Motorcoach Run-Off-the-Bridge and Rollover
Sherman, Texas
August 8, 2008

Accident Report

NTSB/HAR-09/02
PB2009-916202

National
Transportation
Safety Board

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Notation 8078A
Adopted October 27, 2009

Highway Accident Report

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

National Transportation Safety Board. 2009. *Motorcoach Run-Off-the-Bridge and Rollover, Sherman, Texas, August 8, 2008*. Highway Accident Report NTSB/HAR-09/02. Washington, DC.

Abstract: About 12:45 a.m. on August 8, 2008, a 56-passenger motorcoach was northbound on U.S. Highway 75 when it was involved in a single-vehicle accident in Sherman, Texas. The motorcoach had left Houston, Texas, about 8:30 p.m. on August 7, 2008, with a driver and 55 passengers onboard, en route to Carthage, Missouri. Before the crash, the motorcoach was traveling in the right lane of the four-lane divided highway. As the motorcoach approached the Post Oak Creek near Sherman, its right steer axle tire failed. The motorcoach departed the roadway, overrode a 7-inch-high, 18-inch-wide concrete curb, and struck the metal bridge railing. After riding against the bridge railing for about 120 feet, the motorcoach went through the railing and off the bridge. It fell about 8 feet and slid on its right side before coming to rest on the inclined earthen bridge abutment adjacent to the creek. As a result of the accident, 17 motorcoach passengers died, the motorcoach driver received serious injuries, and 38 passengers received minor-to-serious injuries.

The major safety issues identified in the accident investigation included the need for tire pressure monitoring systems on commercial vehicles; the need for criteria for the selection of bridge railing designs; the lack of oversight of the Federal commercial vehicle inspections delegated to the states; the lack of motorcoach occupant protection systems; and the deficiencies in Federal safety oversight of new entrant motor carriers. As a result of its investigation, the NTSB makes recommendations to the Federal Highway Administration, the Federal Motor Carrier Safety Administration (FMCSA), the National Highway Traffic Safety Administration (NHTSA), the American Association of State Highway and Transportation Officials, the American Association of Motor Vehicle Administrators, and Motor Coach Industries, Inc. The NTSB also reiterates previous recommendations to the FMCSA and NHTSA.

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Acronyms and Abbreviations

AAMVA	American Association of Motor Vehicle Administrators
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ADT	average daily traffic
ANPRM	Advance Notice of Proposed Rulemaking
Bridgestone	Bridgestone Americas, Inc.
CDL	commercial driver's license
CFR	*Code of Federal Regulations*
CVSA	Commercial Vehicle Safety Alliance
DOT	U.S. Department of Transportation
DWI	Driving While Intoxicated
ECE R66	United Nations Economic Commission for Europe Regulation 66
ECM	electronic control module
EDA	evasion detection algorithm
EMS	emergency medical services
EU	European Union
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FMCSRs	*Federal Motor Carrier Safety Regulations*
FMVSSs	*Federal Motor Vehicle Safety Standards*
GAO	U.S. Government Accountability Office
GAWR	gross axle weight rating
Goodyear	Goodyear Tire & Rubber Company
Greyhound	Greyhound Lines, Inc.
GVWR	gross vehicle weight rating
HbA1c	hemoglobin A1c
Liberty	Liberty Charters and Tours
LRFD	Load and Resistance Factor Design
MASH	*Manual for Assessing Safety Hardware*
MCI	Motor Coach Industries, Inc.

MCMIS	Motor Carrier Management Information System
MCSAP	Motor Carrier Safety Assistance Program
Michelin	Michelin North America, Inc.
µg/mL	micrograms per milliliter
mg/dL	milligrams per deciliter
mm	millimeter
NCHRP	National Cooperative Highway Research Program
NHS	National Highway System
NHTSA	National Highway Traffic Safety Administration
PRISM	Performance and Registration Information Systems Management
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
SEE-80-5	1980 Safety Effectiveness Evaluation of Traffic Safety Barriers
THC	tetrahydrocannabinol
TL-1 (through TL-6)	Test Level One (through Test Level Six)
TPMS	tire pressure monitoring system
TRB	Transportation Research Board
TREAD Act	Transportation Recall Enhancement, Accountability, and Documentation Act
TxDOT	Texas Department of Transportation
TxDPS	Texas Department of Public Safety
USDOT number	U.S. Department of Transportation number
US-75	U.S. Highway 75

Executive Summary

About 12:45 a.m., central daylight time, on Friday, August 8, 2008, a 2002 56-passenger Motor Coach Industries, Inc., motorcoach, operated by Iguala BusMex, Inc., was northbound on U.S. Highway 75 when it was involved in a single-vehicle, multiple-fatality accident in Sherman, Texas. The chartered motorcoach had departed the Vietnamese Martyrs Catholic Church in Houston, Texas, at approximately 8:30 p.m. on August 7, 2008, with a driver and 55 passengers onboard, en route to the Marian Days Festival in Carthage, Missouri. When the accident occurred, the motorcoach had completed about 309 miles of the approximately 600-mile-long trip.

Before the crash, the motorcoach was traveling in the right lane of the four-lane divided highway. As the motorcoach approached the Post Oak Creek bridge at a speed of about 68 mph, its right steer axle tire failed. The motorcoach departed the roadway on an angle of about 4 degrees to the right, overrode a 7-inch-high, 18-inch-wide concrete curb, and struck the metal bridge railing. After riding against the bridge railing for about 120 feet and displacing approximately 136 feet of railing, the motorcoach went through the bridge railing and off the bridge. It fell about 8 feet and slid approximately 24 feet on its right side before coming to rest on the inclined earthen bridge abutment adjacent to Post Oak Creek. As a result of the accident, 17 motorcoach passengers died; 12 passengers were found to be dead at the crash site, and 5 others later died at area hospitals. In addition, the 52-year-old driver received serious injuries, and 38 passengers received minor-to-serious injuries.

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the right steer axle tire, due to an extended period of low-pressure operation, which resulted in sidewall, belting, and body ply separation within the tire, leading to loss of vehicle control. Contributing to the severity of the accident was the failure of the bridge railing to redirect the motorcoach and prevent it from departing the bridge. The lack of an adequate occupant protection system contributed to the severity of the passenger injuries.

The following safety issues are identified in this report:

- The tire failure and the need for tire pressure monitoring systems on commercial vehicles;
- The failure of the bridge railing and the need for criteria for the selection of appropriate bridge railing designs;
- The lack of oversight of the Federal commercial vehicle inspections that are delegated to the states;
- The lack of motorcoach occupant protection systems; and
- The deficiencies in Federal safety oversight of new entrant motor carriers.

As a result of the investigation, the NTSB makes recommendations to the Federal Highway Administration, the Federal Motor Carrier Safety Administration (FMCSA), the National Highway Traffic Safety Administration (NHTSA), the American Association of State Highway and Transportation Officials, the American Association of Motor Vehicle Administrators, and Motor Coach Industries, Inc. The NTSB also reiterates previous recommendations to the FMCSA and NHTSA.

Factual Information

Accident Narrative

About 8:30 p.m., central daylight time,[1] on Thursday, August 7, 2008, a 2002 56-passenger Motor Coach Industries, Inc. (MCI), motorcoach, operated by Iguala BusMex, Inc., departed the Vietnamese Martyrs Catholic Church in Houston, Texas, with a driver and 55 passengers on board. The chartered motorcoach was en route to the Marian Days Festival in Carthage, Missouri, a trip of approximately 600 miles. About 4 hours later, the motorcoach had completed about 309 miles of the trip and was northbound on U.S. Highway 75 (US-75). About 12:45 a.m., the motorcoach was involved in a single-vehicle, multiple-fatality accident in Sherman, Texas. (See location map in figure 1.)

Before the crash, the motorcoach had traversed a 1,389-foot-long, 2.3-degree right curve with a 3.75-percent downgrade and had begun traversing a 1.5-degree left curve on a 0.4-percent ascending grade as it approached the Post Oak Creek bridge. (See figure 2.) As the motorcoach approached the bridge at a speed (provided by electronic control module [ECM]) of about 68 mph, its right steer axle tire failed.[2] The motorcoach departed the roadway on an angle of about 4 degrees to the right, overrode a 7-inch-high, 18-inch-wide concrete curb, and struck the 31-inch-high metal bridge railing.[3] After riding against the bridge railing for about 120 feet and displacing approximately 136 feet of railing, the motorcoach went through the bridge railing and off the bridge.[4] It fell about 8 feet and slid approximately 24 feet on its right side before coming to rest on the inclined earthen bridge abutment adjacent to the creek.

Seventeen of the 55 passengers died as a result of this accident; 12 motorcoach passengers were found to be dead at the crash site, and 5 others later died at area hospitals. In addition, the 52-year-old driver received serious injuries, and 38 passengers received minor-to-serious injuries.

Investigators found no indication that the driver had been engaged in nondriving tasks, such as text-messaging or talking on a citizens band radio, loudspeaker, or cellular telephone, when the accident occurred. Postaccident interviews were conducted with 17 passengers; they indicated that there had been no distractions caused by passengers. At the time of the accident, the weather was clear and the roadway was dry.

[1] Unless otherwise indicated, all times in this report are central daylight time.

[2] This motorcoach had three axles—a steer axle in the front, a drive axle connected to the power train, and a tag axle in the rear that provided support and stability.

[3] A bridge railing is a longitudinal barrier intended to prevent a vehicle from running off the edge of a bridge.

[4] The first bridge railing displaced by the motorcoach was struck midway along its length.

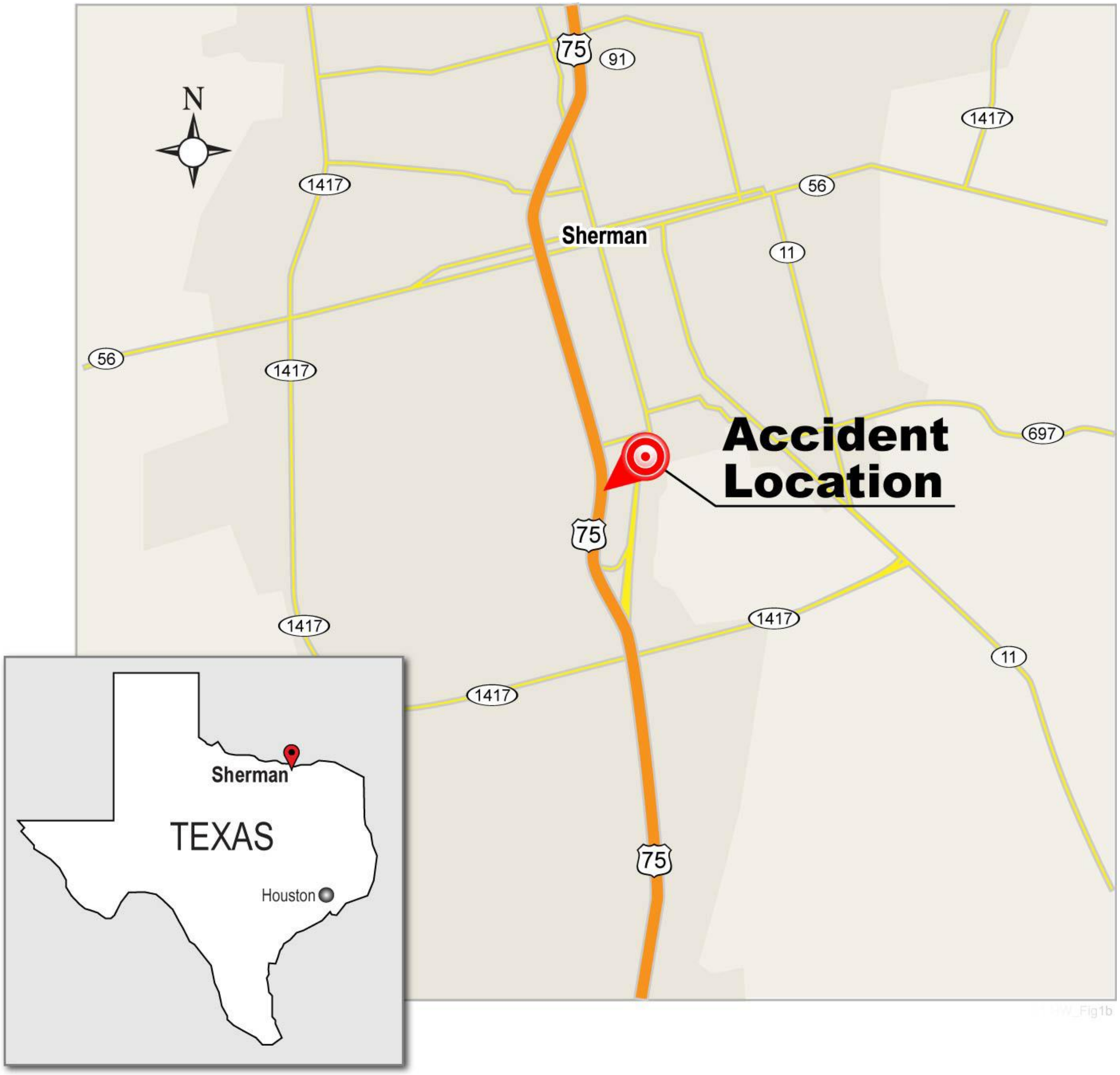

Figure 1. Map of accident location.

Figure 2. View of approach to Post Oak Creek bridge. (Photograph was taken after postaccident repairs were made to the bridge.)

Injuries

See table 1 for injury information.

Table 1. Injury summary.

Injury Severity	Motorcoach Driver	Passengers	Total
Fatal	0	17	17
Serious	1	26	27
Minor	0	12	12
None	0	0	0
Total	1	55	56

Title 49 *Code of Federal Regulations* (CFR) 830.2 defines fatal injury as “any injury which results in death within 30 days of the accident” and serious injury as “any injury which: (1) requires hospitalization for more than 48 hours, commencing within 7 days from the date the injury was received; (2) results in a fracture of any bone (except simple fractures of fingers, toes, or nose); (3) causes severe hemorrhages, nerve, muscle, or tendon damage; (4) involves any internal organ; or (5) involves second- or third-degree burns, or any burns affecting more than 5 percent of the body surface.”

The motorcoach driver sustained serious traumatic injuries to the head and upper torso, as well as internal injuries. The majority of those killed and seriously injured incurred blunt force trauma to the head, neck, chest, and spine. Minor injuries were characterized by lacerations and contusions.

Based on interviews with passengers, as well as information provided by Sherman police, fire, and emergency medical services (EMS) personnel, investigators established the seating positions of the motorcoach occupants. (See figure 3.) Thirteen of the 17 passengers who died as a result of the accident were on the right side of the motorcoach at the time of the accident, and 8 of those 13 were in the first five rows. The four fatalities who had been seated on the left side of the motorcoach at the time of the accident were in rows 3 through 7. One seat was unoccupied; it was the aisle seat in row 9 on the right side of the motorcoach. Nineteen passengers were male; 36 were female. The average age of passengers on the motorcoach was 46; nine passengers were younger than 16, and eight were older than 70. The average age of the 17 passengers who died was 62, and the average age of the 38 passengers who survived was 39.

None of the passenger seating positions were equipped with occupant restraints. The driver's seat was equipped with a 2-point lap seat belt, but the driver was not wearing it at the time of the accident.

First responders and motorcoach occupants told investigators that some passengers had been ejected as a result of the accident. Investigators established that at least four passengers were fully or partially ejected; however, the exact number of fully and partially ejected passengers could not be determined. Partially ejected passengers were seated in seats 9B and 12D; fully ejected passengers were seated in seats 6D and 13C. First responders' records regarding ejections were inconclusive because other passengers rendered immediate assistance, and the injured were moved quickly away from the wrecked motorcoach because of passenger fears of a postcrash fire. Also, some passengers who had been partially ejected were trapped under the vehicle, making it difficult for witnesses to determine how many had been ejected.

