit.

The motor carrier stated that the driver was responsible for pretrip planning. Based on pretrip planning, map reference, and two previous trips through Atlanta, the driver likely expected the I-75 HOV-only traffic lane to diverge to the left from the general purpose through traffic lanes for the interstate merge with I-85. Without a clear indication of the Northside Drive exit ramp's relative position to the interstate through lane, the driver could have mistaken the Northside Drive HOV-only left exit ramp for the high-speed ramp between interstates (I-75 and I-85). This situation is made even more likely because of the infrequent use of left exits; Northside Drive is one of only seven in the Atlanta area.

In the weeks following the accident, other drivers who had experienced problems navigating the I-75 HOV-only left exit ramp at the accident location contacted Safety Board investigators. One, a professional motorcoach driver, had mistakenly taken the exit ramp and run the stop sign on Northside Drive at the top of the ramp but was able to negotiate a right turn and stop the motorcoach. He explained that he had unintentionally followed the solid yellow edge line on the left up the exit ramp.

If the accident driver was expecting the left ramp to connect I-75 HOV traffic with I-85 HOV traffic, he may also have focused on the solid yellow line on the left side of the HOV lane as a cue for following that route. Given the dark travel conditions and the limited sight distance of the exit ramp as the highway curved behind the retaining wall, this driver may have narrowed his attention to follow the yellow edge line as a salient navigational cue.

Left interstate exits are an uncommon road design. GDOT records identified several similar accidents that had occurred at this location that should have alerted GDOT to the need for additional driver guidance. Seven of the nine accidents documented by GDOT in the accident vicinity involved drivers who had taken the exit ramp at interstate speeds and failed to stop at the intersection. Following fatal accidents in 2001 and 2002, GDOT conducted a review of the intersection traffic control devices at Northside Drive. The Northside Drive intersection did not meet the accident experience criteria or other MUTCD warrants and, therefore, signals were not installed. GDOT's postaccident safety evaluations did not consider whether remediating traffic control devices were needed before the required stop. Consequently, the Safety Board concludes that GDOT failed to identify the Northside Drive HOV-only left exit, which was in a left curve preceding a high-speed left interstate merge, as an unexpected arrangement that required additional traffic control devices to guide road users.

The primary issue under investigation in this accident was the adequacy of the highway signage and roadway markings to reliably alert drivers of the HOV-only left exit ramp and to provide route guidance for interstate through traffic. First, the driver inadvertently and unknowingly exited the interstate; and second, once on the HOV-only left exit ramp, he received insufficient cues to alert him that he was no longer on the interstate. By the time the driver realized the route mistake, he had insufficient time to stop the motorcoach at the Northside Drive intersection. The following section describes the specific roadway design elements and traffic control devices that influenced the motorcoach driver's route decisions and collision avoidance behavior.

Inadequate Signage at Northside Drive Exit

The original signage plan for I-75 included a pull-through sign mounted adjacent to the exit sign; this pair of signs is shown in figure 18. But, according to GDOT, the pull-through sign was installed 0.2 mile north of the Howell Mill Road overpass (so that the southbound accident driver encountered it earlier than the exit sign) because of installation problems with the dual cantilevered structure. An alternative to the cantilevered sign structure would have been a full overhead structure[45] capable of holding both the exit sign and the interstate pull-through sign. GDOT did not use that solution, however, stating that the addition of a pull-through sign would have limited the sight distance for the signs mounted on the Northside Drive overpass. The overpass signage consists of two periodically recurring HOV-lane use message signs *(BUSES/CARPOOLS ONLY)* and an advance route guide sign for three general purpose traffic exits that occur after the upcoming interstate merge in 1.25 miles. A sight distance of more than 1,120 feet (the length of the exit ramp) is more than adequate for these general signs, and, in fact, is a greater sight distance than that afforded users of the Northside Drive exit sign (based on a sight distance of 875 feet).

[45] GDOT refers to this sign support as a Type V sign structure.

Guidance provided by the FHWA after the accident[46] states that the pull-through sign is of particular importance when the direct exit could be mistaken for a preferential lane that continues, as occurs on curved alignments or where other physical roadway features, such as an overpass, make it difficult to discern the exit geometry from the approach. Positioning the exit sign to the left of the pull-through sign in a side-by-side configuration would have alerted road users of the lane positions; separated, the pull-through and exit signs lost their spatial relationship. Further, removing the pull-through sign from the location where the original design plans called for it to be mounted also removed it from the decision point on the highway where it was most needed. Moreover, the information on the Northside Drive overpass signs that GDOT was concerned about obscuring was not critical to immediate route guidance. The Safety Board therefore concludes that GDOT, in changing the original design plan by separating the Northside Drive HOV exit sign from the I-75 South pull-through sign, caused the effective meaning of the paired signs to be lost at a critical decision point on the highway. The Safety Board also concludes that positioning the Northside Drive HOV-only left exit direction sign next to the I-75 South pull-through sign will promote positive guidance to motorists on the appropriate travel lanes at a critical decision point on the highway.

The southbound I-75 HOV lane starts at the Interstate 285 beltway approximately 7 miles north of the Northside Drive exit. Along that route, the accident driver would have encountered 48 HOV diamond pavement markers and experienced 34 HOV diamonds on median-mounted or overhead signs. The Northside Drive exit ramp also displayed an HOV diamond pavement marking just past the exit gore, and the exit gore sign displayed an HOV diamond with an arrow. The exit ramp design at Northside Drive was unconventional and problematic, most notably because it was the first left exit along the route and, as such, was unexpected. The Safety Board therefore concludes that, because of the unique combination of geometric features and lane restrictions of an HOV-only left exit, redesigning the Northside Drive exit signs to include a message plaque with the legend *LEFT* in black on a yellow background placed at the top left edge of the *1 MILE* and *1/2 MILE* guide signs will better alert drivers to the unconventional exit design. The Safety Board believes that GDOT should install a *LEFT* message plaque on the *1 MILE* and the *1/2 MILE* advance exit guide signs and on the directional arrow exit sign for Northside Drive and position the pull-through sign for the southbound I-75 HOV through lane so that it is next to the Northside Drive left-exit direction sign. To ensure that other left exits are readily recognized by motorists, the Safety Board also believes that GDOT should install exit signs with *LEFT* message plaques for left interstate exits. The Safety Board further believes that GDOT should install pull-through signs next to the exit direction (arrow) signs to ensure positive route guidance at exits with limited sight distance, short ramps, or multiple route choices. The Safety Board also believes that, to ensure that these signage conventions are applied consistently throughout the Nation's interstate highway system, the FHWA should include in an MUTCD

[46] FHWA Associate Director for Operations, August 3, 2007, page 2.

standard the requirements for HOV-only left exits to have *LEFT* message plaques on all exit guide signs and for exit direction (arrow) signs to be positioned next to pull-through signs at exits with limited sight distance, short ramps, or multiple route choices.

In addition, the Northside Drive exit ramp had no advisory speed sign (MUTCD W13-2) to advise the driver of a slower speed, despite the ramp's relatively short length of 1,120 feet. Such signage would seem particularly relevant along a route where, based on the postaccident speed study, traffic exceeds the posted speed limit. A sign advising motorists of a lower exit ramp speed offers yet another opportunity to assist drivers in safely navigating the elevated ramp, particularly at night when sight distances are restricted. The Safety Board could not reliably determine whether the motorcoach headlamps were on high or low beam, but it is likely that the accident driver, like many travelers in urban traffic, would have been traveling with low-beam illumination. On a lighted roadway under those conditions, a vehicle's headlights would illuminate the elevated roadway, but only after some distance up the ramp would they illuminate the *STOP AHEAD* pavement markings or the *STOP* sign, at which point, the accident motorcoach was within a few hundred feet of the intersection and still traveling at highway speeds (50 to 60 mph). This situation afforded the driver only 1 to 2 seconds to perceive the sign message, understand its meaning, make a decision, and execute that decision. According to the MUTCD, this reaction time can vary from several seconds for general warning signs to 6 seconds or more for warning signs requiring a high degree of road user judgment. A reduced speed advisory sign early in the exit ramp would have indicated a different traffic situation to the driver and, if he had slowed, would have afforded him more time to process the stop sign information and execute a stop. The Safety Board concludes that because the Northside Drive exit ramp is short and terminates at a nonsignalized intersection, an advisory ramp speed sign is needed for motorist safety. The Safety Board believes that GDOT should install an advisory speed limit sign (MUTCD W13-2) on the Northside Drive HOV exit ramp and on interstate left exit ramps throughout the State. The FHWA's recent NPA also addresses advisory exit speed signs, proposing in the section titled "Advisory Exit and Ramp Speed Signs" to revise the MUTCD standard to require the use of advisory speed limit signs on interstate ramps. The Safety Board agrees with the proposal and believes that the FHWA should include in an MUTCD standard criteria for the use of advisory speed limit signs for all interstate exit ramps.