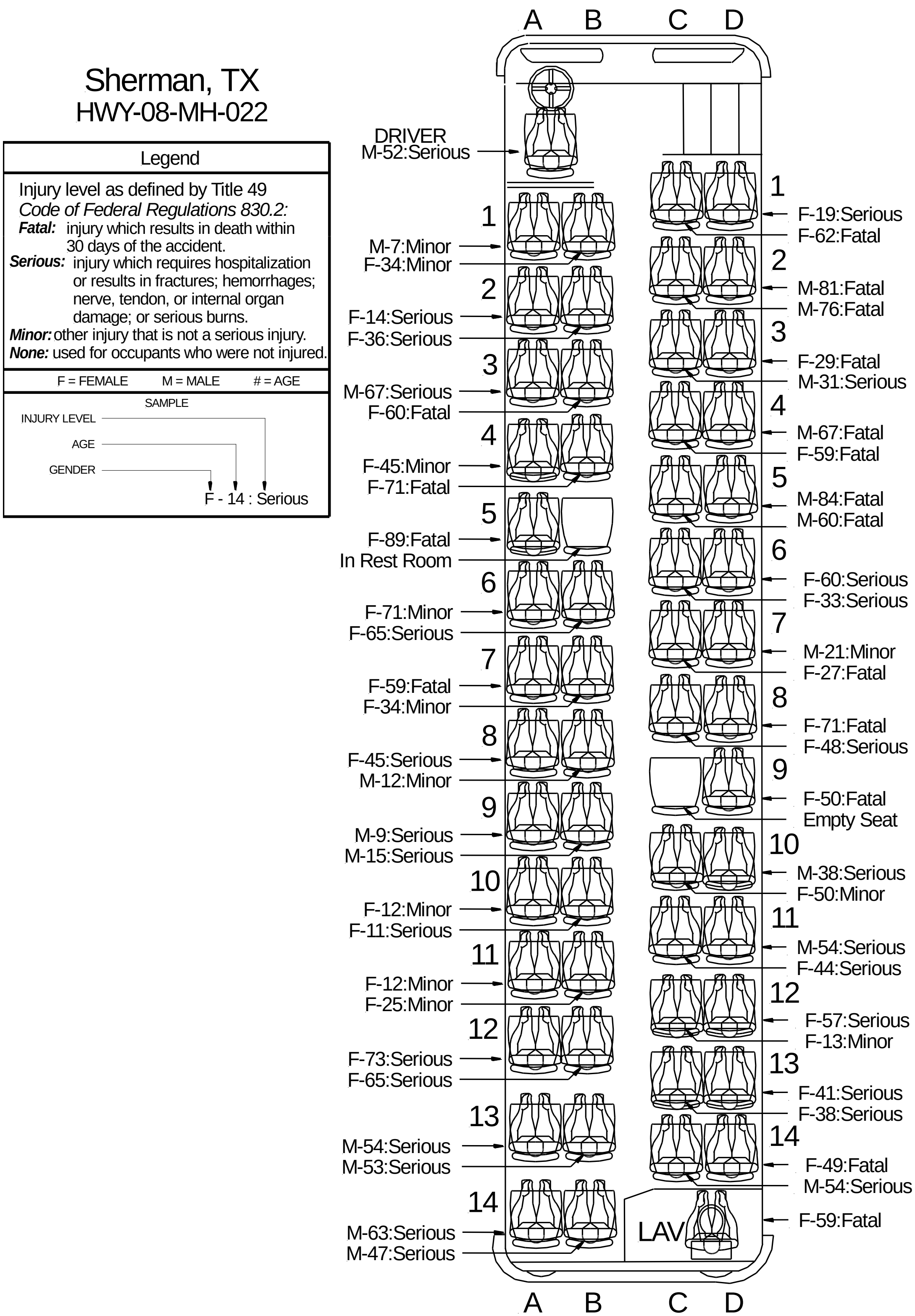

Figure 3. Motorcoach seating chart.

Emergency Response

The City of Sherman Communications Center received initial notification of the accident at 12:45 a.m. from a motorist who saw the motorcoach depart the roadway. Police, fire, and EMS personnel were dispatched at 12:46 a.m. and arrived on the scene about 12:50 a.m. The City of Sherman and Grayson County Communications Centers worked to coordinate on-scene resources. The Sherman fire chief served as the incident commander, establishing a mobile command post near the accident site. Separate transfer points were established for ground ambulance and helicopter transport. Nineteen helicopter EMS response trips were executed by units from Sherman, McKinney, and Frisco, Texas.[5] About 25–30 ground ambulances from nine different service departments responded.[6] The injured were transported to nine regional medical facilities.[7] Seven of the injured were transported to a local medical facility in Sherman; most were transported 30–40 miles to regional treatment facilities. Four were taken to two facilities in the Dallas, Texas, area, approximately 60 miles away; and one patient was transported to a facility in Fort Worth, Texas, about 90 miles away. The Dallas and Tarrant County Medical Examiner's Offices also responded. By 1:08 a.m., within 23 minutes of the initial notification of the accident, the most critically injured patients had arrived at local medical facilities in Sherman and nearby McKinney, Texas.[8] By 2:39 a.m., 1 hour 54 minutes after the accident, all the injured had been transported to medical facilities.

Grayson County has an emergency response plan that includes all the county's public safety agencies and area medical facilities. The response plan contains annexes with checklists and process descriptions for responding to mass casualty transportation accidents. During the emergency, the Sherman Fire Department activated the regional mutual aid plan to staff the ongoing work shift requirements for fire and rescue personnel called to the accident.

Motorcoach Driver

The 52-year-old male driver held a Texas class B commercial driver's license (CDL) with a passenger endorsement, issued on December 15, 2005, and due to expire in 2010. There were no restrictions on the license. The driver said he began driving motorcoaches in 1983 while employed by the Houston Metropolitan Transit Authority. On the driver's employment application at Angel Tours, Inc.,[9] dated April 28, 2008, he indicated that he had been employed

[5] Life Star in Sherman, Texas, responded. Sky Med (PHI) in McKinney, Texas, approximately 30 miles from the accident site, and Care Flight in Frisco, Texas, approximately 40 miles from the accident site, also responded.

[6] Ambulances responded from the Sherman, Bells, Denison, Grayson, McKinney, and Van Alstyne Fire Departments and from the Preston, Texas Vital, and Bryan County EMS organizations.

[7] These facilities were the Texoma Medical Center, Denison, Texas; Wilson N. Jones Medical Facility, Sherman, Texas; Parkland Health and Hospital System, Dallas, Texas; McKinney Medical Center, McKinney, Texas; Medical Center of Southwest Oklahoma, Durant, Oklahoma; Presbyterian Medical Center, Allen, Texas; North Central Medical Center, McKinney, Texas; Methodist Hospital, Dallas, Texas; and Harris Methodist Medical Center, Fort Worth, Texas.

[8] Approximately one-third of those transported went to two facilities; the Wilson N. Jones Medical Facility in Sherman received seven patients, and the McKinney Medical Center in McKinney, about 40 miles away, received eight patients.

[9] The "Motor Carrier" section of this report discusses the business relationship between Iguala BusMex and Angel Tours, Inc.

by Genesis Tours from March 2004 to March 2007,[10] by Autobuses Adame Tours from December 2002 to February 2004, by Continental Tours from April 2000 to November 2002, and by Carrington Tours from March 1999 to March 2000. In a postaccident interview with investigators, the driver said that he had additional driving experience with Greyhound Lines, Inc. (Greyhound), from 1989–1995 and with Grayline from 1995–1999. Further, the driver said that he had completed "numerous safety classes," as well as a Greyhound training course in Oklahoma.

Greyhound verified that it had employed the driver 13 years earlier. The driver told NTSB investigators that he had been terminated by Greyhound for failure to report for a medical examination. Information that the NTSB subpoenaed from Greyhound indicated that the driver had been terminated on March 21, 1995, because he tested positive for cocaine during a mandatory random drug test. NTSB investigators were unable to contact several of the other employers that the driver cited due to incomplete information and/or disconnected telephone numbers for the carriers.[11]

The NTSB attempted to obtain additional information about the driver's history of controlled substance testing. The state of Texas maintains records on the results of controlled substance tests for commercial drivers. The NTSB asked Texas to check its database of drug and alcohol test results for information concerning the accident driver. The state required the NTSB to serve a subpoena upon the Texas Department of Public Safety (TxDPS) to obtain access to the information. The available database information showed no records for the driver. (The dates of the driver's positive test results when he was employed by Greyhound preceded the establishment of the Texas database, which was initiated in January 2003, with mandatory reporting beginning in September 2005.)

On his application for employment, the driver denied having had any accidents, traffic convictions, or forfeitures in the preceding 3 years. He also said that he had not been denied a license, permit, or privilege to operate a motor vehicle, and that he had not had a suspension or revocation of license, permit, or privilege to operate a motor vehicle. However, the driver's history of motor vehicle violations obtained by the Sherman Police Department and the TxDPS showed that the driver had two speeding violations, one on March 20, 2007, and another on May 3, 2004.[12] He was also convicted on August 16, 2001, of Driving While Intoxicated (DWI), following his refusal to submit to an alcohol screening test.[13]

The driver had undergone two roadside inspections in the 16 months preceding the accident. On May 2, 2007, and August 6, 2007, the driver was placed out of service for violation of 49 CFR 395.8(k)(2), because he did not have a record-of-duty status log covering the

[10] Investigators found another application in the driver's qualification file that indicated his dates of employment with Genesis Tours as February 2003 to April 2006.

[11] Title 49 CFR 391.51 requires employers to maintain driver qualification files for 3 years after an employee leaves employment.

[12] In a postaccident interview, the driver stated that he received a speeding ticket in a commercial vehicle while working for Autobuses Adame Tours.

[13] The adjudicative docket NTSB investigators obtained from the Texas District Courts did not distinguish vehicle type. The driver stated that his DWI violation took place while driving his personal vehicle.

preceding 7 days in his possession at the time of those inspections. Additionally, for the May 2007 inspection, the motor carrier was cited for the driver's failure to possess a valid medical certificate.[14]

According to the driver's record-of-duty status logbook, in the days preceding the Sherman accident, he was on duty Monday, August 4, 2008, from midnight to 12:30 p.m. The driver did not work on Tuesday, August 5. He returned to work on Wednesday, August 6, at 7:45 a.m., and worked until 10:00 a.m., when he went off duty. He resumed driving at 1:15 p.m., and he went off duty at 2:45 p.m. On Thursday, August 7, the driver went on duty at 5:00 p.m. He had a 1-hour break at 7:15 p.m. He resumed driving at 8:15 p.m. and continued driving until the accident occurred at 12:45 a.m. on August 8. The driver's pattern of work is shown in figure 4.

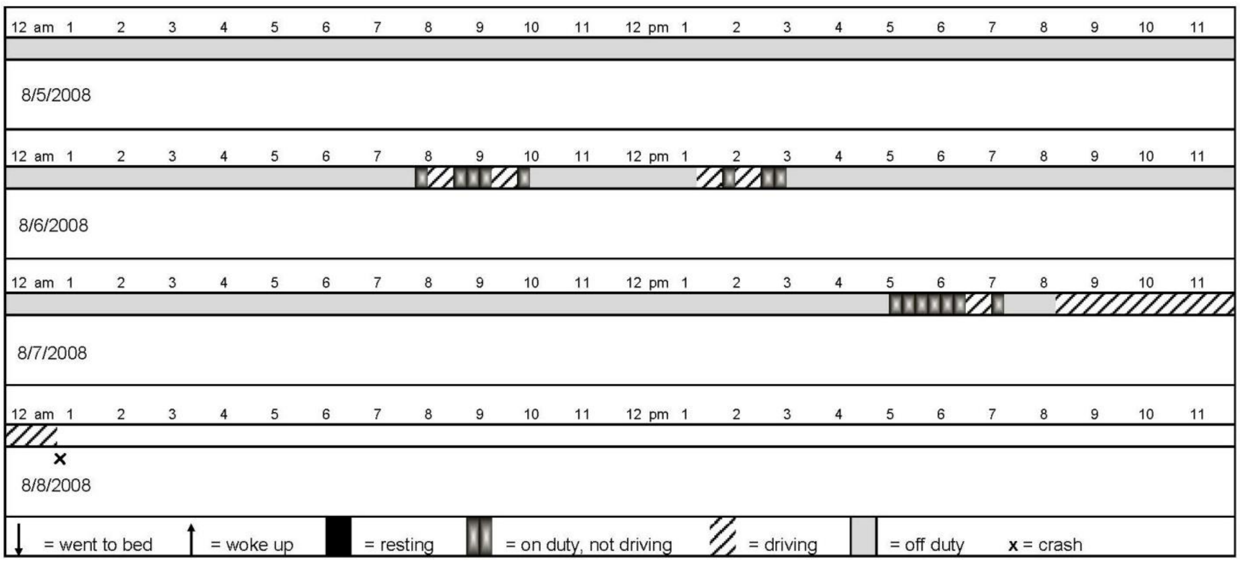

Figure 4. Motorcoach driver's 72-hour work/rest history. [Note: Due to his injuries, investigators were unable to interview the driver immediately following the accident; when he was interviewed—weeks later—he provided only limited information about his off-duty activities.]

Driver Interview

The driver was critically injured in the crash and gave only a brief statement to NTSB investigators on August 8, 2008, while he was in the hospital. When investigators attempted to interview the driver again on August 9, his medical condition had deteriorated such that he could not be interviewed then, or for the duration of the on-scene investigation.

Two months later, in the presence of his legal counsel, the driver was interviewed. During the October 9, 2008, interview, the driver said that he had spent much of the day preceding the accident (August 7) in bed resting in preparation for the nighttime trip. He said that

[14] In 2007, it was not an out-of-service violation for a driver not to have a current medical certificate. On April 1, 2009, the Federal Motor Carrier Safety Administration changed inspection procedures to make lack of a valid medical certificate an out-of-service violation.

he also recalled going for a walk and washing clothes for the trip. He said that he had never been diagnosed with a sleeping disorder. He said that on the day of the trip, he arrived at the carrier about 4:45 p.m. and conducted a pretrip inspection of the motorcoach. He said that he examined the tires, looking for protrusions, wear and tear, and discoloration; he said he also kicked the tires. He said the bus appeared to be in good shape and that it drove smoothly, with no pulling to either side.

He said that when he arrived at the first pick-up location, he met with the chaperone. He waited about 40 minutes for passengers to arrive, loaded the luggage, and then departed about 6:45–6:50 p.m. for a second pick-up location. He said that after he loaded luggage at the second pick-up site, he completed another walk-around inspection to ensure that the luggage bins were locked, and he also checked the motorcoach's fluids. He indicated that most of the luggage had been stored in the first and second compartments from the bus's front. He said that he began driving about 8:15 p.m. and stopped about 10 minutes later at a convenience store so he could purchase gum and an energy drink, because he knew he was going to be driving all night. The driver stated that he had previously made the trip to Carthage, Missouri, a year or two earlier.

The driver said that the first 4 hours of the trip were uneventful. In describing the accident event, the driver said that he first felt a sway or vibration with the bus and let off the accelerator because he was unsure of what was causing it. Then, within seconds, he heard an explosion, and the right front of the bus dropped. He stated that he "tried not to apply the brakes real hard." He tried to hold onto the steering wheel, but it quickly became impossible, and the bus drifted to the right.

The driver told investigators that, while driving for another company many years earlier, he had experienced a tire failure on the tag axle. He recalled that during that incident, he could feel the tire rubber breaking off and could smell it. He stated that he had had no difficulty controlling that vehicle and had been able to pull it over to the shoulder. The driver also stated that in training he recalled being told, with respect to tire blowouts, not to hit the brakes.

Driver's Medical Certification

At the time of the accident, the driver had an expired medical certificate. It had been issued on May 24, 2007, and had expired on May 24, 2008. The driver's May 24, 2007, Medical Examination Report for Commercial Driver Fitness Determinations indicated "Yes" to "High Blood Pressure" and "Medications: Lisinopril." The report indicated "No" to all other items under "Health History," including "Regular, frequent alcohol use," and "Narcotic or habit forming drug use." The driver's blood pressure was noted as 108/78. The medical examiner noted that the driver met standards, but because of his taking high blood pressure medication, which would require periodic evaluation, the driver was qualified for 1 year, rather than the typical 2-year period.