Inadequate Pavement Markings at Northside Drive Exit

The driver's intended route of travel was the southbound I-75 HOV lane and, given his speed of 50 to 60 mph, it is apparent that his movement to the exit ramp was a mistake. Because the driver likely did not realize that the motorcoach was on the exit ramp, he also did not realize the need to stop at the top of the ramp. His first visual cue for the ramp was the dashed white edge line separating the ramp from the HOV lane. A reliance on the yellow edge line that had guided him through the long and gradual left curve of I-75 may have diminished his awareness of the dashed white line and also have contributed to his missing the barrier-mounted *EXIT* sign on the right in the gore area. Since the accident, GDOT has changed the dashed white line to a dashed yellow line; however, no MUTCD standard provides for the use of a dashed yellow line to delineate left exits. The MUTCD's standard notes that yellow longitudinal markings delineate the separation of traffic traveling in opposite directions, the left edge of divided roadways, and the separation of two-way left turn lanes. The FHWA's information memorandum regarding traffic control devices for preferential lane control sent to Division Administrators after the accident recommended that a dashed white guide line marking be used to separate an exit lane from a continuing through preferential lane; the guidance did not specifically address left exits.

Because yellow lines mark the left edge of divided roadways, and because dashed lines indicate an option for traffic crossing, GDOT used a yellow dashed line for postaccident marking on the Northside Drive exit ramp divergence from the interstate through lane. Although there is not specific guidance for that action, GDOT's efforts to more positively mark the exit ramp merit consideration. If the driver was using the yellow edge line as his primary lane tracking cue, he might have been more likely to notice the dashed yellow marking delineating the exit. The Safety Board concludes that the use of yellow dashed lines for left exit pavement markings and white dashed lines for right exit pavement markings should be considered to emphasize and distinguish left exits. The Safety Board believes that the FHWA should evaluate the MUTCD standard for guide line marking requirements for interstate left exits.

Both the exit ramp and the I-75 HOV through lane contain an HOV diamond roadway pavement marking just past the start of the exit. The driver would have experienced a regular display of these HOV diamond pavement markings along his interstate route, and the exit ramp diamond pavement markings appeared identical to the I-75 HOV through lane markings. Further, the exit lane did not have an *EXIT* pavement marking. After the accident, GDOT added an *EXIT* pavement marking to the Northside Drive exit ramp's diamond pavement marking. The Safety Board agrees that this modification enhances the lane markings and helps to ensure that motorists realize they are exiting the interstate. The Safety Board concludes that pairing an *EXIT* pavement marking with the HOV diamond pavement marking is a useful traffic control enhancement for all left HOV exits. The Safety Board therefore believes that GDOT should add an *EXIT* pavement marking paired with the HOV diamond pavement marking at all left HOV interstate exits.

HOV Traffic Control Devices

Route guidance signs for HOV motorists traveling on I-75 South used the regulatory sign color convention of a black legend on a white background (see figures 14 through 17). Although this convention is appropriate to communicate the HOV information for preferential lane use (buses and two-person carpools), motorists are accustomed to looking for a sign with a white legend on a green background for route guidance. Current managed lane facilities are split between those that use green guide signs and those that favor regulatory signs with white as their primary background color.[47] Developing a national consistency of terminology, color, and symbology for managed lanes is the FHWA's number one priority on its 2007 prioritized research list. The Safety Board agrees that this issue should be a priority. Consistency is the main factor in driver expectation, and driver expectancies for traffic control devices are based on previous experience of similar traffic situations. The Safety Board concludes that this accident illustrates the importance of HOV traffic control devices being sufficiently similar, regardless of their geographic location, to create consistent expectations related to common geometric, operational, and route characteristics.

The FHWA relies on a volunteer organization of professionals, the National Committee on Uniform Traffic Control Devices, to develop and revise the MUTCD. In 2003, the FHWA committed to an update cycle of 5 years, indicating that the next edition will be released in 2008. The comment period for the MUTCD NPA[48] closed on July 31, 2008. The Safety Board believes that the FHWA should work with the National Committee on Uniform Traffic Control Devices to ensure that the next edition of the MUTCD is issued as scheduled in 2008 and that the revision comprehensively addresses the uniformity of HOV traffic control devices, including left exits.

In the MUTCD NPA, the FHWA is proposing a standard to require black-on-yellow *LEFT* message plaques for left exits and advance guide signs, with a phase-in period of 10 years for existing signs. Although 10 years is a common phase-in compliance period for new sign requirements, because the message plaques would be added to the top left edge of existing left exit signs and, in most cases, would not involve replacing existing signs in good condition, the Safety Board concludes that the supplemental *LEFT* message plaques should be phased in sooner than the typical 10-year MUTCD compliance timeframe. Therefore, the Safety Board believes that the FHWA should require a phase-in period of 5 years for supplemental *LEFT* message plaques in the standard proposed for the next edition of the MUTCD.

Driver's Medical Condition

The driver had several risk factors for obstructive sleep apnea: he was overweight, had previously reported snoring, and was on medications for the treatment of high blood pressure and anxiety. Although it is possible that the driver had some level of sleep apnea that prevented him from getting a restful night's

[47] S. Chrysler and B. Kuhn, *Traveler Information and Traffic Control Devices for Managed Lanes* (College Station, Texas: Texas Transportation Institute, April 2007).

[48] *Federal Register*, Vol. 73, No. 1 (January 2, 2008).

sleep, the Safety Board was unable to find evidence for that conclusion. Despite his risk factors for the disorder, he had never undergone a medical evaluation for sleep apnea.

Following a 12-day period of being off duty, the driver drove 10.5 hours the day before the accident. He was off duty for nearly 9 hours (from 7:37 p.m. on March 1, 2007, until 4:30 a.m. on March 2), thereby meeting the regulatory requirements for being off duty for 8 hours. Based on previous investigations,[49] the Safety Board has determined that the most important measures in predicting whether a driver will have a fatigue-related accident are (1) the duration of the last sleep period, (2) the total hours of sleep obtained in the 24 hours preceding the accident, and (3) whether a split sleep/work pattern was followed. However, none of these conditions applied to this driver; he had the opportunity to receive 7 to 8 hours sleep the night before the accident, he was not following a split sleep/work pattern, and he had only been driving for approximately an hour when the accident occurred. These factors, combined with the fact that the driver was maintaining control of the vehicle as it followed the exit ramp lane, indicate that he was not operating the vehicle asleep. The Safety Board concludes that the investigation found no evidence of the driver being asleep or otherwise incapacitated prior to the accident.

The driver was taking sertraline to control depression. The medication was found in his blood at a level many times than would be expected with the dose that he was prescribed, but near the level expected with the maximal dose of the substance.[50] Controlled studies of the medication have not shown any significant sedation or interference with psychomotor performance at recommended doses, and the medication appears to improve performance in depressed patients.[51] The driver was also prescribed clonazepam at bedtime to assist with sleep, but it is not clear when he might have taken the medication. The medication was not detected in the driver's blood, but therapeutic concentrations are considerably below the levels typically reported by the CAMI toxicology laboratory.[52] Clonazepam has been shown to impair cognitive and psychomotor tasks for at least 2 hours in the dose prescribed for the driver.[53] Though it seems unlikely that the driver would have taken the medication within a few hours of the time of the accident, it cannot be completely excluded that the driver may have been impaired by the use of clonazepam.