Review of the driver's personal medical records revealed that he had been treated for high blood pressure, diabetes, and high cholesterol, as well as gastritis due to alcohol use. On May 9, 2008, the driver's blood sugar was 293 milligrams per deciliter (mg/dL) (reference range

70–110), and his hemoglobin A1c (HbA1c) was 11.2 percent.[15] The driver was advised at that time to begin using injectable insulin, and he received a prescription for insulin.[16] The driver was also prescribed an oral antidiabetic medication at that time (metformin). Testing performed on a blood specimen obtained from the driver following the accident showed an HbA1c of 8.2 percent.

Several bottles of prescription medications were among the driver's personal effects recovered following the accident. According to the labels on the bottles, the medications and instructions for use were as follows: lisinopril, 20 mg, 1–2 daily;[17] metformin HCL, 500 mg, once daily;[18] and omeprazole, 20 mg, twice daily.[19] In addition, a bottle of nonprescription Tylenol PM was found.[20]

Toxicology Results

Blood and urine specimens were obtained from the motorcoach driver at 4:26 a.m. (approximately 3.75 hours after the accident) and analyzed by the Federal Aviation Administration Civil Aerospace Medical Institute. The results were positive for benzoylecgonine in the blood (0.242 micrograms per milliliter [µg/mL]) and urine (11.09 µg/mL), and for cocaine (0.171 µg/mL) and cocaethylene (0.293 µg/mL) in the urine.[21] Ecgonine methyl ester[22] was detected at unspecified levels in the blood and urine. Diphenhydramine[23] was detected in the blood (0.0075 µg/mL) and at unspecified levels in the urine. No ethanol, cocaine, or cocaethylene was detected in the blood.

Survival Factors

A 2-point lap belt was available at the driver's seat. Investigators examined the belt and found it inoperative. The right side hasp portion of the belt was jammed in its retaining reel, preventing belt extension. The motorcoach was not equipped with passenger seat belts.

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15 HbA1c is used to monitor the blood sugar control of diabetics over time. HbA1c levels above 6 percent are considered abnormal. HbA1c provides an indication of the average glucose level in the blood over the previous few months.

16 No refills were documented in the records investigators reviewed.

17 Lisinopril is a prescription medication used for the treatment of high blood pressure and certain other cardiovascular disorders and to help prevent certain complications of diabetes.

18 Metformin is a prescription oral medication used for the treatment of diabetes.

19 Omeprazole is an antacid medication used to treat a variety of gastrointestinal disorders that is available over the counter in the United States.

20 Tylenol PM is a compound of acetaminophen and diphenhydramine, available over the counter. Acetaminophen is a widely used pain reliever and fever reducer, and diphenhydramine is a sedating antihistamine. Tylenol PM is marketed as a combined analgesic and sedative, intended to treat occasional headaches and minor aches and pains with accompanying sleeplessness.

21 Benzoylecgonine is an inactive metabolite of cocaine, which is a central nervous system stimulant. Cocaethylene is an active substance formed in the body when cocaine and alcohol have been consumed together.

22 Ecgonine methyl ester is a metabolite of cocaine.

23 Diphenhydramine, commonly known by the trade name Benadryl, is an ingredient of Tylenol PM.

The bus sustained significant impact damage on the right front corner near the boarding door extending across the width of the front and approximately 53 inches aft from the right front corner to about the midpoint of the right steer axle wheel. (See figure 5.) The front windshield, passenger boarding door, and seven emergency window exits along the right side of the vehicle were destroyed. The roof was damaged along the front portion, especially on the right front corner. The emergency hatches were intact and functional.

Figure 5. Postaccident view of the accident motorcoach.

The sidewalls and the emergency windows on both sides of the motorcoach were vertically deformed. The window frames of the seven emergency window exits on the right side were intact; however, the safety glass was broken. The emergency windows on the left side remained intact and were functional but had not been used.

All the passenger seats were intact and secured to the floor, except the right side aisle seat in row 12, which had its seat pan detached,[24] and the double-retractable passenger seat on the left side of the row, which was moved by first responders during the rescue operation. The 3/4-inch

[24] "Seat pan" refers to the structural support for the lower seat cushion.

plywood floor decking on the right side near row 1 failed, as did the floor decking across the width of the motorcoach at row 12.

Overhead luggage racks, affixed with cast aluminum brackets to the roof and sidewall above the passenger seats, sustained damage at their anchorage points.[25] The left side overhead luggage rack was 36 feet long and affixed with 11 brackets attached to the ceiling with two 1/2-inch bolts per bracket and to the sidewall with two inline 1/2-inch bolts. The right side rack, which was 3 feet shorter than the left, was attached by nine aluminum brackets. The brackets on the right side were found broken at their connection points to the ceiling and sidewall. The rack on the right side became detached and came to rest along the tops of the passenger seats on the right side, extending diagonally across the aisle on top of the seats to the left of the aisle. According to interviews with first responders, the displaced luggage rack was blocking the aisle near rows 3 and 4 as well as the right side emergency window exits. The underside of the detached luggage rack showed evidence of passenger contact along its length.

Accident Reconstruction

Accident investigators used documented physical evidence in conjunction with electronic engine data to reconstruct the accident event sequence. This factual information included tire marks, scraping and gouging of the roadway and bridge surfaces, tire fragments and debris locations, engine load/rpm, vehicle speed/rpm, and brake and throttle status. Distances calculated based on engine time records are approximate.

The tire failure was initiated by the separating of steel belting materials, which led to belt edge lifting and shoulder rubber tearing, and ultimately to the detachment of belting and tread materials. During the belting and tread detachment phase, the tire casing ruptured, and an immediate inflation pressure loss resulted. (See figure 6 for cross-sectional diagram of a tire similar to those on the accident motorcoach, labeled to show significant tire elements.)

[25] The contents of the luggage racks were not documented at the scene of the accident, and some personal belongings had been removed before NTSB investigators arrived.

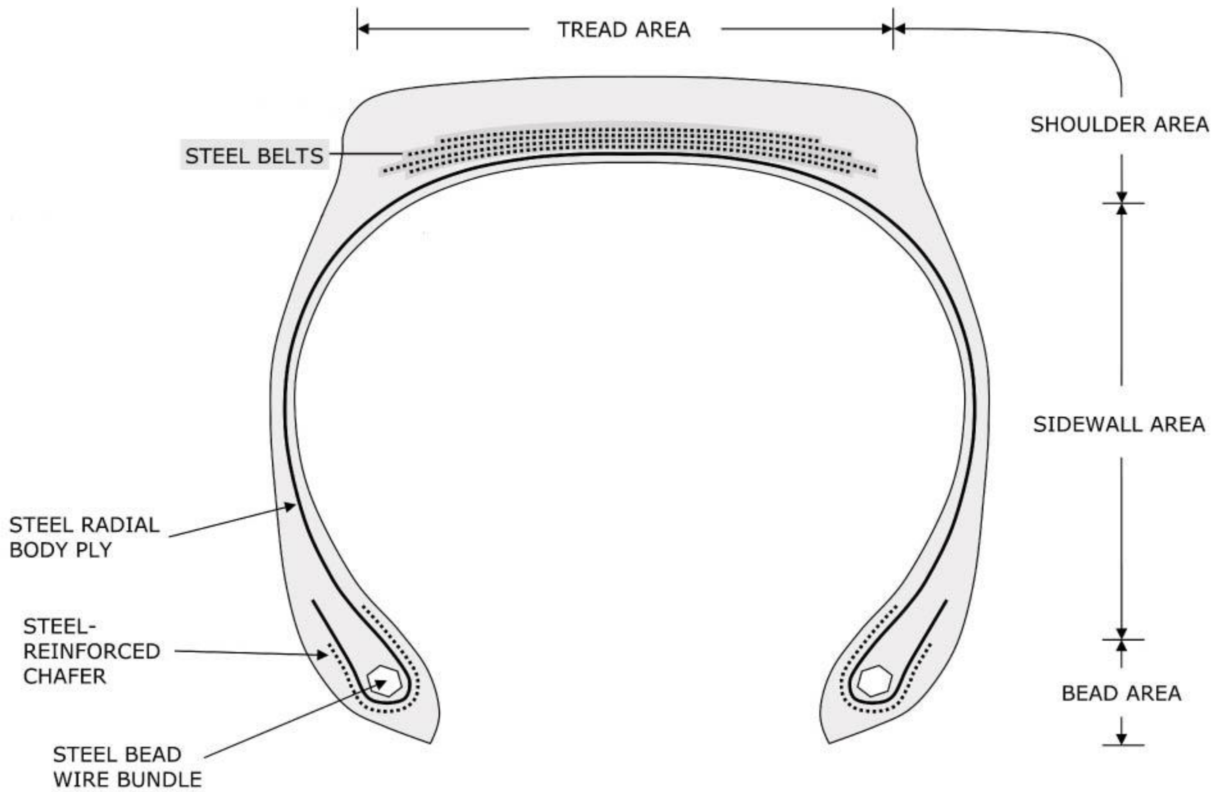

Figure 6. Cross-sectional diagram of a tire similar to those on the accident motorcoach, labeled to show significant tire elements.

As the motorcoach traveled north toward the bridge, at a point 685 feet prior to the impact with the bridge, the motorcoach's right steer axle tire began marking and depositing tire fragments. At this time, the motorcoach was traveling about 68 mph (approximately 100 feet per second). From this point to the tire blowout, the motorcoach traveled for 4.3 seconds. Vehicle engine data indicated variation in the percent throttle in these seconds preceding the blowout.[26] The tire casing rupture (blowout) occurred approximately 3.0 seconds before impact with the bridge. The driver activated the brakes 1.1 seconds after the tire blowout, and the motorcoach struck the bridge railing 1.9 seconds later. Brake application reached 90 psi 0.7 second after driver input and reached maximum force about 1.0 second following driver input, when the motorcoach was traveling about 54 mph.

The motorcoach struck the bridge railing while traveling about 44 mph. The right steer wheel departed the roadway as the motorcoach rotated clockwise along its longitudinal axis, traveling approximately 35 mph. Once the motorcoach had gone through the bridge railing, traveling about 29 mph, it fell 8 feet to the earthen bridge abutment and slid 24 feet. From the point of impact with the bridge railing to final rest, the motorcoach traveled 186 feet. The sequence of events is shown in figure 7.

[26] Percent throttle varied between 32 percent and 58 percent in the 6 seconds before the hard braking event that followed the blowout.

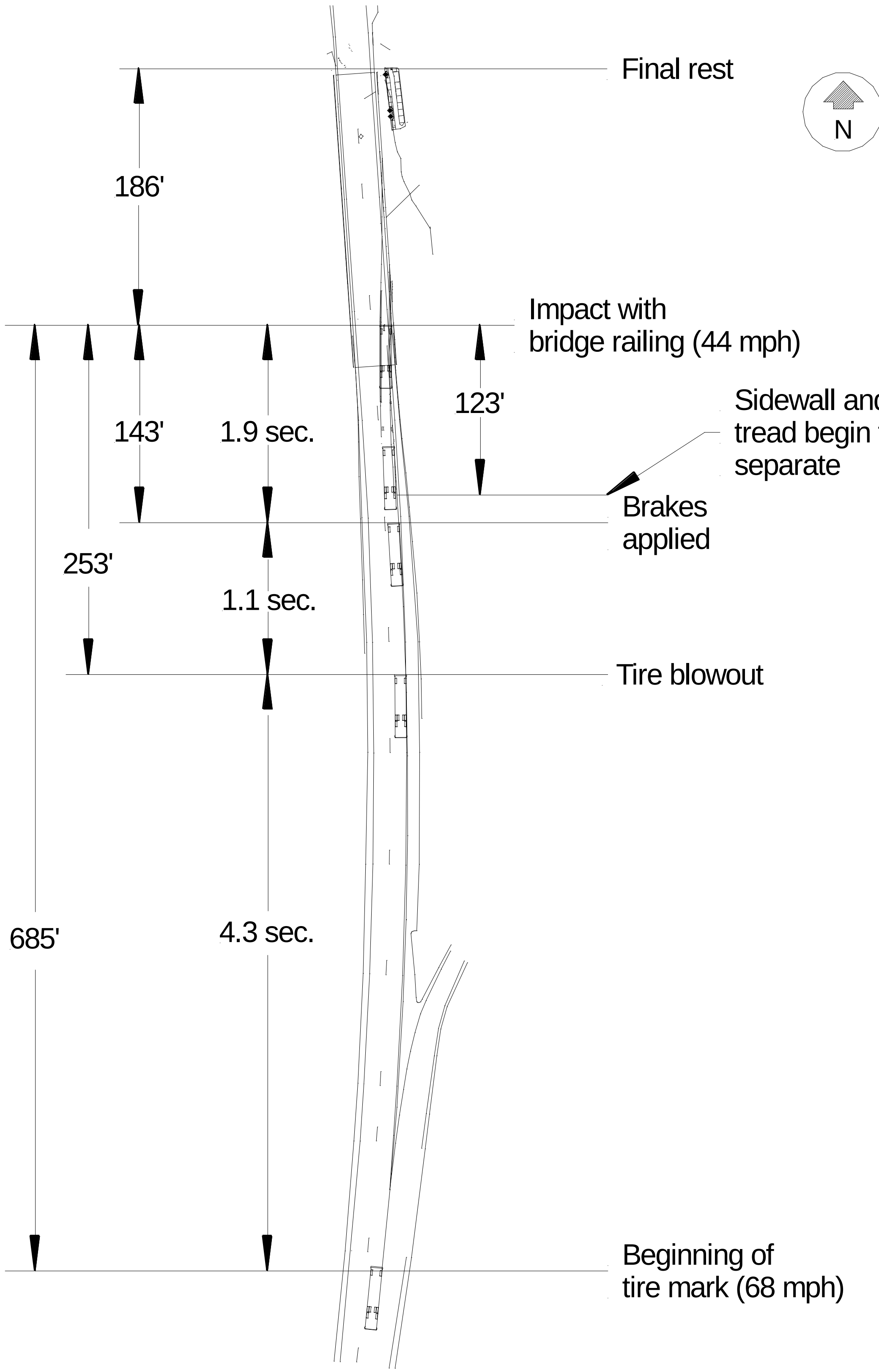

Figure 7. Accident reconstruction diagram.

The motorcoach and its occupants experienced multiple impact events. The impact forces first resulted from contact with the curb, uprights, and bridge railing, then from the right front corner of the motorcoach striking the earthen abutment, and then from the side and rear of the motorcoach striking the abutment.

Vehicle

The 2002 MCI model J4500 56-passenger-capacity motorcoach was 45 feet 7 inches long, 8 feet 6 inches wide, and 11 feet 9 inches high. Its gross vehicle weight rating (GVWR) was 54,000 pounds, with a steer axle weight rating of 16,500 pounds, a drive axle weight rating of 23,000 pounds, and a tag axle weight rating of 16,500 pounds.[27] Due to the vehicle's extensive frontal deformation, postaccident axle weights were not obtained; however, the motorcoach weight as recovered, including the baggage, was determined to be approximately 44,000 pounds. The gross vehicle weight, including the estimated weight of occupants, was 51,707 pounds.

The accident motorcoach had been previously owned by Schoolman Transportation System, Inc.,[28] which traded it to MCI Sales and Service. It was received at MCI's Blackwood, New Jersey, facility on November 30, 2007. The motorcoach remained at the Blackwood facility until January 9–10, 2008, when it was transferred to MCI's Loudonville, Ohio, facility for refurbishing. Once the refurbishment was completed, the motorcoach was transferred to the MCI Sales and Service facility in Dallas, Texas, for resale, where it was purchased by Angel Tours, Inc.,[29] on July 19, 2008. The vehicle was operating with a Texas temporary registration (P13705) that expired August 9, 2008, the day after the accident.