[49] National Transportation Safety Board, *Factors That Affect Fatigue in Heavy Truck Accidents*, NTSB Safety Study NTSB/SS-95/01 (Washington, DC: NTSB, 1995).

[50] Based on data in R.C. Baselt, *Disposition of Toxic Drugs and Chemicals in Man*, 5th ed. (Foster City, California: Chemical Toxicology Institute, 2000).

[51] See, for example: (a) W. Bondareff, M. Alpert, A.J. Friedhoff, E.M. Richter, C.M. Clary, and E. Batzar, "Comparison of Sertraline and Nortriptyline in the Treatment of Major Depressive Disorder in Late Life," *American Journal of Psychiatry* Vol. 157, No. 5 (May 2000): 729-36 and (b) M. Siepmann, J. Grossmann, M. Muck-Weymann, and W. Kirch, "Effects of Sertraline on Autonomic and Cognitive Functions In Healthy Volunteers," *Psychopharmacology* Vol. 168, No. 3 (2003): 293-8.

[52] Baselt, *Disposition of Toxic Drugs and Chemicals in Man*.

[53] J.D. Wildin, B.J. Pleuvry, G.E. Mawer, T. Onon, and L. Millington, "Respiratory and Sedative Effects of Clobazam and Clonazepam In Volunteers," *British Journal of Clinical Pharmacology* Vol. 29, No. 2 (February 1990): 169-77.

Medical Certification

The driver did not possess a valid medical certificate at the time of the accident, but there is no evidence that the State or the motor carrier knew the driver would be operating the accident trip with an invalid medical certificate. It is also unclear whether the driver was aware that his medical certificate had expired 1 day before the accident trip. Being out of compliance by a matter of hours provides no indication of the driver's medical condition, but it does mean that the driver was not medically examined and certified according to 49 CFR 391.45. Executive Coach was responsible for ensuring that only medically qualified drivers were operating commercial vehicles in interstate commerce (49 CFR 391.41) and for having a copy of the current medical examiner's certificate in its driver qualification files (49 CFR 391.51).

The driver visited his primary care provider 10 days before the accident, but no record could be found that he had completed a medically qualifying exam at that time. He had used three different providers to complete his last three medical certification examinations, and it is possible that he completed such an exam but had not provided the motor carrier with a copy of a certificate or report obtained. No current mechanism exists for the tracking of such examinations.

The Safety Board's Most Wanted List of Transportation Safety Improvements includes the prevention of medically unqualified drivers from operating commercial vehicles. Safety Recommendations H-01-17 through -24,[54] issued as a result of the Safety Board's investigation of a 1999 motorcoach accident in New Orleans,[55] address Federal medical oversight of commercial drivers.[56] The two safety recommendations that are relevant to this accident—H-01-18, which covers the establishment of a tracking mechanism for exams performed, and H-01-20, which covers the provision of specific guidance for examiners—are both classified "Open—Unacceptable Response." The Safety Board is aware that the FMCSA recently addressed the issue of guidance on obstructive sleep apnea at a Medical Review Board meeting in Salt Lake City in January 2008. The Medical Review Board recommended screening guidelines for the disorder, which the FMCSA is now considering. The Safety Board's recommendations on the medical certification process of commercial vehicle drivers address all aspects of an appropriate, comprehensive program, and the Safety Board is closely following the FMCSA's work to develop such a program.

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[54] Only three of these eight recommendations are currently in "Acceptable" status: H-01-19, on updating medical certification regulations, and H-01-22 and -23, on the enforcement of medical certificate requirements.

[55] National Transportation Safety Board, ***Motorcoach Run-Off-The-Road Accident, New Orleans, Louisiana, May 9, 1999,*** Highway Accident Report NTSB/HAR-01/01 (Washington, DC: NTSB, 2001).

[56] For more information, see <http://www.ntsb.gov/recs/mostwanted/medical_certification.htm>.

Motor Carrier Driver Oversight

The accident driver failed to properly record hours-of-service information for the trip from Ohio to Georgia, and the investigation revealed that Executive Coach did not track the work hours of part-time drivers employed by other companies. Further, on April 4, 2007, the FMCSA conducted a postaccident safety assessment of Executive Coach. Although the carrier received a satisfactory rating, several regulatory requirements were not being met. Driver-related violations included the following: failure to ensure that random drug and alcohol tests were unannounced (382.305(k)(1)); using a driver not medically examined and certified during the preceding 24 months (391.45(b)(1)); failure to complete a record of duty status (395.8(e)); failure to require the driver to prepare a record of duty status in the prescribed form and manner (395.8 (f)); failure to obtain from a driver used for the first time or intermittently a signed statement providing total time on duty the preceding 7 days and the time last relieved from duty (395.8(j)(2)); failure to ensure that driver vehicle inspection reports are complete and accurate (396.11(b)); and failure to ensure that the driver signs the vehicle inspection report when defects or deficiencies are noted (396.13(c)). This lax record-keeping, along with the fact that Executive Coach was unaware that the accident driver would be operating the trip with an expired medical certificate, leads the Safety Board to conclude that Executive Coach inadequately monitored its drivers to determine their compliance with the *Federal Motor Carrier Safety Regulations* related to motorcoach operation.

As a result of its 1999 special investigation on motorcoach issues,[57] the Safety Board asked the FMCSA to change its safety fitness rating methodology so that either adverse vehicle or driver performance alone is sufficient to result in an overall unsatisfactory rating of the carrier (H-99-6). The status of that recommendation is currently "Open—Acceptable Response," and the issue remains on the Safety Board's Most Wanted List. In its 2005 response to the Safety Board regarding that recommendation, the FMCSA described its Comprehensive Safety Analysis 2010 (CSA 2010) initiative and plans for further rulemaking action regarding performance-based safety fitness procedures. Subsequent to that response, the Safety Board has had numerous briefings concerning the progress of CSA 2010. As recently as February 2008, the Safety Board received a status briefing from the FMCSA on its progress with CSA 2010, which provided an overview of a prototype system that targets unsafe practices and measures driver and carrier performance. According to the FMCSA, CSA 2010 contains both carrier and driver components and will result in a performance-based operational model for determining motor carrier safety. The agency began limited testing of the CSA 2010 program in 2008.[58]

[57] National Transportation Safety Board, *Selective Motorcoach Issues*, Special Investigation Report NTSB/SIR-99/01 (Washington, DC: NTSB, 1999).

[58] Three of the seven behavioral analysis and safety improvement categories and eight of nine interventions will be tested in four States: Colorado, Georgia, Missouri, and New Jersey.

In its December 2007 report,[59] the Government Accountability Office (GAO) reviewed the framework that the FMCSA has developed for managing and testing CSA 2010 and concluded that it is reasonable. According to the GAO report, the FMCSA expects to implement the carrier safety measurement system by 2010 but does not anticipate the testing and deployment of CSA 2010's driver safety measurement system and interventions to occur until after 2010.

As a result of its investigation of the Wilmer, Texas, accident during the evacuation of Hurricane Rita,[60] the Safety Board reiterated Safety Recommendation H-99-6 and issued a new recommendation as follows:

> H-07-3
>
> To protect the traveling public until completion of the Comprehensive Safety Analysis 2010 Initiative, immediately issue an Interim Rule to include all *Federal Motor Carrier Safety Regulations* in the current compliance review process so that all violations of regulations are reflected in the calculation of a carrier's final rating.

The current status of Safety Recommendation H-07-3 is "Open—Initial Response Received"; the FMCSA's response to this recommendation is currently being evaluated by the Safety Board. The FMCSA's postaccident compliance review rating for Executive Coach provides further evidence that a change in the assessment of motor carrier safety fitness methodology is warranted.

Event Data Recorders

An EDR is a device or function that records a vehicle's dynamic, time-series data just before a crash (vehicle speed versus time) or during a crash (change in velocity versus time). Intended for retrieval after the crash event, EDR data can provide critical safety system performance information.[61] To enhance crash testing with real-world data, it is important that data from motorcoach crashes be used for postaccident analysis, forensics, and design evaluation. At a recent SAE International (SAE) symposium on highway EDRs,[62] industry representatives presented the status of standards work, current system operating experience, and evidence that many operators currently use vehicle data recorders to improve

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[59] U.S. Government Accountability Office, *Motor Carrier Safety: The Federal Motor Carrier Safety Administration Has Developed a Reasonable Framework for Managing and Testing Its Comprehensive Safety Analysis 2010 Initiative*, GAO-08-242R (Washington, DC: GAO, December 2007).

[60] NTSB/HAR-07/01.

[61] The Safety Board's 1999 bus crashworthiness special investigation identifies minimum vehicle parameters for recording. For more information, see National Transportation Safety Board, *Bus Crashworthiness Issues*, Highway Special Investigation Report NTSB/SIR-99/04 (Washington, DC: NTSB, 1999) 66.

[62] *Highway Vehicle Event Data Recorder Symposium*, *September 5-6, 2007* (Ashburn, Virginia: SAE International).

operational control, to support insurance rates and claims, and to respond to litigation.

It is unfortunate that the Atlanta accident motorcoach was not equipped with any level of technology to provide vital precrash data. Lack of valuable crash data continues to restrict accident investigations; for example, in this accident, data concerning the exact vehicle speed, status of the cruise control and high beams, throttle position, and driver steering and brake inputs, as well as several other parameters, could not be precisely determined based on physical evidence. The Safety Board's investigation into the cause of passenger injuries and the points of ejection was severely limited because insufficient data were available from which to calculate reliable crash pulses.[63] An EDR would have provided vehicle dynamics information throughout the accident sequence. Crash pulses and/or Delta V are often used to calculate passenger occupant kinematics, help evaluate injury exposure, and help evaluate passenger protection safety devices and systems. Using these data, investigators can predict potential injury mechanisms and the effects of various design elements on occupant protection systems.

Although crash forces can sometimes be estimated by comparing the accident vehicle's physical damage to instrumented crash test data, this method is not always reliable—particularly when crash test data are substantially limited, as they are for motorcoaches, and when the accident involves a barrier collision or a collision with a hard paved surface. The ability to estimate crash pulses was also limited by the fact that some surfaces of the motorcoach may have undergone multiple collisions. The Safety Board concludes that information on the acceleration time history (or crash pulses) critical to the evaluation of vehicle performance and occupant protection systems was unavailable to accident investigators and researchers because of the motorcoach's lack of an EDR.

As a result of its 1996 safety study on child restraint systems[64] and subsequent 1997 air bag forum,[65] the Safety Board recommended that the National Highway Traffic Safety Administration (NHTSA) address the on-board recording of crash data.[66] About that time, the National Aeronautics and Space Administration and the Jet Propulsion Laboratory also recommended that NHTSA study the feasibility of installing and obtaining crash data for safety analysis from crash recorders on vehicles. In response, NHTSA organized the EDR Working Group,

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[63] The term *crash pulse*, as used here, refers to the acceleration versus time history. It may be more helpful to think in terms of "crash forces" because the forces a vehicle is subjected to as a result of a collision are a direct function of the crash pulse.

[64] National Transportation Safety Board, *The Performance and Use of Child Restraint Systems, Seatbelts, and Air Bags for Children in Passenger Vehicles*, Safety Study NTSB/SS-96/01 (Washington, DC: NTSB, 1996).

[65] National Transportation Safety Board, *Proceedings of the National Transportation Safety Board Public Forum on Air Bags and Child Passenger Safety*, Report of Proceedings NTSB/RP-97/01 (Washington, DC: NTSB, 1997).

[66] Safety Recommendation H-97-21 asked that automobile manufacturers develop and implement a plan to gather better information on crash pulses and other crash parameters in actual crashes, utilizing current or augmented crash sensing and recording devices.

which first met in October 1998. In 1999, the Safety Board held a symposium on transportation recorders.[67] Later that year, as a result of its special investigation on bus crashworthiness,[68] the Safety Board made the following two EDR-related recommendations to NHTSA:

> H-99-53
>
> 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-99-54
>
> 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.

In October 2000, NHTSA organized the Truck and Bus Event Data Recorder Working Group to focus on data elements, survivability, and event definitions related to trucks, school buses, and motorcoaches. The group's results and findings

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

[68] NTSB/SIR-99/04.

were published in May 2002.[69] In 2004, the NCHRP completed a project that examined current U.S. and international methods and practices for the collection, retrieval, archiving, and analysis of EDR data for roadside and vehicle safety.[70] Both the IEEE[71] and SAE have published voluntary industry motor vehicle EDR standards.[72] A second SAE standards committee, J2728—Commercial Vehicle Event Data Recorders, is specifically addressing data elements for medium- and heavy-duty trucks.[73] Industry initiatives in standards development include the American Trucking Associations Technology and Maintenance Council's publication of a recommended practice to define the collection of event-related data on board commercial vehicles. The recommended practice outlines data elements, storage methodology, and retrieval approach for event data recording on commercial vehicles.

In the meantime, the FMCSA's "Commercial Vehicle Safety Technology Diagnostics and Performance Enhancement Program" (also known as the "CV Sensor Study") has worked to define driver and vehicle assistance products and systems and, in particular, advanced sensor and signal processors in trucks and tractor-trailers, with an emphasis on on-board diagnostic and improved safety-related products. The program involves developing EDR requirements for the analysis of accident data from the FMCSA's *Large Truck Crash Causation Study*, with the goal of developing EDR functional specifications for both complete accident reconstruction and crash analyses. To date, this project has developed requirements for EDR components, hardware, software, sensors, and databases and has completed a cost-effectiveness analysis.[74]

In recent years, NHTSA has made progress in developing EDR data standards for light vehicles, which include passenger cars, multipurpose passenger vehicles, light trucks, and vans with a gross vehicle weight rating of 3,855 kilograms (8,500 pounds) or less.[75] In August 2006, NHTSA published a final

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[69] National Highway Traffic Safety Administration, *Event Data Recorders, Summary of Findings by the NHTSA EDR Working Group, Vol. II--Supplemental Findings for Trucks, Motorcoaches, and School Buses,* DOT HS 809 432 (Washington, DC: NHTSA, 2002).

[70] H.C. Gabler, D.J. Gabauer, H.L. Newell, and M.E. O'Neill, *Use of Event Data Recorder Technology for Highway Crash Data Analysis,* NCHRP Project 17-24: Contractor's Final Report (Washington, DC: TRB, 2004).

[71] Formerly the Institute of Electrical and Electronics Engineers, Inc., the organization is now known exclusively by the acronym IEEE.

[72] IEEE Standard 1616-2004, *IEEE Standard* for *Motor Vehicle Event Data Recorders* (February 2005), and SAE Recommended Practice J1698-1, *Vehicle Event Data Recorder Interface—Output Data Format* (December 2003).

[73] Safety Recommendation H-02-35 called for the IEEE to develop on-board recorder standards that include time-stamped brake and transmission electronic fault codes using a recognized clock synchronized with other on-board EDR devices.

[74] See FHWA IVI Program 134, "Development of Requirements and Functional Specifications for Event Data Recorders," <http://www.itsdocs.fhwa.dot.gov/JPODOCS/REPTS_TE/14146.htm>, accessed April 3, 2008.

[75] See Event Data Recorders—Final Rule, 49 *CFR* Part 563, NHTSA docket no. 25666, August 28, 2006. The rule includes qualifications for an unloaded vehicle weight of 2,495 kg (5,500 pounds or less), with the

rule that standardizes the information EDRs collect, making EDR data retrieval easier, and that addresses the survivability requirements for EDRs based on crash testing.[76] The final rule was amended on January 14, 2008, in response to numerous petitions for reconsideration. Based on this revised rule, compliance dates have been changed to September 1, 2012, for most light vehicles, and to September 1, 2013, for vehicles manufactured in two or more stages. The new rule, however, does not address vehicles over 8,500 pounds and thus would not apply to buses or motorcoaches.

In its August 2007 "Approach to Motorcoach Safety,"[77] NHTSA included a discussion of EDRs, stating that the agency has recently defined mandatory data elements for the voluntary installation of EDRs in light passenger vehicles. However, crash characteristics and relevant measurements for motorcoaches are different, as supported by the 2001 NHTSA EDR Working Group final report's "Summary of Findings":[78]

> given the differing nature of cars, vans, SUVs [sport utility vehicles] and other lightweight vehicles, compared to heavy trucks, school buses, and motorcoaches, different EDR systems may be required to meet the needs of each vehicle class.