Vehicle Systems

The motorcoach had a Detroit Diesel, Series 60, 12.7-liter, 6-cylinder, engine-brake-equipped, electronically controlled diesel engine. The transmission was an Allison B500 automatic transmission. The Detroit Diesel engine was equipped with an ECM capable of recording limited operating data. Data from the ECM indicated a "hard brake" event and a "last stop" event in connection with the accident.[30] Three diagnostic fault codes were identified but were determined not to be relevant to the accident.[31]

[27] The GVWR is the manufacturer-recommended upper limit to the operational weight for a motor vehicle and any cargo or passengers to be carried. The GVWR may be less than but not more than the sum of the gross axle weight ratings.

[28] Schoolman Transportation System, Inc., operates in Bohemia, New York.

[29] Angel Tours, Inc., received interstate operating authority in 1994 but was placed out of service for interstate transportation on June 23, 2008. The owner then applied for operating authority under the name Iguala BusMex, Inc. Business transactions were comingled between the two companies. Further information on this business relationship appears in the "Motor Carrier" section of this report.

[30] An ECM "hard brake" report contains 1 minute of data prior to the triggering event and 15 seconds following the event. In this case, a hard brake was triggered when the vehicle's calculated speed decelerated faster than 7 mph per second. A "last stop" event is triggered when the vehicle transitions from a driving state to a stopped state and remains stopped for at least 15 seconds or when the ignition is switched off.

[31] Diagnostic codes or records can contain engine parameter data that are present when a fault code is generated. None of the diagnostic records were associated with the accident.

The motorcoach was equipped with a power-assisted steering system that utilized a hydraulic pump mounted at the front of the engine. The hydraulic pump was examined and tested on November 26, 2008, at Ixetic USA Inc.[32] No physical damage to the pump's external or internal components was observed, and performance-based testing found the pump functioning within the production parameters of a newly manufactured pump.

The motorcoach was equipped with pneumatically actuated S-cam drum brakes with a 6S/6M Meritor-Wabco antilock control system.[33] Brake system components are shown in table 2. Postaccident inspection found all brakes to be within the Commercial Vehicle Safety Alliance (CVSA) *North American Standard Out-of-Service Inspection Criteria*. Examination of the steer axle brake components revealed that the right brake drum had fractured as a result of the crash. No defects were found with the brake components on the drive axle. Inspection of the tag axle revealed oil and grease/road debris contamination of the left brake drum and lining friction surfaces with considerable caking and buildup, which is a rejection defect within the Minimum Periodic Inspection Standards in appendix G to subchapter B of the *Federal Motor Carrier Safety Regulations* (FMCSRs).[34]

Table 2. Brake system components.

Axle	Type/Size Chamber	Type/Size Adjuster (inches)	Measured Applied Stroke (inches)	Measured Lining Thickness (inches)	Brake Drum Size (inches)
Steer right	Clamp 30	5.5 Auto	1 3/4	3/4 & 7/8	16.5 X 6
Steer left	Clamp 30	5.6 Auto	1 5/8	7/8 & 5/8	16.5 X 6
Drive right	Clamp 30L/30	6.0 Auto	2 1/8	7/8 & 7/8	16.5 X 8.625
Drive left	Clamp 30L/30	6.0 Auto	2 3/8	3/4 & 3/4	16.5 X 8.625
Tag right	Clamp 24L/24	5.5 Auto	1 5/8	5/8 & 1/2	16.5 X 6
Tag left	Clamp 24L/24	5.5 Auto	2 1/4	3/4 & 3/4	16.5 X 6

[32] NTSB investigators attended the testing.

[33] The citation "6S/6M" indicates that the system was equipped with six wheel-speed sensors and six modulator valves.

[34] Appendix G criteria of the FMCSA annual inspection standards reject vehicles with any defective brakes, air leaks, etc. The brake contamination defect would have caused the motorcoach to be rejected during a required annual safety inspection. The CVSA *North American Standard Out-of-Service Inspection Criteria* allow 20-percent defective brakes on nonsteering axles before placing a vehicle out of service; therefore, a single contaminated brake out of six would not have placed the vehicle out of service.

Tires

General. The three-axle motorcoach was equipped with eight tires;[35] two tires on the steer axle, four on the drive axle, and two on the tag axle. All tread depths were examined postaccident and found to be within the *North American Standard Out-of-Service Inspection Criteria*, as well as the FMCSRs.[36] All the tires were mounted on 22.5-inch by 9-inch one-piece steel wheel assemblies, with the exception of the two tires on the tag axle, which were mounted on 8.25-inch wheel assemblies.[37] (See table 3.)

Table 3. Postaccident tire make, size, and pressure information.

Axle	Make	Size	Pressure
Right steer	Goodyear G409 MBA (retreaded)[a]	315/80 R22.5	Deflated - failed
Left steer	Firestone FS-400	315/80 R22.5	118 psi @ 79°F
Right drive inner	Ling Long LLF02	315/80 R22.5	94 psi @ 79°F
Left drive inner	Firestone FS-400	315/80 R22.5	96 psi @ 79°F
Right drive outer	Ling Long LLF02	315/80 R22.5	0 psi @ 79°F (debeaded)[b]
Left drive outer	Firestone FS-400	315/80 R22.5	93 psi @ 79°F
Right tag	Ling Long LLF02	315/80 R22.5	89 psi @ 79°F
Left tag	Goodyear G409 MBA	315/80 R22.5	88 psi @ 79°F

[a] "Retreaded" tires have had a new layer of surface rubber with a tread pattern added (often called "recapped") to extend the life of the tire.

[b] "Debeading" is a separation of the tire from the rim at the tire bead, resulting in an immediate loss of tire pressure.

The motorcoach's vehicle specification plate indicated that the recommended tires for the coach were 315/80 R22.5-size tires. According to the specification plate, the recommended tire inflation pressures were as follows: steer axle, 120 psi; drive axle, 90 psi; and tag axle, 120 psi.[38] The information in table 4 appeared in the 2001 MCI J4500 maintenance manual for the accident motorcoach regarding required tire inflation rates by make and model of tire; table 5 indicates the discrepancies between the measured tire pressures and those recommended on the vehicle's specification plate. Table 6 provides tire pressure and load capacity data for 315/80 R22.5-size tires.

[35] The postaccident vehicle inspection found four new tires, which had been purchased on July 29, 2008, two days before the motorcoach's July 31, 2008, annual inspection. Two of the new tires were on the right drive axle (inner and outer positions), one was on the right tag axle, and one was used as a spare.

[36] See 49 CFR 393.75.

[37] The mounting and use of a size 315/80 R22.5 tire on a rim designed with a bead width less than 9 inches or more than 9.75 inches does not comply with the 2007 interchangeability of tires, rims, and allied parts standards established by the Tire and Rim Association, Inc. However, according to the Tire and Rim Association, Inc., *Engineering Design Information* (Rev. 5, October 2006), p. 3-41, the use of 8.25-inch wheels with 315/80 R22.5 tires is permissible, if the maximum allowable load is reduced to 8,000 pounds per tire in single usage and 7,610 pounds per tire in dual usage, when inflated to 120 psi.

[38] Pressures vary by position because of differences in axle weight rating and number of tires.

Table 4. Tire inflation information in the MCI J4500 maintenance manual (May 2001).

Make and Type of Tire	Size	Steer Axle (psi)	Drive Axle (psi)	Tag Axle (psi)
Goodyear G391	315/80 R22.5	120	85	105
Goodyear G124 (snow tires)	12 R22.5	Not approved	85	Not approved
Michelin XM + S4 (snow tires)	12 R22.5	Not approved	95	Not approved
Firestone HP3000	315/80 R22.5	120	85	105
Goodyear G291	315/80 R22.5	120	85	105
Michelin PXZA 1	315/80 R22.5	120	90	105

Table 5. Comparison of postaccident tire inflation pressures with recommended tire inflation pressures, as indicated by the motorcoach vehicle specification plate.

Axle	Measured Left Tire Pressure (psi)	Measured Right Tire Pressure (psi)	Specification Plate Recommended Pressure (psi)
Steer	118	deflated	120
Drive inner	96	94	90
Drive outer	93	0, debeaded	90
Tag	88	89	120

Table 6. Tire pressure and load capacity data for tire size 315/80 R22.5.

Pressure (psi)		80	85	90	95	100	105	110	115	120
Load capacity (lbs.)										
	Single	6175	6415	6670	6940	7190	7440	7610	7920	8270
	Dual	5675	5840	6070	6396	6545	6770	6940	7210	7610
	(Load range)				(G)			(H)		(J)

Source: Values per Tire and Rim Association standards publication*, 2009 Year Book.*

The *MCI Operator Manual* for the accident motorcoach indicates that the tire pressures should be checked before each trip using an accurate gauge. The manual also indicates that a 5-psi underinflation of a steer axle tire can cause hard steering, create steering hazards, and cause an unsafe condition. It also states that underinflation of a tag tire can affect braking.

Postaccident examination revealed that the right front tire on the steer axle was a retreaded tire. According to 49 CFR 393.75(d), "No bus shall be operated with regrooved, recapped or retreaded tires on the front wheels." In accordance with Federal regulations, the tire was identifiable as a retreaded tire.[39] The original tire casing was a Goodyear model G409 MBA

[39] The tire was marked "[R]ANC-B23507."

radial tire that had been retreaded with a Bandag model T4100 tread. The tire was retreaded by Henise Tire Service of Cleonea, Pennsylvania, which received the tire from MCI Sales and Service of Blackwood, New Jersey, on August 30, 2007. Henise Tire retreaded the tire and returned it to MCI Sales and Service on September 6, 2007. The accident tire is shown in figure 8.

Figure 8. Right steer axle tire of the accident motorcoach.

Retreading a tire involves bonding a new tread to the tire casing through the application of heat and pressure over time.[40] The Tire Retread and Repair Information Bureau and the Technology and Maintenance Council of the American Trucking Associations have stated that retread tires are as safe as originally manufactured tires. In addition, a recent National Highway Traffic Safety Administration (NHTSA) heavy vehicle tire study[41] found that nearly half of heavy vehicle replacement tires are retreads, and evidence from road debris collected and

[40] From *Understanding Retreading* (Louisville, Kentucky: International Tire and Rubber Association Foundation, Inc., 2001). See <http://www.retread.org/PDF/UnderstandingRetreading.pdf>, accessed March 13, 2009.

[41] J.F. Woodrooffe, O. Page, D. Blower, and P.F. Green, *Commercial Medium Tire Debris Study*, prepared for DOT/NHTSA, DOT HS 811 060, contract number DTNH22-05-D-01019, task order 0012, December 2008.

examined as part of the study indicated that retread tires do not fail at rates higher than new tires.[42]

It is not known when the retread tire was mounted on the accident motorcoach's steer axle. MCI provided photographs of the accident motorcoach dated January 10, 2008 (before refurbishment), and June 23, 2008 (after refurbishment and approximately 6 weeks prior to the accident). Both photographs show the right steer axle tire to be a Firestone brand (the retread tire was a Goodyear brand). The vehicle was purchased by Angel Tours on July 19, 2008, from MCI. Vehicle maintenance and inspection records, as well as financial records, included no documentation that the tire was positioned on the steer axle before its annual safety inspection (July 31, 2008), which was conducted 8 days prior to the accident.

Inspections of Failed Tire. NTSB investigators, in conjunction with representatives of the Goodyear Tire & Rubber Company (Goodyear), examined the right steer axle tire of the accident vehicle on November 24, 2008.[43] They noted the following conditions:

- Multilayer tearing into the belts and multilayer tearing into the belt coat compound.
- Good coarse tear lines and good ply-belt wire cord impressions.
- Wheel flange impressions on the face of both beads.
- Circumferential impressions at the mid-base of both beads.
- Diagonal undulations to the face of both beads.
- Heat discoloration on the serial side bed and on the belt coat stock on the crown.
- Circumferential abrasion bands on the wheel taper/bead seat.
- A puncture/cut through the casing on the serial side tread shoulder rib.
- Tread rubber around the puncture/cut is abraded/bruised and torn.

Goodyear attributed the tire failure to the following factors:

> Short term underinflation caused by the puncture/cut resulted in severe overdeflection[44] of the tire. The stress and heat generated from the overdeflection and the forces acting on the rotating tire caused loss of adhesion between tire components, and eventual separation and detachment of tread and belt pieces.

[42] The NHTSA tire debris study also included interviews with industry operators. Sales estimates for medium-duty tires were 34–36 million per year. The proportion of retread tires was estimated at 50 percent or higher for drive tires. For trailer tires, the proportion was estimated at 70–100 percent. (See page 80, NHTSA *Commercial Medium Tire Debris Study*.)

[43] Information was obtained from Goodyear's January 15, 2009, written report to the NTSB, received January 24, 2009.

[44] Tire "deflection" is the tread and sidewall flexing where the tread comes into contact with the road. "Overdeflection" is a deflection [of the tire] that is greater than that intended for the rated load and inflation pressure. Overdeflection occurs when the load is excessively high or the inflation pressure is too low, or when a combination of load and inflation pressure creates an excessively high deflection, resulting in a flattening of the tire. (Information obtained from the e-book *The Pneumatic Tire*, A.N. Gent and J.D. Walter, eds. [Akron, Ohio: University of Akron and National Highway Traffic Safety Administration, 2005].)

> With tread and belt detachment, the unsupported casing ruptured exhausting any remaining inflation pressure.

Goodyear also concluded that there were "No defects in materials, workmanship or manufacture" of the tire. It stated that

> The multi-layer and multi-level tearing through crown components and the coarse tear lines and ply-belt wire cord impressions indicate good initial component adhesion within the casing and between the casing and the retread.

At NTSB's request, Bridgestone Americas, Inc. (Bridgestone), in conjunction with NTSB investigators, conducted an additional independent inspection of the tire on November 25–28, 2008.[45] Based on the examination, Bridgestone indicated that the tire failure "Initiated and propagated within the original casing." Bridgestone also indicated that the puncturing object gouged and tore the tread surface and the bulk of the rubber but did not pass through the tire casing. The tread rubber hole was abraded/bruised and torn, indicating that there had been some time between the puncture and the blowout. Further, the "Belt edge lift and shoulder rubber tearing occurred along the serial side (outboard facing) shoulder as the tread/belt detachment initiated in this area due to the centrifugal force of highway speed tire rotation." Bridgestone identified multiplane tear patterns, including fatigue and crack propagation, as well as evidence of adequate adhesion and tear resistance on the separated and detached tread, belt, and casing surfaces. It found numerous exposed rubber surfaces that had a "blue-tint" appearance, indicating excessive heat generation during operation. Bridgestone found no indication of separation or detachment of retread material along the splice or along any surface of the casing buffed during the retread process.

Bridgestone concluded that the failure of the right steer axle tire was a result of

> Damage caused by over-deflected operation. In this case, the most probable cause of over-deflection is underinflation due to an un-repaired puncture to the tire which lead [sp] to inflation pressure loss and damaging stress/strain and heat build-up...

Bridgestone also found that the tire was retreaded properly, and the failure was not related to the retreading. The Bridgestone report further stated that the puncture that led to the failure occurred after the tire was retreaded and put back into service. Bridgestone also said the puncturing object

> Most likely ejected from the tire during the tread/belt detachment process.
>
> Although it is difficult to state with precision how long the subject tire operated in an over-deflected manner, the tread/belt tear patterns and a lack of polishing of the separated surfaces indicate relatively short-term operation in such a condition, most likely for less than 1000 miles.

[45] Bridgestone provided the NTSB with a written report dated March 13, 2009.

Visual Inspection of Tire Inflation. According to NHTSA, the fact that a tire is inflated to half its recommended inflation value may not be detected by visual inspection.[46] Figure 9 shows a Goodyear 315/80 R22.5 tire inflated to 115 psi and 60 psi, respectively.