The EDR Working Group's final report also noted the following:

- EDRs can improve highway safety for all vehicle classes by providing more accurate data for accident reconstructions, and
- U.S. and European studies have shown that the number and severity of crashes is reduced when drivers know that an on-board EDR is in operation.

However, NHTSA's "Approach to Motorcoach Safety" also makes the seemingly contradictory statement that Safety Recommendations H-99-53 and -54 concerning EDRs do not specifically relate to changes that would have a direct or quantifiable safety benefit for motorcoach occupants.[79] The Safety Board disagrees; the lack of useful event data associated with accident motorcoaches represents a missed opportunity to better understand crash forces, ejection dynamics, and crashworthiness. The Safety Board concludes that EDRs would provide the accurate and detailed event data necessary to better understand crash causation and to establish design requirements for motorcoach crashworthiness and

exception of walk-in type vans or vehicles that are designated to be sold exclusively to the U.S. Postal Service.

[76] The rule includes standards for 45 EDR data elements: 15 standard data elements and 30 extra data elements for advanced EDRs.

[77] National Highway Traffic Safety Administration, "Approach to Motorcoach Safety," NHTSA docket no. 2007-28793-0001, page 20.

[78] NHTSA docket no. 1999-5218-0009, page xi.

[79] NHTSA docket no. 2007-28793-0001, page 20.

occupant protection systems. The need for such information is particularly significant as EDRs become more widely used in the truck and transit industry, as evidenced at the September 2007 EDR symposium sponsored by SAE.[80] During the symposium, representatives from industry noted that EDR applications are being more widely used for motor carrier analysis of accidents and to support more accurate insurance underwriting and risk analysis.

Also in its "Approach to Motorcoach Safety," NHTSA states "Upon completion of SAE J2728, consideration of a requirement for heavy vehicle EDR installation into motorcoaches would be appropriate."[81] The Safety Board recognizes NHTSA's progress in developing EDR standards for light vehicles. As a result of NHTSA's work to date, Safety Recommendations H-99-53 and -54 are currently classified "Open—Acceptable Response." However, this accident again clearly illustrates the importance of this issue for heavy vehicles. The Safety Board therefore concludes that establishing EDR performance standards for motorcoaches and buses is necessary for the timely and efficient implementation of EDRs, which will, in turn, provide the data needed to develop effective occupant protection systems. The Safety Board urges NHTSA to actively push to complete standards work and, based on the development of standards for large motorcoaches, to require EDRs on all new motorcoaches. The Safety Board therefore reiterates Safety Recommendations H-99-53 and -54.

Survival Aspects and Motorcoach Occupant Protection

Of the 35 motorcoach occupants in this accident, 7 were killed, including the driver and his wife, both of whom wore lap belt restraints. The other five fatally injured occupants were ejected from the motorcoach. Five additional occupants were ejected and two more occupants were partially ejected.

From 2000 through 2006,[82] 43 motorcoach accidents occurred in which at least one occupant was fatally injured. In these motorcoach accidents, which resulted in 122 total fatalities (17 fatalities per year), 41 occupants were partially or fully ejected from the motorcoach (34 percent). In 15 of the 43 accidents (35 percent), the motorcoach rolled over; 38 of the 41 ejected fatalities (93 percent) occurred during rollover accidents. Similar analyses of occupant injury data can be found in studies conducted by other countries.[83]

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[80] *Highway Vehicle Event Data Recorder Symposium*, September 5 through 6, 2007, Ashburn, Virginia, SAE International.

[81] *Approach to Motorcoach Safety*, NHTSA docket no. 2007-28791, page 21.

[82] The Safety Board's analysis of Fatality Analysis Reporting System data involved motorcoaches defined as a cross-country/intercity bus type or buses with no specific body type having a gross vehicle weight rating of 26,000 pounds or greater that are being used in scheduled service, commuter service, or as charter, tour, or shuttle buses.

[83] M. Matolcsy, "The Severity of Bus Rollover Accidents," *Proceedings: 20th International Technical Conference on the Enhanced Safety of Vehicles, Lyon, France, June 18 through 21, 2007*, Paper No. 07-0989 (2007). See <http://www-nrd.nhtsa.dot.gov/pdf/nrd-01/esv/esv20/07-0152-O.pdf>, accessed April 3, 2007.

The *Federal Motor Vehicle Safety Standards* contain 22 standards on crashworthiness. Most of these standards exempt motorcoaches with a gross vehicle weight over 10,000 pounds, and no Federal regulations require that motorcoaches in the United States be equipped with an occupant protection system. Although motorcoaches must comply with Federal Motor Vehicle Safety Standard (FMVSS) 217, which establishes minimum requirements for motorcoach window retention and release, and FMVSS 302, which establishes standards for the flammability of interior materials,[84] they do not have to comply with the host of other FMVSS occupant protection standards that apply to school buses[85] and passenger cars.

A well-designed vehicle will manage the energy of a crash through its structure and minimize the energy transfer to passengers through an occupant protection system, which functions to retain the passengers within the seating compartment throughout the accident sequence and minimize the risk of injury. One example of an occupant protection system, known as "compartmentalization,"[86] has been studied, tested, and required in school buses but not in motorcoaches.

Occupant Protection Initiatives

In 1994, the European Commission initiated a project to improve safety by fitting seat belts on motorcoaches.[87] That study found that passenger ejection is a major cause of death and injury and that, although seat belts can significantly reduce or prevent passenger ejection, the whole system—seats, seat belts, and all anchorages—must be considered to ensure effectiveness. A more recent European Union (EU) study, by TNO-Automotive in the Netherlands,[88] concluded that wearing either a lap or a lap/shoulder belt[89] is safer than not wearing a seat belt and that the main advantage of wearing seat belts in a motorcoach is to prevent ejection during rollover accidents, as well as during frontal accidents.

[84] FMVSS 208, Occupant Crash Protection; FMVSS 209, Seat Belt Assemblies; and FMVSS 210, Seat Belt Assembly Anchorages presently apply to the driver's seat only.

[85] 49 *U.S.C.* §30125 defines a *school bus* as any vehicle that is designed for carrying a driver and more than 10 passengers and which, as NHTSA determines, is likely to be "used significantly" to transport "preprimary, primary, and secondary" students to or from school or related events (which include school-sponsored field trips and athletic events). This definition was enacted in 1974, as part of a comprehensive effort by Congress to enhance school bus safety.

[86] *Compartmentalization* is an occupant protection system using closely spaced seats that have energy-absorbing seatbacks to create a protective envelope for the occupant.

[87] D. Kecman and others, "Study of the Technical Requirements for Fitment of Seat Belts on Minibuses and Coaches," Cranfield Impact Centre Report to European Commission, DGIII, Contract No. ETD/94/B5–3000/MI/05 (1994-1995).

[88] C.G. Huijskens, M. Schrooten, and P. de Coo, "Frontal Occupant Safety Simulation for Coach and Bus Passengers," *Proceedings: 18th International Technical Conference on the Enhanced Safety of Vehicles, Nagoya, Japan, May 19 through 22, 2003,* Paper No. 284 (2003). See <http://www-nrd.nhtsa.dot.gov/pdf/nrd-01/esv/esv18/CD/Files/18ESV-000284.pdf>, accessed April 16, 2008.

[89] Two-point belts extend across the lap; three-point belts are lap/shoulder combinations.