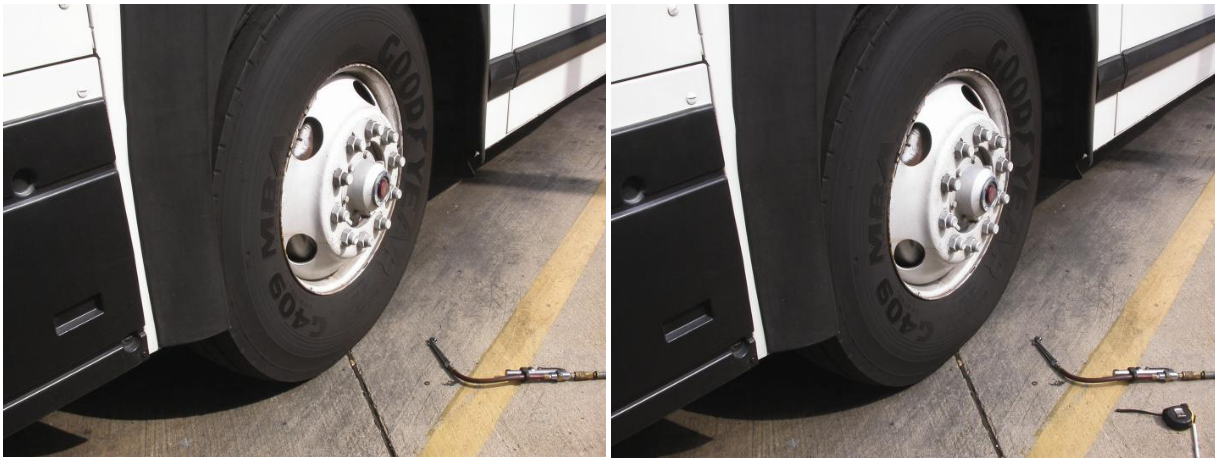

Figure 9. Photographs of a Goodyear 315/80 R22.5 tire inflated to 115 psi (left) and 60 psi (right).

The photographs illustrate the difficulty in visually detecting proper tire inflation. Visual detection of proper tire inflation on such larger vehicles may be negatively affected by the nature of commercial vehicle tire construction, which employs stronger materials, including stiffer sidewalls and harder rubber compounds, than are typically used in tires for light trucks and passenger vehicles.

Tire Pressure Information in MCI Model J4500 Maintenance Manual. Investigators found that the *MCI Model J4500 Maintenance Manual* contained inaccurate tire information and inflation pressure. Drive axle tire inflation for tire size 315/80 R22.5 was listed as 85 psi, rather than the correct inflation pressure of 90 psi. Tag axle tire inflation for tire size 315/80 R22.5 was listed as 105 psi, rather than 120 psi.[47] Additionally, the manual's GENERAL DESCRIPTION material, section 15A "Wheels" and section 15C "Tires," incorrectly stated that the motorcoach's steer axle gross axle weight rating (GAWR) was 16,000 pounds rather than 16,500 pounds.

Vehicle Maintenance

About 3 weeks before the accident, on July 19, 2008, Angel Tours purchased the motorcoach from MCI as a refurbished vehicle. The carrier did not identify any maintenance actions between the purchase date and the accident. MCI refurbishment records documented extensive inspection and corrective actions to bring the vehicle into proper operating specifications prior to the motorcoach's sale.

[46] Data and photographs on checking tire pressure may be viewed at NHTSA's Safercar website <http://www.safercar.gov/portal/site/safercar/menuitem.13dd5c887c7e1358fefe0a2f35a67789/?vgnextoid=2dbdcf6677526110VgnVCM1000002fd17898RCRD>, accessed August 4, 2009.

[47] The manual listed the correct tire inflation pressure for the steer axle tires, which is 120 psi.

Commercial Motor Vehicle Inspections

Title 49 CFR 396.17 requires commercial vehicles to receive annual inspections utilizing criteria set forth in appendix G of subchapter B of the FMCSRs. Under 49 CFR 396.23(b)(1), a motor carrier may meet the regulatory inspection requirements if the vehicle is subject to a mandatory state inspection program. The Federal Motor Carrier Safety Administration (FMCSA) certified the state of Texas's vehicle inspection program as meeting the Federal inspection requirements at 49 CFR 396.17. In Texas, motor vehicles, including motorcoaches, are inspected and approved by privately owned and operated garages and repair facilities. Official vehicle inspection stations in Texas are required to operate under the state's *Rules and Regulations Manual*.[48] The state sets and regulates the fees charged for the inspection of vehicles; currently, the fee for a commercial vehicle safety inspection of a motorcoach in Texas is $62.

A TxDPS-approved facility inspected the motorcoach 8 days before the accident, on July 31, 2008. After the inspection, the motorcoach received a Texas Commercial Vehicle Inspection Certificate sticker, indicating that the motorcoach "Complies with all Federal and state inspection requirements." The inspection was conducted at the "5 Minute Inspections" facility in Houston, Texas. The inspection report data obtained from the TxDPS concerning the garage's inspection actions contained, in part, the following: the odometer reading was 0 miles; no Texas Department of Transportation (TxDOT) number was entered; and the insurance expiration date was given as October 12, 2009 (more than 1 year into the future for an annual policy). During a postaccident interview with the mechanic who conducted the inspection, he stated that he remembered the accident motorcoach, and he recalled that it took 30–45 minutes to complete the inspection. NTSB investigators visiting the facility noted that it did not have a service pit or a commercial vehicle lift capable of lifting a motorcoach.

On August 7, 2008, another Angel Tours[49] motorcoach was inspected at 5 Minute Inspections. That vehicle, like the accident motorcoach, received an "all items passed" inspection report and a Texas Commercial Vehicle Inspection Certificate sticker. The following day, August 8, 2008, the vehicle underwent a Motor Carrier Safety Assistance Program (MCSAP)-sponsored roadside inspection conducted by the Missouri Highway Patrol. The vehicle was placed out of service with numerous equipment violations, including that the right steer axle, left steer axle, and right tag axle brakes were in violation. The automatic brake adjustor on the air brake system was also cited for a safety violation.

NTSB staff contacted the TxDPS Houston Regional Office several times to request an audit of the 5 Minute Inspections station, as well as of the subject inspector. On March 10, 2009, a TxDPS representative visited the station, interviewed the inspector, and confirmed the inspector's certificate. The TxDPS sent the NTSB a copy of its internal memorandum on this visit, dated March 11, 2009. The memorandum did not include any reference to audit processes (other than use of the emissions analyzer), knowledge testing, or practical exercises.

[48] The Texas *Rules and Regulations Manual* is issued and maintained by the TxDPS in accordance with the Texas Transportation Code, "Compulsory Inspection of Vehicles," chapter 548.

[49] See the "Motor Carrier" section of this report for a discussion of Angel Tours's relationship with Iguala BusMex.

Highway

The accident occurred on the Post Oak Creek bridge, along a portion of US-75 classified as urban principal arterial roadway.[50] It is a four-lane highway with the two northbound lanes separated from the two southbound lanes by an earthen median and a 32-inch-high, Jersey-shape concrete median barrier. Lanes of same direction travel are separated by dashed white pavement striping. The right shoulder of the northbound lanes is delineated from the main travel lanes by a solid white pavement stripe, and the left shoulder is delineated from the travel lanes by a solid yellow pavement stripe. The right shoulder is 9 feet wide as it approaches the bridge and narrows to 30 inches on the bridge deck. Rumble strips are located on the right shoulder as it approaches the bridge. The left shoulder is 4 feet wide and narrows to 22 inches on the bridge deck. A speed limit sign posted about 1 mile south of the bridge indicated the daytime speed limit as 70 mph and the nighttime limit as 65 mph. Figure 10 shows the accident scene, and figure 11 shows the final position of the motorcoach near the creek.

Figure 10. Highway accident scene, looking at the motorcoach's path off the bridge. (Photograph was taken after postaccident repairs were made to the bridge.)

[50] "Urban principal artery" is a functional classification of road. Urban principal arterial roadways serve major metropolitan centers and corridors with the highest traffic volumes and longest trip lengths. They carry most trips entering and leaving urban areas and provide continuity for all rural arterials that intercept urban boundaries.

Figure 11. Motorcoach on the bank of the Post Oak Creek. [Courtesy Sherman Police Department]

Beginning approximately 1/3 mile before the accident site, the design plan profile for the roadway indicates a 3.75-percent downgrade as the road makes a slight (2.3-degree) curve to the right, followed by a transition into a slight (1.5-degree) curve to the left for 768 feet. The approach to the bridge was equipped with a 279-foot-long, 27-inch-high metal beam guardrail fence. It comprised a 47-foot-long safety end treatment, followed by a 180-foot-long main section element, and then a 25-foot-long transition area into the bridge end, terminating with a 27-foot-long turned-down end piece that was anchored into the bridge railing curb.[51] The safety end treatment area of the guardrail had double wooden blocks for support. The main element had 28 blocked metal posts spaced at 6-foot 6-inch intervals. The transition area into the bridge end had eight metal blocked posts at 3-foot 1 1/2-inch intervals to stiffen the barrier in case of impact close to the bridge.

[51] TxDOT design records indicate that the bridge railing was a Type II rail designed in 1954 in accordance with the 1953 American Association of State Highway Officials *Bridge Specifications Manual*.

The bridge had an 7-inch-high, 18-inch-wide concrete curb above the bridge deck, as shown in figure 10. The bridge also had a 210-foot-long metal bridge railing composed of seven 30-foot-long sections with 1-inch-long nominal separations for expansion. The railing was 12 inches wide and 1/4 inch thick and was positioned 23 3/4 to 24 inches above the curb, for a total height of approximately 31 inches. It was connected to the curb with 36-inch-long by 5-inch-wide steel I-beams (five I-beam supports per section of railing) that were bolted to the railing with four bolts. I-beams were attached to the concrete bridge deck by 18-inch-long bolts cast into place in the curb during the 1958 construction of the bridge.

A June 10, 2007, bridge inspection report by TxDOT noted repairs to the bridge railing on two 30-foot-long sections of the east railing in the northern span of the bridge. It noted those repairs to be marginal because the original cast-in-place bolts, damaged as the result of a 2001 truck-semitractor accident that penetrated the bridge railing, were replaced with bolts into the side of the deck and reinforced with steel plates welded to the I-beam structure.

Following the August 2008 accident, TxDOT repaired the bridge railing to its existing design. (See figure 12.) According to TxDOT, in September 2009 it completed a railing retrofit for the accident bridge and four others along the same road segment, upgrading the accident bridge railing to a T-501 railing, which complies with a Test Level Four standard.[52] (Bridge railing designs are discussed in the "Other Information" section of this report.) In addition to the bridge railing retrofit project, the TxDOT Bridge Division has identified a U.S. corridor improvement project for US-75 and is exploring funding options.[53]

Physical Evidence

The physical evidence at the accident scene indicated a right steer axle tire mark beginning 685 feet before the motorcoach struck the curbing and bridge railing. Approximately 100 feet beyond that initial road mark, pieces of tire were found. Deflated right steer axle tire marks began 130 feet before the motorcoach struck the curbing and bridge railing. The motorcoach hit the curb at about a 4-degree angle about 29 feet north of the bridge. The motorcoach came into contact with the bridge railing midway along the second 30-foot-long section of railing (about 47 feet from the beginning of the northbound railing). The motorcoach bowed in the second section of railing to a depth of about 32 inches, breaking two of the five support posts. It then struck the leading edge of the third railing section at the expansion space. The bolts at the bottom of the I-beams sheared off, and the third section of railing came to rest about 25 feet below in Post Oak Creek. Four more sections of bridge railing, totaling 136 feet, were displaced from the bridge deck.

The bridge railing showed evidence of past vehicle strikes. No corrosion was found on the metal of the bridge railing or its fixtures.

[52] Test levels for bridge railing designs are in National Cooperative Highway Research Program Report 350, *Recommended Procedures for the Safety Performance Evaluation of Highway Features.*

[53] TxDOT estimates that the US-75 corridor improvement project will cost $125 million.

Figure 12. Two views of the repaired bridge railing. (Top) Looking down along the inside of the repaired railing from the roadway. (Bottom) Looking at the outside of the repaired railing from the bank of Post Oak Creek.

Traffic Metrics

In 2006, TxDOT performed an average daily traffic (ADT) count for US-75 in the vicinity of the bridge. The ADT was 46,961 vehicles. TxDOT indicated that the ADT of the northbound bridge lanes was about 21,000. Commercial vehicles composed approximately 16 percent of the total traffic.

TxDOT conducted a speed survey on August 18 and 21, 2008, during daylight conditions. The 85th percentile speed was 72 mph.[54]

Accident data for a 6-year period indicated that 42 additional accidents occurred in the vicinity of this accident. (See table 7.) One fatal accident occurred along this road segment in 2003, but it did not involve the bridge. Some vehicle contact was indicated by the evidence of vehicle strikes on the bridge railing, but no reports of passenger cars leaving the roadway after contact with the bridge railing were found. In the bridge's 50-year history, only two accidents, including this motorcoach event, resulted in a bridge railing failure, and both accidents involved large commercial motor vehicles. As has been noted, in 2001, an injury accident occurred when a truck tractor penetrated the bridge railing, destroying two 30-foot-long sections. No motorcoaches were involved in past accidents at this location.

Table 7. Accident history.

Year	Number of Accidents	Number of Fatalities
2003	6	1
2004	5	0
2005	5	0
2006	11	0
2007	9	0
2008[a]	6	0
6-year total	42	1

[a] Not including the August 8, 2008, accident.

Environmental Conditions

Surface weather observations were obtained from the National Oceanic and Atmospheric Administration, National Climatic Data Center for Sherman/Denison, Texas–Grayson County Airport, for August 8, 2008, at 12:26 a.m. The weather was clear, with visibility of at least 10 miles, temperature 77° F, relative humidity 79 percent, and winds calm. U.S. Naval Observatory records indicated that there was a first quarter moon on the night of August 7–8, 2008.[55]

[54] The 85th percentile speed is the speed at which or below 85 percent of surveyed vehicles are traveling.

[55] A first quarter moon has one-half of its surface illuminated.

Motor Carrier

The motor carrier Iguala BusMex, Inc., was operating the Sherman accident motorcoach. The owner of Iguala BusMex also owned Angel Tours, Inc., a motor carrier that operated from the same address. Angel Tours had received operating authority in 1994 but was placed out of service by the FMCSA on June 23, 2008. Just over a month later, on July 27, 2008, the owner of Angel Tours applied to the FMCSA for motor carrier operating authority under the name "Iguala BusMex, Inc." As of the accident date, the FMCSA had not granted operating authority to Iguala BusMex because its application was incomplete.

The owner of Iguala BusMex had an unsigned lease arrangement with Liberty Charters and Tours (Liberty) to provide drivers and buses to Liberty. The FMCSA, in part C of its postaccident compliance review, indicated that Iguala BusMex used Liberty's operating authority and U.S. Department of Transportation (DOT) number (USDOT number)[56] to engage in interstate commerce.

Information on these motor carriers and their relationships is provided below.

Angel Tours

According to state of Texas tax records, the owner of Iguala BusMex was also the owner of Angel Tours, Inc., which had been operating from the same location as Iguala BusMex. The owner of Angel Tours told FMCSA inspectors that he was the owner of Iguala BusMex. According to FMCSA records, Angel Tours received its authority to operate in 1994. It was an interstate, for-hire passenger carrier that had six buses and six drivers.

On May 1, 2008, the FMCSA conducted a compliance review of Angel Tours, which resulted in an unsatisfactory rating. Three critical violations were found, as well as several other violations. (See table 8.) The compliance review records showed that in the previous year, Angel Tours had traveled 400,000 miles with no recordable accidents.[57] The compliance review documented that the carrier had had five roadside inspections during the previous year, resulting in two vehicles being placed out of service (40 percent).[58] According to roadside inspection data for the 24 months prior to the Sherman accident, Angel Tours had 31 vehicle inspections with 6 vehicles placed out of service (19.4 percent), and 27 driver inspections with 7 drivers placed out of service (25.9 percent).

[56] The USDOT number is a registration number and is required for interstate operations.

[57] According to 49 CFR 390.5, an "accident" is defined as an occurrence involving a commercial motor vehicle operating on a highway in interstate or intrastate commerce which results in (i) a fatality; (ii) bodily injury to a person who, as a result of the injury, immediately receives medical treatment away from the scene of the accident; or (iii) one or more motor vehicles incurring disabling damage as a result of the accident, requiring the motor vehicles to be transported away from the scene by a tow truck or other motor vehicle.