Since 1997, EU member states have required two-point lap belts and energy-absorbing seats or three-point lap and shoulder belts on all M3 motorcoaches.[90] Economic Commission for Europe (ECE) Regulation 80 specifies the strength of seats on large passenger buses (16 or more passengers), requiring passengers to remain in the predetermined zone in cases of a 30-kilometer-per-hour impact. ECE Regulation 14 addresses seat anchorages, and ECE Regulation 16 mandates safety belts for occupants of power-driven vehicles. The EU has tested a universal motorcoach safety seat that employs a lap/shoulder belt to restrain a 50th percentile dummy under the most extreme conditions (as defined by ECE Regulation 80) and simultaneously restrains unbelted or lap-belted 50th percentile dummies seated behind the test seat. The specified injury criteria for lap-belted or unbelted dummies seated behind the test seat are also met when the test seat is empty. Recent research considering occupant safety issues in EU countries finds that the use of seat belts is strongly recommended during vehicle rollover and that the use of lap/shoulder belt systems is recommended for front- and rear-impact events.[91]

Australia applies a set of design rules in addition to ECE requirements.[92] The Federal Office of Road Safety in Canberra conducted a 5-year study (1988 to 1993) of 23 motorcoach accidents to identify occupant protection issues involving long distance coaches.[93] Since 1994, Australian Design Rule 68/00 has required that all newly manufactured motorcoaches have a lap/shoulder belt system.

NHTSA's 2007 "Approach to Motorcoach Safety" from the Office of Crashworthiness Standards states, "Installing seat belts [on motorcoaches] would be the most direct method of retaining passengers within a seating compartment." Yet, NHTSA also states that the fundamental information necessary to establish adequate performance requirements for seat belts on motorcoaches does not exist. Had NHTSA promptly set about defining the FMVSS requirements for motorcoach occupant protection following the Safety Board's 1999 bus crashworthiness special investigation, as has been accomplished by the EU and Australia, these standards could now be identified for U.S. motorcoaches.[94] NHTSA has only recently reinstated a program to characterize restraint response in rollovers. Consequently, the Safety Board concludes that because of NHTSA's delay in defining motorcoach

[90] Within the EU, the M-definition of buses provides a common classification of coaches based on weight. M3 coaches are defined as weighing more than 5 tons. The M-definitions are further separated into classes I through III based on application.

[91] E. Mayrhofer, H. Steffan, and, H. Hoschopf, "Enhanced Coach and Bus Occupant Safety," *Proceedings: 19th International Technical Conference on the Enhanced Safety of Vehicles, Washington, D.C., June 6–9, 2005,* Paper No. 05-0351 (2005). See <http://www-nrd.nhtsa.dot.gov/pdf/nrd-01/esv/esv19/05-0351-O.pdf>, accessed April 3, 2008.

[92] Australia requires three-point seat belts and 20 g seats.

[93] K.B. Smith, "Fatal and Serious Injury Bus Crashes," Working Document WD117 (Canberra, Australia: Federal Office of Road Safety, November 1993).

[94] M. Sword and L. Sullivan, "NHTSA Research on Improved Strength in Rollovers," *Proceedings: 20th International Technical Conference on the Enhanced Safety of Vehicles, Lyon, France, June 18 through 21, 2007*, Paper No. 07-0297 (2007). See <http://www-nrd.nhtsa.dot.gov/pdf/nrd-01/esv/esv20/07-0279-O.pdf>, accessed April 16, 2007.

occupant protection performance standards, U.S. motorcoaches have not been equipped with such systems, leaving the traveling public inadequately protected during motorcoach collisions, particularly during rollovers.

Past Investigations and Actions

Between 1968 and 1973, the Safety Board issued a series of recommendations to the FHWA and NHTSA concerning occupant protection. Safety Recommendation H-73-42, calling for bus passenger restraints, was classified "Closed—Reconsidered" in June 1988, with the provision that the Safety Board would continue to monitor motorcoach accidents to determine whether the installation and use of seat belts would mitigate injuries. From 1968 to 1997, the Safety Board investigated 36 motorcoach accidents resulting in 168 occupant fatalities, 106 (63 percent) of which occurred in accidents involving a rollover.[95] Of those 106 fatally injured passengers, 64 were ejected.

In 1999, the Safety Board published two special investigation reports[96] that addressed motorcoach occupant protection; in May 2000, this issue was placed on the Safety Board's Most Wanted List. Two recommendations related to motorcoach occupant protection particularly apply to the circumstances of this accident: Safety Recommendation H-99-47,[97] which calls for the development of standards for motorcoach occupant protection systems, and Safety Recommendation H-99-48, which calls for those systems, once developed, to be required on newly manufactured motorcoaches. NHTSA's initial response indicated that work had begun to develop a research plan to accomplish these recommendations. Two years later, NHTSA reported forming the Bus Manufacturer's Council; in 2002, the agency held a public forum on motorcoach safety with Transport Canada. During meetings with NHTSA in 2004, the Safety Board was informed that the agency was focusing on roof crush and window retention technology to keep occupants in the vehicle and had initiated a joint study with Transport Canada.

Safety Recommendations H-99-47 and -48, issued as a result of the Safety Board's 1999 bus crashworthiness special investigation, were reiterated in 2001 following a 1999 motorcoach accident in New Orleans.[98] Since 1998, the Safety Board has investigated 33 more motorcoach crashes involving 255 ejections and 123 fatalities (see appendix C). These accidents, the majority of which involve rollover crashes, clearly show that passengers who remain in their seating compartments sustain fewer injuries and that ejected passengers are the most likely to be killed.

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95 See NTSB/SIR-99/04, appendix F, for a list of these accidents.

96 NTSB/SIR-99/04 examined 46 accidents, 36 of which involved motorcoaches; NTSB/SIR-99/01 examined 2 motorcoach accidents.

97 The Safety Board classified Safety Recommendation H-99-47 "Open—Acceptable Response" at its November 8, 2007, progress meeting and update of Most Wanted issues.

98 NTSB/HAR-01/01.

Today, 9 years after the Safety Board concluded in its bus crashworthiness special investigation that one of the primary causes of preventable injury in motorcoach accidents involving rollover and/or ejection is occupant motion out of the seating compartment, no Federal regulations or standards require that motorcoaches operated in the United States be equipped with occupant protection systems.[99] Consequently, the Safety Board again reiterates the following recommendations to NHTSA:

H-99-47

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

H-99-48

Once pertinent standards have been developed for motorcoach occupant protection systems, require newly manufactured motorcoaches 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.

The Safety Board recognizes that NHTSA has recently conducted crash tests and, in fact, Safety Board investigators observed a frontal motorcoach crash test performed in December 2007 at the Vehicle Research and Test Center and two tests of motorcoach roof strength and occupant survivable space performed in February 2008 by the MGA Research Corporation, under contract to NHTSA.[100] The Safety Board will carefully follow the analysis of those test results.

The Safety Board notes that, based on accident statistics, motorcoaches are among the safest vehicles on the road. However, motorcoaches transport a substantial number of people traveling in a single vehicle with a high exposure to crash risk;[101] typically involve commercial fees for travel; and operate with established systems for inspections, specialized training, and driver medical requirements. Moreover, special populations, such as students and older adults, rely on motorcoach travel. These factors demand that motorcoaches meet the highest level of safety.

[99] Except for restraints at the driver's position.

[100] These tests used the following protocols: FMVSS 220, School Bus Rollover Protection, which involves loading the vehicle roof using a force 1.5 times its unloaded weight, and international standard ECE Regulation 66, Uniform Provisions Concerning the Approval of Large Passenger Vehicles With Regard to the Strength of Their Superstructure, which involves a rollover test from a tilt platform.

[101] Motorcoaches transport 631 million passengers annually. VanHool recently introduced an 80-passenger, double-decked motorcoach, model TD925, into the U.S. market. Such large-capacity vehicles have the potential to further increase the number of passengers involved per accident.

Conclusions

Findings

1. The following factors neither caused nor contributed to the accident: the weather; the mechanical condition of the vehicle; the driver's qualifications and driving record; or driver impairment due to alcohol, illicit drugs, or narcotic pain medication.

2. The emergency response was timely and effective.

3. The Georgia Department of Transportation failed to identify the Northside Drive HOV-only left exit, which was in a left curve preceding a high-speed left interstate merge, as an unexpected arrangement that required additional traffic control devices to guide road users.

4. The Georgia Department of Transportation, in changing the original design plan by separating the Northside Drive HOV exit sign from the Interstate 75 South pull-through sign, caused the effective meaning of the paired signs to be lost at a critical decision point on the highway.

5. Positioning the Northside Drive HOV-only left exit direction sign next to the Interstate 75 South pull-through sign will promote positive guidance to motorists on the appropriate travel lanes at a critical decision point on the highway.