[58] The FY 2008 national average bus out-of-service rate was 7.7 percent, and the average bus driver out-of-service rate was 4.8 percent.

Table 8. Violations identified in May 2008 FMCSA compliance review of Angel Tours.

Critical Violations:[a] • Using a driver before the motor carrier received a negative preemployment controlled substance test result. • Using a driver not medically examined and certified during the preceding 24 months. • Failing to require a driver to prepare a driver vehicle inspection report.
Additional Violations: • Failing to conduct random alcohol testing at an annual rate of driver positions. • Failing to conduct random controlled substance testing at an annual rate of driver positions. • Failing to provide educational material explaining the drug and alcohol policy as required. • Failing to ensure that persons designated to drive undergo reasonable suspicion testing training for controlled substances. • Using a driver who has not completed an employment application. • Failing to maintain a driver's driving record in driver qualification file. • Failing to investigate a driver's background within 30 days of employment. • Failing to investigate previous DOT-regulated employers that employed the driver within the previous 3 years. • Failing to maintain a driver's employment application in driver qualification file. • Failing to maintain a list or certificate relating to violations of motor vehicle laws and ordinances required by FMCSR 391.27. • Requiring or permitting a passenger-carrying commercial motor vehicle driver to drive more than 10 hours. • Failing to require a driver to prepare record-of-duty status in the form and manner prescribed. • Failing to keep maintenance records that identify vehicles, including make, serial number, year, and tire size. • Failing to have a means of indicating the nature and due dates of various inspection and maintenance operations to be performed. • Failing to keep a record of tests conducted on push-out windows, emergency doors, and emergency door marking lights. • Using a commercial motor vehicle not periodically inspected.

[a] During a safety audit, the FMCSA gathers information by reviewing a motor carrier's compliance with "acute" and "critical" regulations. Acute regulations are those in which noncompliance is so severe as to require immediate corrective actions by the motor carrier regardless of the overall basic safety management controls of the motor carrier. Critical regulations are those in which noncompliance relates to management and/or operational controls. Violations are indicative of breakdowns in a carrier's management controls. (Per appendix A to 49 CFR Part 385 "Explanation of Safety Audit Evaluation Criteria," paragraphs III [b] and [c]).

The motor carrier had 45 days to submit a corrective action plan to the FMCSA to change its unsatisfactory rating. On June 23, 2008, the FMCSA placed Angel Tours out of service because it had not submitted an action plan. Angel Tours submitted an action plan on June 24, but the FMCSA denied its request to change its rating due to the lateness of the submission and the inadequacy of the response. A review of the Angel Tours driver logbook records revealed several trips in interstate travel after the FMCSA had placed the motor carrier out of service.

Iguala BusMex

Iguala BusMex applied to the FMCSA for operating authority on July 27, 2008. It registered with the FMCSA as an interstate, for-hire passenger carrier. The FMCSA listed Iguala BusMex as having two buses and five drivers.[59]

As part of its application for authority to operate, Iguala BusMex was required to provide proof of the required $5 million insurance coverage (per 49 CFR 387.33). The FMCSA advised Iguala BusMex that its authority to operate would not be granted until proof of insurance could be verified. When the accident occurred, Iguala BusMex had not provided proof of the $5 million insurance coverage required to obtain operating authority; therefore, the FMCSA considered Iguala BusMex's operating authority to be pending. According to the insurance company from which Iguala BusMex was seeking insurance, as of the date of the accident, the carrier had submitted paperwork to obtain insurance, but the insurance company had not reviewed the documentation; consequently, Iguala BusMex had no active insurance policy at the time of the accident. Review of the logbooks of Iguala BusMex bus drivers indicated that the company had conducted several trips in June 2008 without operating authority and in August 2008 with pending operating authority.

On August 9, 2008, a day after the Sherman accident, the FMCSA issued an imminent hazard and out-of-service order for Iguala BusMex and Angel Tours and their officers and directors. The bases of the imminent hazard order were the operation of vehicles in a mechanically unsafe operating condition; the failure to ensure that the vehicles were properly and regularly inspected, repaired, and maintained; and the failure to ensure compliance with the Federal controlled substance and alcohol use and testing requirements, driver qualifications requirements, and driver hours-of-service requirements.[60] Iguala BusMex and Angel Tours were required to cease all motor vehicle operations.[61] The FMCSA also said that "Angel Tours' continuity of operation through Iguala BusMex demonstrated a blatant disregard for previous FMCSA Out-of-Service Orders, which were issued based upon the company's substandard safety record."[62]

The FMCSA's Motor Carrier Management Information System (MCMIS) report on the carrier did not indicate any roadside inspections for Iguala BusMex. The day after the Sherman accident, August 9, 2008, the FMCSA began a compliance review of Iguala BusMex, but FMCSA personnel were asked by the company owner to leave within 2 hours of starting the review. The FMCSA obtained a subpoena for the company records, and the compliance review was continued on September 19, 2008. The subpoena for company records and the imminent hazard shutdown order were obtained on August 9, 2008, and were served to an attorney

[59] In a postaccident interview, the accident driver stated that the company operated six buses.

[60] U.S. Department of Transportation, FMCSA, Operations Out-of-Service Order issued August 9, 2008, at <http://www.fmcsa.dot.gov/about/news/news-releases/2008/IH-Order-Angel-Tours-Iguala-Busmex-8-9-08.pdf>, accessed August 4, 2009.

[61] The Missouri State Police placed a second Iguala BusMex motorcoach out of service after it arrived in Carthage, Missouri.

[62] The FMCSA's review of the motor carrier operations demonstrated that Angel Tours and Iguala BusMex were motor carriers that transported passengers on identical routes, had the same customer base, used the same equipment and drivers, operated from the same physical location, and were controlled by the same owner.

representing the company. The delay in conducting the compliance review involved negotiations with the attorney to obtain copies of Iguala BusMex corporate records. No principals of the company were available to be subpoenaed or questioned during the conduct of the compliance review. The compliance review resulted in an unsatisfactory rating. Iguala BusMex received unsatisfactory ratings for the Driver, Operational, and Vehicle factors and a conditional rating for the General factor. The violations listed in table 9 were noted in the review.

Table 9. Violations identified in September 2008 FMCSA compliance review of Iguala BusMex.

Acute Violation: • Operating a motor carrier without having in effect the required minimum levels of financial responsibility.
Critical Violations: • Using a driver before the motor carrier received a negative preemployment controlled substance test result. • Using a driver not medically examined and certified during the preceding 24 months. • Failing to maintain a medical examiner's certificate in driver's qualification file. • Failing to require a driver to forward, within 13 days of completion, the original of the record-of-duty status. • Failing to keep records of inspection and vehicle maintenance indicating their date and nature. • Failing to require a driver to prepare driver vehicle inspection reports.
Other Violations: • Using a driver who had not completed and furnished an employment application. • Failing to maintain a road test certificate in a driver's qualification file, or a copy of the license or certificate the motor carrier accepted as equivalent. • Operating without the required operating authority. [*Sherman accident trip*] • Making false reports of record-of-duty status. • Operating a motor vehicle in such a condition as likely to cause an accident or breakdown.

Liberty Charters and Tours

The FMCSA conducted a compliance review of Liberty on August 11, 2008. During its compliance review, the FMCSA found an unsigned vehicle lease agreement between Liberty and Angel Tours, covering the period from June 28 through September 28, 2008.[63] Part C of the FMCSA's postaccident compliance review also stated that the owner of Liberty had agreed to let the owner of Iguala BusMex/Angel Tours use Liberty's operating authority to engage in interstate commerce.

In its compliance review of Liberty, the FMCSA found 24 violations, including the following: using a driver known to have tested positive for a controlled substance, failing to adequately conduct random alcohol and controlled substance testing, failing to investigate

63 The lease agreement document called for Angel Tours to provide Liberty with three motorcoaches. The agreement identified the vehicles by year and make but did not include vehicle identification numbers.

drivers' backgrounds, failing to maintain drivers' qualification files, and making false record-of-duty status reports. Liberty received an unsatisfactory rating.

The FMCSA issued an out-of-service order to Liberty on August 12, 2008, citing Liberty's affiliation with Angel Tours and Iguala BusMex as an imminent hazard and stating that continued motor carrier operations with Angel Tours, Iguala BusMex, or the owner of these companies was prohibited. Liberty had 45 days to submit a corrective action plan to have its unsatisfactory rating changed. The FMCSA conducted a second compliance review of Liberty on November 13, 2008. Six violations, none critical or acute, were found during that review. The carrier received a satisfactory rating. Restrictions associated with the imminent hazard order remain; Liberty cannot have any dealings with Angel Tours, Iguala BusMex, or the owner of these companies.

Other Information

Bridge Railing Design Guidance

This section summarizes the NTSB's past investigative and recommendation history concerning highway barriers—a general category of highway safety appurtenances—and bridge railings, an important subcategory of barriers. It includes a discussion of the design documents used by highway engineers and distinguishes between guidance documents, which bridge owners *may* follow, and requirement specifications, which *must* be followed.

NTSB History. On May 21, 1976, a 29-fatality school bus crash occurred on Interstate 680 near Martinez, California.[64] That accident and the NTSB's investigation of it served as catalysts for the development of higher performance bridge railings. In that accident, a school bus climbed the bridge railing, fell to the ground below, and landed on its roof. As a result of that investigation, the NTSB issued Safety Recommendations H-77-12 through -14 to the Federal Highway Administration (FHWA) concerning bridge railings, as follows:

> Develop bridge railing designs that will meet performance standards to be established by the FHWA for various classes of vehicles and that will be sufficient in number to meet the various state requirements with regard to climatic and other physical conditions that affect the operation and maintenance of a roadway system. Such bridge barrier railing designs should be available to states that do not desire to develop their own designs in accordance with mandatory performance standards issued by the FHWA. (H-77-12)

> Investigate through dynamic crash testing and analytical procedures the effects of various geometric configurations and adjacent roadway surfaces on the performance of traffic barrier rail systems. The investigation should also consider how maintenance practices or the lack of maintenance affects the performance of the barrier rail systems. (H-77-13)

[64] *Student Transportation Lines, Inc., Charter Bus Climbing of Bridge Rail and Overturn Near Martinez, California, May 21, 1976,* Highway Accident Report NTSB/HAR-77/02 (Washington, DC: National Transportation Safety Board, 1977).

> In cooperation with the states, establish priority guidelines for improving, through modification or retrofit, the performance of existing traffic barrier rail systems at bridges. Consideration should be given in the priority guidelines to the potential for multi-fatality accidents involving high occupancy vehicles such as buses. (H-77-14)[65]

In 1980, the NTSB completed a Safety Effectiveness Evaluation of Traffic Safety Barriers (SEE-80-5). That report reviewed the NTSB's previous work on the issue[66] and evaluated the FHWA effort to develop safer traffic barriers. SEE-80-5 contained Safety Recommendation H-80-64, to the FHWA, which reads as follows:

> Establish mandatory performance standards, and associated test procedures to be used in determining compliance, for all traffic barriers constructed on Federal-aid roads after January 1, 1982. The performance standards should first address automobiles and should be expanded for heavier passenger vehicles and trucks as research is completed to provide needed information. (H-80-64)[67]

In November 1983, a fatal bus crash in which the bus penetrated the bridge railing occurred in Livingston, Texas.[68] This accident prompted the NTSB to make Safety Recommendation H-84-65 to the Texas State Department of Highways and Public Transportation, which reads as follows:

> As part of any major pavement improvement project, provide wherever feasible for the installation of advanced barrier systems on and approaching bridges in the state of Texas. (H-84-65)[69]

Following the issuance of SEE-80-5, the NTSB continued to investigate both barrier and bridge railing accidents. Accident investigations to date involving barriers have included Fairfield, Connecticut; Memphis, Tennessee; New Orleans, Louisiana; Slinger, Wisconsin; and St. Louis County, Missouri.[70] Past investigations involving bridge railings have included Atlanta,

[65] Safety Recommendation H-77-12 was "Closed—Superseded," Safety Recommendation H-77-13 was "Closed—Acceptable Action," and Safety Recommendation H-77-14 was "Closed—Unacceptable Action."

[66] Five highway accident investigations were reviewed. They were as follows: (a) NTSB/HAR-77/02; (b) *Transport Company of Texas, Tractor Semitrailer (Tank) Collision with Bridge Column and Sudden Dispersal of Anhydrous Ammonia Cargo, Houston, Texas, May 11, 1976*, Highway Accident Report NTSB/HAR-77/01 (Washington, DC: National Transportation Safety Board, 1977); (c) *Automobile Collision With and Collapse of the Yadkin River Bridge, Near Siloa, North Carolina, February 23, 1975*, Highway Accident Report NTSB/HAR-76/03 (Washington, DC: National Transportation Safety Board, 1976); (d) *Automobile Crash Off the Silliman Evans Bridge, I-24/65, Nashville, Tennessee, July 27, 1973*, Highway Accident Report NTSB/HAR-74/02 (Washington, DC: National Transportation Safety Board, 1974); (e) *Wilmeth Cattle Company Truck/Bridge Transportation Enterprises, Inc., Bus, U.S. 60-84, Fort Sumner, New Mexico, December 26, 1972*, Highway Accident Report NTSB/HAR-74/01 (Washington, DC: National Transportation Safety Board, 1974).

[67] Safety Recommendation H-80-64 was "Closed—Acceptable Alternate Action."

[68] *Trailways Lines, Inc., Bus/E.A. Holder, Inc., Truck, Rear End Collision and Bus Run-Off-Bridge, U.S. Route 59, Near Livingston, Texas, November 30, 1983*, Highway Accident Report NTSB/HAR-84/04 (Washington, DC: National Transportation Safety Board, 1984).

[69] Safety Recommendation H-84-65 was "Closed—Unacceptable Action."

[70] (a) *Multiple Vehicle Collision on Interstate 95, Fairfield, Connecticut, January 17, 2003*, Highway Accident Report NTSB/HAR-05/03 (Washington, DC: National Transportation Safety Board, 2005); (b) *15-Passenger Child*

Georgia; Omaha, Nebraska; White Plains, New York; Middletown, New Jersey; Frederick, Maryland; and Hermanville, Mississippi.[71]

Design Documents. The Post Oak Creek bridge, built in 1958, was designed according to the 1953 American Association of State Highway Officials (AASHO)[72] *Bridge Specifications Manual*. Since 1958, several new design standards and associated guides for their usage have been introduced. The following chronology summarizes the development of guidelines addressing the intent of the NTSB's original bridge railing performance standard recommendations (Safety Recommendations H-77-12 through -14).[73]

FHWA memorandums show that bridges constructed prior to 1964 generally do not have crash-tested bridge railings. In the late 1960s and early 1970s, some states, such as California and Texas, began crash-testing programs to develop crashworthy bridge railings. By 1972, California had a standard design for bridge railings that would redirect passenger cars, but the design did not address heavier vehicles.

The Transportation Research Board (TRB) National Cooperative Highway Research Program (NCHRP) Project 22-2(4) was initiated to recommend procedures for the safety performance evaluation of barrier systems. That project resulted in a 1980 report, NCHRP Report 230, *Recommended Procedures for the Safety Performance Evaluation of Highway Safety Appurtenances*, which served thereafter as the primary reference for full-scale crash testing in the United States.[74] The crash-test procedures were based on three performance levels to evaluate the

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Care Van Run-Off-Road Accident, Memphis, Tennessee, April 4, 2002, Highway Accident Report NTSB/HAR-04/02 (Washington, DC: National Transportation Safety Board, 2004); (c) *Motorcoach Run-Off-The-Road, New Orleans, Louisiana, May 9, 1999*, Highway Accident Report NTSB/HAR-01/01 (Washington, DC: National Transportation Safety Board, 2001); (d) *Multiple Vehicle Crossover Accident, Slinger, Wisconsin, February 12, 1997*, Highway Accident Report NTSB/HAR-98/01 (Washington, DC: National Transportation Safety Board, 1998); (e) *School Bus-Loss of Control and Collision With Guard Rail and Sign Pillar, U.S. Highway 70 Near Lucas and Hunt Road, St. Louis County, Missouri, November 11, 1985*, Highway Accident Report NTSB/HAR-87/02 (Washington, DC: National Transportation Safety Board, 1987).