6. Because of the unique combination of geometric features and lane restrictions of an HOV-only left exit, redesigning the Northside Drive exit signs to include a message plaque with the legend *LEFT* in black on a yellow background placed at the top left edge of the *1 MILE* and 1/2 *MILE* guide signs will better alert drivers to the unconventional exit design.

7. Because the Northside Drive exit ramp is short and terminates at a nonsignalized intersection, an advisory ramp speed sign is needed for motorist safety.

8. The use of yellow dashed lines for left exit pavement markings and white dashed lines for right exit pavement markings should be considered to emphasize and distinguish left exits.

9. Pairing an *EXIT* pavement marking with the HOV diamond pavement marking is a useful traffic control enhancement for all left HOV exits.

10. This accident illustrates the importance of HOV traffic control devices being sufficiently similar, regardless of their geographic location, to create consistent expectations related to common geometric, operational, and route characteristics.

11. The supplemental *LEFT* message plaques required by the *Manual on Uniform Traffic Control Devices*' proposed standard should be phased in sooner than the typical 10-year compliance timeframe.

12. The investigation found no evidence of the driver being asleep or otherwise incapacitated prior to the accident.

13. Executive Coach Luxury Travel, Inc., inadequately monitored its drivers to determine their compliance with the *Federal Motor Carrier Safety Regulations* related to motorcoach operation.

14. Information on the acceleration time history (or crash pulses) critical to the evaluation of vehicle performance and occupant protection systems was unavailable to accident investigators and researchers because of the motorcoach's lack of an event data recorder.

15. Event data recorders would provide the accurate and detailed event data necessary to better understand crash causation and to establish design requirements for motorcoach crashworthiness and occupant protection systems.

16. Establishing event data recorder performance standards for motorcoaches and buses is necessary for the timely and efficient implementation of event data recorders, which will, in turn, provide the data needed to develop effective occupant protection systems.

17. Because of the National Highway Traffic Safety Administration's delay in defining motorcoach occupant protection performance standards, U.S. motorcoaches have not been equipped with such systems, leaving the traveling public inadequately protected during motorcoach collisions, particularly during rollovers.

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the motorcoach driver's mistaking the HOV-only left exit ramp to Northside Drive for the southbound Interstate 75 HOV through lane. Contributing to the accident driver's route mistake was the failure of the Georgia Department of Transportation to install adequate traffic control devices to identify the separation and divergence of the Northside Drive HOV-only left exit ramp from the southbound Interstate 75 HOV through lane. Contributing to the severity of the accident was the motorcoach's lack of an adequate occupant protection system.

Recommendations

New Recommendations

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

To the Federal Highway Administration:

Include in a *Manual on Uniform Traffic Control Devices* standard the requirements for HOV-only left exits to have *LEFT* message plaques on all exit guide signs and for exit direction (arrow) signs to be positioned next to pull-through signs at exits with limited sight distance, short ramps, or multiple route choices. (H-08-3)

Include in a *Manual on Uniform Traffic Control Devices* standard criteria for the use of advisory speed limit signs for all interstate exit ramps. (H-08-4)

Evaluate the *Manual on Uniform Traffic Control Devices* standard for guide line marking requirements for interstate left exits. (H-08-5)

Work with the National Committee on Uniform Traffic Control Devices to ensure that the next edition of the *Manual on Uniform Traffic Control Devices* is issued as scheduled in 2008 and that the revision comprehensively addresses the uniformity of HOV traffic control devices, including left exits. (H-08-6)

Require a phase-in period of 5 years for supplemental *LEFT* message plaques in the standard proposed for the next edition of the *Manual on Uniform Traffic Control Devices*. (H-08-7)

To the Georgia Department of Transportation:

Install a *LEFT* message plaque on the *1 MILE* and the *1/2 MILE* advance exit guide signs and on the directional arrow exit sign for Northside Drive and position the pull-through sign for the southbound Interstate 75 HOV through lane so that it is next to the Northside Drive left-exit direction sign. (H-08-8)

Install exit signs with *LEFT* message plaques for left interstate exits. (H-08-9)

Install pull-through signs next to the exit direction (arrow) signs to ensure positive route guidance at exits with limited sight distance, short ramps, or multiple route choices (H-08-10).

Install an advisory speed limit sign (*Manual on Uniform Traffic Control Devices* W13-2) on the Northside Drive HOV exit ramp and on interstate left exit ramps throughout the State. (H-08-11)

Add an *EXIT* pavement marking paired with the HOV diamond pavement marking at all left HOV interstate exits. (H-08-12)

Reiterated Recommendations

The National Transportation Safety Board reiterates the following recommendations:

To the National Highway Traffic Safety Administration:

In 2 years, develop performance standards for motorcoach occupant protection systems that account for frontal impact collisions, side impact collisions, rear impact collisions, and rollovers. (H-99-47)

Once pertinent standards have been developed for motorcoach occupant protection systems, require newly manufactured motorcoaches 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-99-48)

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)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

MARK V. ROSENKER
Chairman

ROBERT L. SUMWALT
Vice Chairman

DEBORAH A. P. HERSMAN
Member

KATHRYN O'LEARY HIGGINS
Member

STEVEN R. CHEALANDER
Member

Adopted: July 8, 2008

Member Hersman filed the following concurring statement on July 16, 2008, and was joined by Vice Chairman Sumwalt.

Board Member Statement

Member Hersman, concurring

The focus of this accident report is a tricky highway configuration and the placement of signage that was not adequate to safely guide drivers through a difficult interchange. The findings, probable cause, and recommendations concentrate on those two issues, as they should. However, a couple of facts that came out of this accident provide the perfect illustration of a safety issue that, while not the spotlight of this accident cause, will increasingly become a focal point of highway accidents in the years ahead.

The 65-year-old driver mistakenly drove his motorcoach at highway speed up an exit ramp, perhaps thinking that he was following the HOV lane to merge with another interstate highway. His actions in this crash repeated eight other similar crashes at this same interchange during the past ten years. All nine crashes involved drivers who apparently mistook the exit ramp for the HOV lane, and all nine crashes involved drivers who were over the age of 50. I don't believe this was a coincidence.

According to the Federal Highway Administration (FHWA), an exit gore on a highway presents a particular challenge to the older driver. The driver has to process a lot of directional information in a short time at a high rate of speed while moving with the traffic stream. In this type of situation, the chances are greater that the driver will become overloaded and make mistakes if the driver is older, according to the FHWA.

Safety Board investigators found that there have been other incidences of drivers mistaking this exit ramp for a continuation of the HOV lane when several people volunteered information about how they nearly crashed at this interchange. We will never know how many drivers have almost had a crash at this interchange because these near-accidents are not reported unless someone volunteers the information. Not all of the people who reported their near-accidents were older drivers, so we can assume with some certainty that not all of the people who experienced near-accidents at this interchange were older. However, all of the nine drivers who did crash at this interchange were older. They thus illustrate the point I attempted to make at the Board meeting and will attempt to make again here: older drivers, because of their age-related characteristics, are the drivers who point out for all of us the interchanges, intersections, highway designs, and signs that are most in need of attention to improve safety. Older drivers are like the canaries in the coal mine—they show us where there is danger because in comparison to most other drivers, they are less likely to be able to quickly compensate for confusing highway and traffic configurations and misleading or ill-placed signs. At this interchange on I-75 in Atlanta, those uncounted drivers who mistook the exit ramp for the HOV lane but managed to avoid a crash did not point out its dangers; the nine older drivers who crashed did.

Older drivers may experience difficulty at highway interchanges and other complex driving situations because of diminished capabilities typically related to age. For example, they have reduced night vision and contrast sensitivity. For every decade after age 25, drivers need twice the brightness at night to receive visual information. Hence, by the time some drivers reach the age of 75, they need 32 times the brightness they required at age 25. Older drivers also experience slowed response time and information-processing ability. The have a reduced ability to quickly localize the most relevant stimuli in a driving situation, and they are not as efficient in switching attention between multiple targets (*e.g.*, noting road signs while attempting to change lanes). They typically have some loss of vision, and they frequently experience increased sensitivity to glare.