[71] (a) *Motorcoach Override of Elevated Exit Ramp, Interstate 75, Atlanta, Georgia, March 2, 2007*, Highway Accident Report NTSB/HAR-08/01 (Washington, DC: National Transportation Safety Board, 2008); (b) *School Bus Run-Off-Bridge Accident, Omaha, Nebraska, October 13, 2001*, Highway Accident Report NTSB/HAR-04/01 (Washington, DC: National Transportation Safety Board, 2004); (c) *Propane Truck Collision with Bridge Column and Fire, White Plains, New York, July 27, 1994*, Highway Accident Report NTSB/HAR-95/02 (Washington, DC: National Transportation Safety Board, 1995); (d) *Academy Lines, Inc., Intercity Bus Run-Off-Roadway and Overturn, Middletown, New Jersey, September 6, 1987*, Highway Accident Report NTSB/HAR-88/03 (Washington, DC: National Transportation Safety Board, 1988); (e) *Intercity Bus Loss of Control and Collision With Bridge Rail on Interstate 70 Near Frederick, Maryland, August 25, 1985*, Highway Accident Report NTSB/HAR-87/01 (Washington, DC: National Transportation Safety Board, 1987); (f) *Pattison Head Start Center School Van Run Off Bridge and Fire, Near Hermanville, Mississippi, December 17, 1981*, Highway Accident Report NTSB/HAR-82/05 (Washington, DC: National Transportation Safety Board, 1982).

[72] AASHO was the predecessor agency to the American Association of State Highway and Transportation Officials.

[73] It should be noted that bridge railings are a distinct category within a larger group of highway safety appurtenances, which includes longitudinal barriers, transitions, end terminals, crash cushions, breakaway supports, truck-mounted attenuators, and work zone traffic control devices. Design guidance is both general to safety appurtenances and specific to bridge railings.

[74] Two earlier documents preceded NCHRP Report 230. The *Highway Research Correlation Services Circular 481* (1962) was a 1-page document that introduced the concept of uniformity to traffic barrier research. NCHRP Project 22-2 resulted in NCHRP Report 153, *Recommended Procedures for Vehicle Crash Testing of Highway Appurtenances*, a 16-page report that expanded on *Circular 481* but was still limited in scope.

structural adequacy of a barrier system. NCHRP Report 230 did not include site-specific guidance as to which performance level would be appropriate for a given location.

The American Association of State Highway and Transportation Officials (AASHTO) 1989 *Guide Specifications for Bridge Railings* categorized crash tests into three performance levels similar to those in NCHRP Report 230[75] and provided guidance to highway engineers regarding the selection of a barrier with an adequate performance level based on a project site's characteristics. The preface to this document contains the following statement: "Bridge railing performance needs differ greatly from site to site over our highway network, and railing designs and costs should match site needs." Use of the AASHTO 1989 *Guide Specifications for Bridge Railings* by state highway agencies is optional, and states are encouraged to develop their own selection criteria.

As knowledge about roadside safety performance evaluations continued to evolve, NCHRP Project 22-7 was formed to update NCHRP Report 230. The result was NCHRP Report 350, *Recommended Procedures for the Safety Performance Evaluation of Highway Features*, issued in 1993. NCHRP Report 350 describes full-scale crash testing using six test levels to evaluate the structural adequacy of a barrier system as follows:

- **TL-1 (Test Level One)** is taken to be generally acceptable for work zones with low posted speeds and very low volume, low-speed local streets;
- **TL-2 (Test Level Two)** is taken to be generally acceptable for work zones and most local and collector roads with favorable site conditions, as well as where a small number of heavy vehicles is expected and posted speeds are reduced;
- **TL-3 (Test Level Three)** is taken to be generally acceptable for a wide range of high-speed arterial highways with very low mixtures of heavy vehicles and with favorable site conditions;
- **TL-4 (Test Level Four)** is taken to be generally acceptable for the majority of applications on high-speed highways, freeways, expressways, and interstate highways with a mixture of trucks and heavy vehicles;
- **TL-5 (Test Level Five)** is taken to be generally acceptable for the same applications as TL-4 and where large trucks make up a significant portion of the average daily traffic or when unfavorable site conditions justify a higher level of railing resistance;
- **TL-6 (Test Level Six)** is taken to be generally acceptable for applications where tanker-type trucks or similar high center of gravity vehicles are anticipated, particularly with unfavorable site conditions.

As with NCHRP Report 230, NCHRP Report 350 did not include specific guidance as to which test level (that is, which performance level) would be appropriate for a given site.

[75] The crash test matrix included in the 1989 *Guide Specifications for Bridge Railings* differed in several areas from the NCHRP Report 230 test matrices.

Work by AASHTO's Highway Subcommittee on Bridges and Structures determined that the *Standard Specifications for Highway Bridges*[76] had gaps and inconsistencies and did not use the latest design philosophy and knowledge.[77] In response, in 1994, AASHTO adopted the *Load and Resistance Factor Design (LRFD) Bridge Design Specifications*, which were published as an alternative to the *Standard Specifications for Highway Bridges*. Section 13 of the *LRFD Bridge Design Specifications* contains recommendations on bridge railing designs and incorporates a crash-test matrix that differs from those used in NCHRP Report 350 and the AASHTO *Guide Specifications for Bridge Railings*.

In May 1996, the FHWA held discussions with the AASHTO Highway Subcommittee on Bridges and Structures, Technical Committee for Guardrails and Bridge Rails. As a result of those discussions, the FHWA issued a memorandum containing its position regarding AASHTO guidance on bridge railings. That 1996 policy memorandum strongly suggested that AASHTO adopt the definitions and test criteria in NCHRP Report 350. But the FHWA memorandum stated that until AASHTO adopts a new railing level selection procedure, the FHWA will accept the procedures in the 1989 *Guide Specifications for Bridge Railings*[78] or a rational, experience-based, consistently applied procedure proposed by the state.

The 2007 *LRFD Bridge Design Specifications* replaced the 1994 specifications, but the document still incorporated six test levels similar to NCHRP Report 350. It provided some general guidance to be considered for site selection but made no provisions for analytically determining the barrier performance level appropriate for a given site. The document also specified that "It shall be the responsibility of the user agency to determine which of the test levels is most appropriate for the bridge site." It also stated the following:

> Agencies should develop objective guidelines for use of bridge railings. These guidelines should take into account factors such as traffic conditions, traffic volume and mix, cost and in-service performance, and life-cycle cost of existing railings.

Most recently, AASHTO has issued the 2009 *Manual for Assessing Safety Hardware* (MASH),[79] developed under NCHRP Project 22-14(02), "Improvement of Procedures for the Safety-Performance Evaluation of Roadside Features." MASH represents the latest evolution in barrier testing and will be used to evaluate the structural adequacy of a barrier system based on updated test vehicles and impact conditions. It contains revised criteria for evaluation of highway safety features based on changes in vehicle fleets. MASH will replace NCHRP Report 350 on

[76] *Standard Specifications for Highway Bridges*, 17th edition (Washington, DC: American Association of State Highway and Transportation Officials, September 1, 2002).

[77] AASHTO Highway Subcommittee on Bridges and Structures, *Grand Challenges: A Strategic Plan for Bridge Engineering*, <http://bridges.transportation.org/Documents/2005strategicplan-websiteversion.pdf>, accessed September 25, 2009.

[78] These are based on the three performance levels developed in NCHRP Report 230, not the six levels in NCHRP Report 350.

[79] MASH has been reviewed and approved by AASHTO's Standing Committee on Highways as of June 1, 2009. As it stands now, immediately upon publication, any new devices, including any modifications and/or revisions to NCHRP Report 350-compliant devices, will have to be crash-tested under the new AASHTO MASH. However, if an NCHRP Report 350 test program has already begun, that program may continue, and results may be submitted to the FHWA prior to January 1, 2011.

January 1, 2011. As with the previous NCHRP project documents, MASH will utilize full-scale crash testing and will not provide site-specific guidance regarding barrier performance.

Guidance for bridge railing design also appears in AASHTO's *Roadside Design Guide*. Guidance in the 2006 edition of the document is similar to what is found in the *LRFD Bridge Design Specifications*, in that the 2006 *Roadside Design Guide* states that "For existing bridges, individual states should develop guidelines for retention, upgrading… of in-place railings," and "Owners should develop warrants for the bridge site."[80]

Texas has developed a *Bridge Rail Manual*; the manual does not contain selection criteria or warrants for the installation of high-performance barriers, including bridge railings. NTSB investigators asked other state departments of transportation what guidance they use when selecting a barrier system for a specific site; many replied that they use AASHTO's *LRFD Bridge Design Specifications*.[81]

Since 1986, the FHWA has required that bridge railings used on Federal-aid projects meet full-scale crash-test criteria.[82] An FHWA policy memorandum, dated 1997, stated, "All new or replacement safety features on the National Highway System [NHS]… are to have been tested and evaluated and found acceptable in accordance with NCHRP Report 350."[83] The minimum acceptable bridge railing will be a TL-3 unless supported by a rational selection procedure. That same memorandum stated that the FHWA does not intend for that requirement to result in the replacement or upgrading of existing installed features beyond the course of normal improvements.

Means Used to Check Tire Pressure

Pretrip Examinations. Title 49 CFR 392.7 requires commercial drivers to examine the tires of their motor vehicles at the beginning of each trip. The regulation does not require that the driver use a tire pressure gauge. If the tire is found to be improperly inflated, the driver must remedy the problem before driving the vehicle.

The American Association of Motor Vehicle Administrators (AAMVA) model CDL manual[84] recommends that drivers check for proper tire inflation by "Using a tire gauge, or by

80 The *LRFD Bridge Design Specifications* define a "warrant" as a document that provides guidance to the designer in evaluating the potential safety and operational benefits of traffic control devices or features. Warrants describe criteria for use of a higher level highway feature; for example, 30 percent truck traffic might indicate that a higher performance barrier is appropriate. The warrant serves to convey concern over a particular traffic hazard and is used to evaluate the potential safety and operational benefits of a highway feature.

81 All states require at least TL-3 barriers on new construction and rehabilitation projects on National Highway System highways. Based on an examination of the 28 state bridge rail policies that are available online, investigators confirmed that some states have requirements for high-performance barriers. Eleven states require TL-4 barriers on National Highway System projects, and seven states either have requirements for TL-5 barriers on interstate projects or have specific guidance on when to select TL-5 barriers (Arizona, Iowa, Maine, Massachusetts, New York, Oregon, and Pennsylvania).

82 Crash tests are conducted using vehicles of known weights operating at controlled speeds and impact angles.

83 See <http://safety.fhwa.dot/roadway_dept/docs/accept.pdf>, accessed July 20, 2009.

84 AAMVA 2005 model *Commercial Driver's License Manual*. The AAMVA model manual is a template used by the states as a guide for preparing their state CDL manuals.

striking tires with a mallet or other similar device." The manual specifically notes that kicking the tires to check for proper inflation is not an effective way to examine them.

The AAMVA model CDL manual lists the following problems to be aware of when conducting a pretrip tire inspection:

- Too much or too little air pressure.
- Bad wear. You need at least 4/32-inch tread depth in every major groove on front tires. You need 2/32 inch on other tires. No fabric should show through the tread or sidewall.
- Cuts or other damage.
- Tread separation.
- Dual tires that come in contact with each other or parts of the vehicle.
- Mismatched sizes.
- Radial and bias-ply tires used together.
- Cut or cracked valve stems.
- Regrooved, recapped, or retreaded tires on the front wheels of a bus. These are prohibited.

According to the FMCSA, a sampling of commercial vehicle tires indicated that approximately 7.08 percent of all such tires were underinflated by as much as 20 psi. Only 44.15 percent of all tires were within ± 5 psi of their target pressure.[85] Data also showed that only 34.55 percent of chartered motorcoach tires were within ± 5 psi of their target pressure and that 9.37 percent of chartered motorcoach tires were underinflated by 20 psi or more. Motorcoach fleets with fewer than 50 power units had 11.75 percent of their tires underinflated by 20 psi or more, while fleets with more than 500 power units had 2.09 percent of their tires underinflated by 20 psi or more.

Tire Pressure Monitoring Systems. A tire pressure monitoring system (TPMS) automatically detects tire pressure information and can communicate it to the driver or fleet manager.[86] Typically, tire inflation pressure is measured with sensors attached to the tire, wheel, or valve stem and is displayed at the valve or on the driver's control panel. "Indirect" TPMSs calculate a tire's apparent state of inflation by monitoring its rotational speed. Indirect systems cannot detect multiple underinflated tire conditions unless equipped with additional sensors and software to capture wheel vibration and load shifts. "Direct" TPMSs use pressure sensors to determine the tire's inflation pressure, and some systems can transmit data from the tire to the driver. Direct systems are capable of identifying multiple underinflated tires simultaneously and

[85] *Commercial Motor Vehicle Tire Pressure Sensors*, FMCSA-PSV-05-002 (Washington, DC: Federal Motor Carrier Safety Administration, July 2005).

[86] *Commercial Motor Vehicle Safety and Security Systems Technology Tire Pressure Monitoring Systems*, available on the FMCSA website. See <http://www.fmcsa.dot.gov/facts-research/systems-technology/product-guides/tire-pressure.htm>, accessed August 4, 2009.

can account for changes in tire pressure due to environmental conditions. Some systems measure temperature in addition to pressure, alerting the driver to the risk of tire failures that can result from underinflation, overloading, or the presence of other dangerous mechanical conditions, such as dragging brakes or failing wheel bearings.

On November 1, 2000, Congress enacted the Transportation Recall Enhancement, Accountability, and Documentation Act (TREAD Act),[87] which directed the Secretary of Transportation to conduct rulemaking to require warning systems on all new motor vehicles that would indicate to the vehicle operator when a tire is underinflated. In 2007, NHTSA rulemaking at 49 CFR Part 571[88] required TPMSs on new passenger cars, multipurpose passenger vehicles, and trucks and buses with GVWRs of 10,000 pounds or less (except for those vehicles with dual wheels on an axle). The rulemaking also established Federal Motor Vehicle Safety Standard (FMVSS) 138,[89] which specifies the system performance requirements.[90] According to FMVSS 138, the TPMS must activate not more than 20 minutes after inflation pressure in one or more tires is equal to or less than 25 percent below the vehicle manufacturer's recommended cold inflation pressure.[91]

No requirement or standard currently exists for the application of TPMSs on commercial vehicles with GVWRs greater than 10,000 pounds.

Motorcoach Crash Testing

In December 2007, NHTSA conducted its first motorcoach crash test.[92] That frontal crash test, and subsequent sled tests, looked at crash forces under different velocities, impact angles, and restraint conditions. In the frontal crash test, the luggage rack failed.

In February 2008, NHTSA conducted roof strength tests on four motorcoaches, comparing U.S. school bus and European motorcoach roof strength requirements. An MCI motorcoach and a Prevost motorcoach were tested under both the FMVSS 220 school bus rollover protection standard and the United Nations Economic Commission for Europe Regulation 66 (ECE R66), "Rollover Protection Strength and Structural Integrity," requirements. The motorcoaches failed both the FMVSS 220 and the ECE R66 tests. An additional ECE R66 test of a 2000 MCI motorcoach was performed in July 2009. Of the two standards, the ECE R66 test is considered a more "real-world" test because it is a dynamic fall onto a hard surface from an 800-millimeter (mm) (about 2.6-foot) step. In this test, the motorcoach is equipped with templates representing the residual space. No object outside of the residual space at the start of the test, including the luggage racks, may intrude upon this space during the test; however, those

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[87] Public Law 106-414.

[88] *Federal Register*, vol. 72, no. 133 (July 12, 2007), p. 38017.

[89] See 49 CFR 571.138.

[90] The regulation is in effect for vehicles manufactured after September 1, 2007.