These factors do not make older drivers inherently poor drivers, but they are more challenging for older drivers than for their younger counterparts. However, these very same factors also make it more obvious to the highway designers and engineers, who may not share these characteristics yet, where improvements should be made. Design improvements for older drivers are already outlined in FHWA and AASHTO guidance. These improvements include, among other things, better signage with larger type and placement for longer reaction time, advance warning signs indicating hazardous conditions on or near the road, improved lighting at intersections, horizontal curves and railroad grade crossings, improved pavement markings and raised lane channelization. Unfortunately, these guidelines are not universally followed.

If we think about the experiences of older drivers as beacons pointing us to the most needed safety improvements, the beacons will be shining a lot more brightly in the coming years. According to the National Highway Traffic Safety Administration, the number of licensed drivers aged 65 and older rose by 18% between 1996 and 2006. During that same time period, the total number of licensed drivers increased by only 13%. This means that our driving population is becoming proportionately older by a significant margin. In fact, the number of older drivers on the road is expected to double in the next 20 years. By the year 2030, just 22 years away, every fifth person on the road will be elderly. Right now, older drivers account for 16% of all traffic crashes. That rate will surely rise as our driving population gets older. The time is *now* to start making design changes in our highways that will accommodate our aging driving population so that when we get to 2030, our crash rate does not rise to unprecedented levels.

The Safety Board has consistently approached highway safety by addressing recommended improvements for discrete segments of the driving community: novice drivers, drinking drivers, motorcyclists, and commercial drivers. I recognize that any category of drivers is not monolithic, and that fact is true of older drivers. There are, however, characteristics common to many drivers in this segment of the driving community, and we should be mindful of those characteristics as our population ages. It is appropriate and timely for us to begin exploring improvements to safeguard the older driver segment, a group that is going to increase in size dramatically in the next two decades. We should use our older drivers as guides to point out the areas most in need of safety improvement and we should make design changes for them. If our streets, highways, intersections, signs, and signals are designed with the older driver in mind, they will be safer, not just for the older drivers among us, but for *all* drivers.

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Appendix A

Investigation

The National Transportation Safety Board was notified of the Atlanta accident on March 2, 2007. An investigative team was dispatched with members from the Washington, D.C., and Arlington, Texas, offices. Member Higgins was the member on scene. Groups were established to investigate human performance, motor carrier operations, event data, highway, vehicle, and survival factors.

Participating in the investigation were representatives of the Federal Highway Administration (FHWA), the Georgia Department of Transportation (GDOT), the Atlanta Police Department, and the Fulton County Police Department. Technical review of the Safety Board's factual material was completed on April 29, 2008. Participating parties included the Federal Motor Carrier Safety Administration, FHWA, and GDOT.

No public hearing was held and no depositions were taken.

In January 2008, Executive Coach Luxury Travel, Inc., was sold and is no longer operating.

Appendix B

Accident History for the Northside Drive Exit, 1997–2007

Date and time	Injuries	Fatalities	Collision type	Object struck	Light	Surface	Vehicle 1	Vehicle 2
12/1/97 12:50 a.m.	2	0	Single vehicle	Bridge rail	Dark (lighted)	Dry	Straight	n/a
12/24/98 3:50 p.m.	0	0	Angle	Vehicle in motion	Daylight	Wet	Changing lanes	Straight
10/17/99 9:10 p.m.	0	0	Single vehicle	Curb	Dark (lighted)	Dry	Straight	n/a
12/27/00 10:55 a.m.	4	0	Angle	Vehicle in motion	Daylight	Dry	Changing lanes	Straight
2/24/01 9:52 p.m.	1	1	Single vehicle	Bridge rail	Dark (lighted)	Dry	Straight	n/a
1/20/02 4:00 a.m.	2	0	Single vehicle	Fixed object	Dark (lighted)	Wet	Straight	n/a
8/11/02 9:41 a.m.	2	1	Single vehicle	Fixed object	Daylight	Dry	Straight	n/a
1/15/03 10:35 a.m.	3	0	Head on	Vehicle in motion	Daylight	Dry	Straight	Straight
3/2/07 5:38 a.m.	28	7	Single vehicle	Bridge rail	Dark (lighted)	Dry	Straight	n/a

Appendix C

Safety Board Motorcoach Accident Investigations

The National Transportation Safety Board's 1999 special investigation on bus crashworthiness issues[1] included statistics on 36 motorcoach accidents investigated by the Safety Board from 1968 through 1997. This appendix summarizes 33 frontal crash and rollover accidents investigated by the Safety Board (major accidents, field investigations, and incidents) since 1998. The table accounts for motorcoach passengers, not drivers, because drivers' use of seat belts decreases the likelihood of ejection.

Table 1. Motorcoach Accidents Investigated by the Safety Board Since 1998

	Year	Accident	Fatalities	Injuries	Ejections	Crash type
1	1998	Burnt Cabins, PA (HWY-98-MH-033)	6	16	0	Frontal impact
2	1998	Old Bridge, NJ (HWY-98-MH-033)	8	14	7	Rollover
3	1999	Santa Fe, NM (HWY-99-FH-012)	2	35[A]	1	Rollover
4	1999	New Orleans, LA (HWY-99-MH-017)	22	21	10	Frontal impact[B]
5	1999	Braidwood, IL (HWY-99-FH-017)	1	23	2	Rollover
6	1999	Canon City, CO (HWY-00-FH-011)	2	57	53	Rollover
7	2000	Eureka, MO (HWY-00-IH-051)	0	25	0	Frontal impact
8	2001	Allamuchy, NJ (HWY-01-FH-011)	0	39	0	Rollover
9	2001	Bay St. Louis, MO (HWY-01-IH-024)	0	16	0	Frontal impact[B]
10	2001	Fairplay, CO (HWY-01-IH-028)	0	45	12	Rollover
11	2001	Pleasant View, TN (HWY-01-FH-03)	1	43	1	Rollover
12	2002	Manchester, TN (HWY-02-IH-002)	6	Unknown[C]	6	Rollover
13	2002	Loraine, TX (HWY-02-MH-021)	3	29	0	Frontal Impact

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

	Year	Accident	Fatalities	Injuries	Ejections	Crash type
14	2002	Victor, NY (HWY-02-MH-025)	5	41	6	Rollover
15	2002	Nephi, UT (HWY-03-IH-001)	6	20	13	Rollover
16	2003	Hewitt, TX (HWY-03-MH-022)	5	29	15	Rollover
17	2003	Tallulah, LA (HWY-04-MH-002)	8	6	1	Frontal impact
18	2003	Apache Co., AZ (HWY-04-IH-007)	0	44	0	Rollover
19	2004	North Hudson, NY (HWY-04-FH-015)	0	47	0	Frontal impact
20	2003	Anahuac, TX (HWY-04-FH-026)	1	35	0	Frontal impact
21	2004	Phoenix, AZ (HWY-04-IH-029)	1	38	0	Frontal impact
22	2004	Jackson, TN (HWY-04-IH-035)	2	18	0	Frontal impact
23	2004	Turrell, AR (HWY-05-MH-006)	14	15	30	Rollover
24	2005	Geneseo, NY (HWY-05-FH-017)	3	20	0	Frontal impact
25	2005	Baltimore, MD (HWY-05-FH-031)	0	33	0	Rollover
26	2005	Osseo, WI (HWY-06-MH-003)	4	35	1	Frontal impact
27	2006	Westport, NY (HWY-06-MH-026)	4	48	22	Rollover
28	2006	Auburn, MA (HWY-06-IH-028)	0	34	0	Rollover
29	2007	Atlanta, GA (HWY-07-MH-015)	6	28	12	Frontal/rollover
30	2007	Clearfield, PA (HWY-07-IH-020)	2	25	2	Rollover
31	2007	Bowling Green, KY (HWY-07-IH-022)	1	64	10	Rollover
32	2008	Victoria, TX [D] (HWY-08-MH-001)	1	46	1	Rollover
33	2008	Mexican Hat, UT (HWY-08-MH-012)	9	42	50	Rollover
Total			123	1,031	255	

[A]Driver injuries unknown.

[B]Run-off-road, then frontal impact into terrain.

[C]Driver attacked by passenger; subsequent injuries unknown.

[D]Lap belts availlable; none reportedly were used.