[91] Title 49 CFR 571.138 also contains a "Low Tire Pressure Warning Telltale Minimum Activation Pressure Table" by tire type load rating that can be used as an alternative reference to the 25-percent manufacturer-recommended pressure.

[92] Based on NHTSA's "Approach to Motorcoach Safety," NHTSA Docket 2007-28793.

racks are unloaded.[93] In the February 2008 ECE R66 test of the MCI motorcoach, the left side luggage rack inboard hangers (supports) rearward of the two front hangers broke, exposing sharp metal edges.[94] In this test, contact was documented between the back of an unrestrained crash test dummy's head and the bottom of the luggage rack. The lap/shoulder-belted dummies on the far side showed much lower risk for injury than the unrestrained dummies. In addition, during the 2007 frontal crash test, several unrestrained crash dummies experienced their highest resultant head accelerations during head contact with the luggage racks.

New Entrant Program

As a result of a 2002 truck tractor-semitrailer accident in Loraine, Texas,[95] the NTSB issued Safety Recommendation H-03-2 to the FMCSA, recommending that it

> Require all new motor carriers seeking operating authority to demonstrate their safety fitness *prior* to obtaining new entrant operating authority by, at a minimum: (1) passing an examination demonstrating their knowledge of the *Federal Motor Carrier Safety Regulations*; (2) submitting a comprehensive plan documenting that the motor carrier has management systems in place to ensure compliance with the *Federal Motor Carrier Safety Regulations*; and (3) passing a Federal Motor Carrier Safety Administration safety audit, including vehicle inspections. (H-03-2)

The recommendation is currently classified "Open—Acceptable Response."

In response to Safety Recommendation H-03-2, the FMCSA developed the New Applicant Screening Program. All new motor carriers operating in interstate commerce are required to apply to the FMCSA for registration as a new entrant. A new entrant carrier is subject to an 18-month safety-monitoring period, and it receives a safety audit sometime after its first 3 months of operation but before it completes 18 months of operation. At a minimum, the safety audit will cover driver qualifications, driver duty status, vehicle maintenance, accident register, and controlled substance and alcohol use testing requirements. If the FMCSA identifies deficiencies, the carrier must provide evidence to the FMCSA that the faults found during the audit are being corrected. The FMCSA has stated that it will grant permanent motor carrier registration only if the new entrant successfully completes the 18-month monitoring period.

On December 16, 2008, the FMCSA published a final rule addressing the New Entrant Safety Assurance Process.[96] The stated intent of the rule is to improve the FMCSA's

[93] NHTSA Motorcoach Roof Crush/Rollover Testing presentation, February 2009 Government Industry Meeting <http://www.nhtsa.dot.gov/staticfiles/DOT/NHTSA/NRD/Multimedia/PDFs/Public%20Paper/SAE/2009/Hott%202009%20SAE.pdf>, accessed September 21, 2009.

[94] *NHTSA ECE Regulation 66-Based Research Test of Motorcoach Roof Strength*, Final Report, ECE66-MGA2007-001, May 2008.

[95] *Collision of Greyhound Lines, Inc., Motorcoach and DelCar Trucking Truck Tractor-Semitrailer, Loraine, Texas, June 9, 2002*, Highway Accident Report NTSB/HAR-03/01(Washington, DC: National Transportation Safety Board, 2003).

[96] *Federal Register*, vol. 73, no. 242 (December 16, 2008), pp. 76472–76497.

> Ability to identify at-risk new entrant motor carriers and ensure that deficiencies are corrected before granting them permanent registration. It also ensures that applicants will become knowledgeable about Federal Safety regulations before they commence interstate operations.

The rule specifically addresses "reincarnated carriers," which are defined in the final rule as "A carrier that attempts to register as a new entrant and operate as a different entity under a new USDOT Number in an effort to evade enforcement action and/or out-of-service orders issued against it by the [FMCSA]." The new regulations state that any carrier that provides false or misleading information or conceals information is subject to revocation of its new entrant registration and civil penalties.[97] In the final rule, the FMCSA stated that it is also planning to address reincarnated carriers under a separate rulemaking in response to section 4113 of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (often referred to as SAFETEA-LU) regarding patterns of safety violations by motor carrier management.

According to the FMCSA, all new entrant applications are sent to its division offices for review. The FMCSA also contacts state agencies to obtain information on the new entrant.[98] The FMCSA has developed an evasion detection algorithm (EDA) to identify those household goods carriers with histories of poor safety performance. In August 2008, the FMCSA began applying the EDA screening process to newly registered passenger carriers before granting them operating authority.[99] The EDA searches selected data to identify new applicants that may be enforcement evaders by detecting matches between new registrants and information provided by previously registered motor carriers.

Following publication of the December 2008 final rule on the New Entrant Safety Assurance Process, a petition for reconsideration challenged that the FMCSA had failed to address section 210(a) of the Motor Carrier Safety Improvement Act of 1999 (Public Law 106-159, 113 Stat. 1764, December 9, 1999) requiring new entrant carriers to demonstrate a minimum knowledge of the safety standards. On August 25, 2009, the FMCSA published an Advance Notice of Proposed Rulemaking (ANPRM)[100] to address the knowledge requirements in 49 CFR Part 385. The ANPRM requested comments on proficiency examinations or alternative methods that the FMCSA should consider implementing to provide assurance that new applicant carriers are knowledgeable about applicable safety requirements. The ANPRM relates to Safety Recommendation H-03-2 (see above), which contains an element that calls for new entrant carriers to pass an examination demonstrating their knowledge of the FMCSRs. Issuance of the ANPRM suggests that work may be underway to fulfill the knowledge examination element of Safety Recommendation H-03-2.

Due to the circumstances of the Sherman accident, the U.S. Government Accountability Office (GAO) was asked to determine the number of carriers registered with the FMCSA as new entrants that were substantially related to carriers previously ordered out of business. The results

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[97] Title 49 *United States Code* 521(b)(2)(A) sets civil penalties not to exceed $2,500.

[98] December 10, 2008, presentation by the director of the FMCSA Office of Enforcement and Compliance to the Motor Carrier Safety Advisory Committee.

[99] In July 2009, the new applicant screening methodology became available as a web-based tool.

[100] *Federal Register*, vol. 74, no. 163 (August 25, 2009), pp. 42833–42836.

of the GAO study were published in late July 2009.[101] The GAO examined the records of carriers placed out of service in fiscal years 2007 and 2008. It identified 20 carriers out of 220 (9 percent) that it believed had most likely attempted to evade enforcement actions by reopening as new companies. The GAO acknowledged that its analysis probably underestimated the true number of reincarnated carriers because it did not look at the entire new entrant population; it considered only those new entrants for which an accident or an inspection had occurred. Also, the GAO analysis required exact matches of at least two data elements to avoid linking carrier records in case typographical errors or abbreviations affected the data match; the study could not identify carriers that had provided false information on their applications. The GAO study did not evaluate the effectiveness of the New Entrant Safety Assurance Process or of new entry safety audits, and it could not determine the extent to which reincarnated carriers are able to avoid detection when registering to operate with the FMCSA.

[101] U.S. Government Accountability Office, *Reincarnating Commercial Vehicle Companies Pose Safety Threat to Motoring Public; Federal Safety Agency Has Initiated Efforts to Prevent Future Occurrences*, GAO-09-924, July 28, 2009.

Analysis

The analysis begins with a discussion of the factors and conditions the NTSB has excluded as neither causing nor contributing to the accident. It then proceeds to a discussion of the safety issues. The safety issues identified in this report are the tire failure and the need for tire pressure monitoring systems on commercial vehicles; the failure of the bridge railing and the need for criteria for the selection of appropriate bridge railing designs; the lack of oversight of the Federal commercial vehicle inspections that are delegated to the states; the lack of motorcoach occupant protection systems; and, the deficiencies in the Federal safety oversight of new entrant motor carriers.

Exclusions

At the time of the accident, skies were clear, the temperature was about 77° F, and no rain was reported. The pavement was dry. Therefore, the NTSB concludes that the weather did not cause or contribute to the accident.

Police, fire, and EMS units were dispatched to the scene within 2 minutes of the initial notification of the accident and arrived on the scene within 6 minutes. All injured passengers were triaged at the scene and transported to nine medical facilities in the region using both air and ground EMS. Emergency response and medical care resources were provided by three Texas counties and one Oklahoma county. The most critically injured arrived at local medical facilities within 23 minutes following the event, and all of the injured were transported to medical facilities in less than 2 hours. Based on interviews with first responders and a review of records from the event, the NTSB concludes that the accident notification and emergency response by surface and air resources were timely and adequate.

Postaccident mechanical inspection of the motorcoach's brake and steering systems indicated that, other than the failed tire, no mechanical defects or deficiencies contributed to the uncontrollability of the motorcoach. Investigators did identify oil and grease contamination in the braking system of one of the six brakes, which presented a safety risk, but determined that braking performance would not have affected the outcome of the accident due to the limited time available for driver response. Similarly, investigators identified the use of wheel rims of improper size on the tag axle tires as a problem that would affect load capacity, but this was not a factor in the accident sequence. Therefore, the NTSB concludes that, with the exception of the right steer axle tire, the mechanical condition of the motorcoach did not contribute to the cause or severity of the accident.

The driver's medical certificate had expired on May 24, 2008. The driver was diagnosed with diabetes after his most recent fitness examination, with markedly elevated blood sugar and HbA1c[102] detected 3 months prior to the accident. He was prescribed insulin but never refilled the prescription. His HbA1c was substantially lower at the time of the accident, consistent with some effective treatment of his diabetes. An oral prescription medication for the treatment of

[102] The HbA1c provides a measure indicating the average blood sugar level over the previous few months.

diabetes was found with his effects. The driver's HbA1c at the time of the accident did not suggest a blood sugar level high enough to have been associated with impairment. The driver was also being treated for high blood pressure and high cholesterol levels but neither of these conditions, nor the medications used for their treatment, was likely to have had a measurable impact on his driving performance. The NTSB concludes that the driver's diabetes, high blood pressure, and high cholesterol were not factors in the accident.

The Accident

Accident Sequence

According to data gathered from the ECM, the motorcoach was traveling about 68 mph at the time the right steer axle tire began leaving tire marks on the highway, approximately 4.3 seconds prior to the blowout. The driver, in a postaccident interview, stated that he felt a sway or vibration of the motorcoach. However, the degree to which these perceptual cues are distinguishable from encountering rumble strips or other vehicle noise is uncertain and probably case-specific, depending on the sequence of tire failure. He said he let off the accelerator, unsure of what was causing the sensation. Within a few seconds, he heard "an explosion" and the right front of the motorcoach "dropped." The vehicle ECM data indicated that percent throttle was varied in the seconds preceding the blowout. It seems likely that the driver experienced unexpected noise or vibration before he understood the impending tire failure.

Tire marks on the roadway, indicating the beginning of the failure of the sidewalls and belt separation, began 685 feet before the motorcoach struck the bridge railing. The blowout occurred 253 feet before impact. The ECM indicated braking input at 1.1 seconds following the tire blowout. Calculations of the motorcoach's braking efficiency indicated a brake lag time (delayed brake actuation) of 0.7 second. The roadway tire marks and travel distances indicate that the motorcoach struck the bridge railing before any appreciable braking occurred. Once the motorcoach mounted the curb and struck the bridge railing and the railing began separating from the bridge deck structure, braking would have been largely ineffective in slowing the vehicle or otherwise altering the vehicle dynamics.

Vehicle handling characteristics have been shown to be drastically altered, and steering efficiency significantly reduced, following a tire failure, particularly on a steer axle wheel.[103] When the right steer axle tire on the Sherman motorcoach failed, the vehicle pulled to the right. Because the right shoulder width on US-75 northbound narrowed to 30 inches on the Post Oak Creek bridge deck, it would most likely have required significant driver input to prevent the motorcoach from striking the bridge curb. The NTSB concludes that given the limited distance between the roadway and the bridge curb and the lack of recovery time, there is no evidence that the actions of the driver caused or contributed to the tire failure, and it is unlikely that the driver had sufficient time to respond to the tire failure and avoid the loss of control, the collision with the bridge railing, and the subsequent departure of the motorcoach from the bridge.

[103] (a) M.W. Arndt, M. Rosenfield, and S.M. Arndt, *Measurement of Changes in Vehicle Handling Due to Tread-Separation-Induced Axle Tramp*, SAE Technical Paper No. 2006-01-1680 (Warrendale, PA: Society of Automotive Engineers, 2006); (b) C.P. Dickerson, M.W. Arndt, and S.M. Arndt, *Vehicle Handling with Tire Tread Separation*, SAE Technical Paper No. 1999-01-0450 (Warrendale, PA: Society of Automotive Engineers, 1999).

Motorcoach Driver

Driver Issues. Toxicological testing performed on samples gathered about 3.75 hours after the accident detected cocaine and its metabolites in the driver's blood and/or urine.[104] One metabolite, cocaethylene, detected in the urine, is formed only when cocaine and ethanol are simultaneously present. The finding of cocaine and cocaethylene (which both have half-lives less than 90 minutes) in the urine, and the levels of benzoylecgonine in the blood and urine, suggest that the driver had used cocaine and alcohol approximately 5 hours prior to the accident.

At the time of the accident, the driver had been on duty for 6 hours 45 minutes (not including a 1-hour-long work break). He had come on duty at 5:00 p.m. He had driven briefly between 6:30 and 7:00 p.m. to pick up passengers and then had had a 1-hour work break between 7:15 and 8:15 p.m. before beginning to drive again. He drove nearly continuously[105] for the 4 hours 30 minutes between 8:15 p.m. and 12:45 a.m., when the accident took place. Therefore, the driver probably used cocaine and alcohol after reporting for work at 5:00 p.m.

The extended period of driving prior to the accident makes it unlikely that the driver was impaired by the effects of cocaine itself. But it is certainly possible that the driver was experiencing aftereffects from use of the drug (primarily resulting in depression and fatigue). Aftereffects from ethanol use have been shown to impair certain aspects of simulator performance in pilots for as long as 14 hours after intoxication.[106] Therefore, the possibility that aftereffects from alcohol or cocaine use or both may have impaired the driver cannot be ruled out. The NTSB concludes that the driver used cocaine and alcohol either during or shortly before starting the trip, and he may have been impaired by aftereffects from either or both drugs.

Postaccident interview statements by the driver describing the accident sequence events indicated that he was alert and responsive to developments. He was aware of his driving tasks—for example, he reported that he felt the vibration of the motorcoach when the tire failed, he said he let off the accelerator, and he said he heard an explosion.

Tire marks on the roadway indicate that the driver had approximately 4.3 seconds before the blowout, as the internal structure of the tire continued to fail. The driver may have been aware of vibration or changes in handling characteristics and was trying to understand what was happening. Once the blowout occurred, the driver reacted quickly, braking in 1.1 seconds. But approximately 1.9 seconds after he applied the brakes, the motorcoach struck and mounted the curb and then the bridge railing. Therefore, the NTSB concludes that fatigue was not a factor in the accident and, based on event timing in the accident reconstruction analysis, even a well-rested, completely alert driver could not have reacted in time to affect the accident sequence.

[104] Title 49 CFR 382.303 requires that postaccident testing be conducted as soon as practicable.

[105] The driver said that he stopped at a convenience store about 10 minutes after beginning driving at 8:15 p.m., to buy gum and an energy drink.

[106] J.A. Yesavage and V.O. Leirer, "Hangover Effects on Aircraft Pilots 14 Hours After Alcohol Ingestion: A Preliminary Report," *American Journal of Psychiatry*, vol. 143, no. 12 (1986), pp. 1546-1550.

Preemployment Checks of Driver History by Motor Carrier. According to the driver, he had almost 25 years of experience driving commercial vehicles. Investigators were able to verify that the driver had been employed by two existing companies, Greyhound and Carrington Tours, during the 1990s, and NTSB subpoenaed records from those companies. Other motor carriers listed on the driver's application for employment could not be contacted because of mergers, acquisitions, or changes in ownership. Cessation of operations by motor carriers is fairly common within the industry, making inquiry into the long-term driving experience of a prospective driver difficult. The driver told investigators that he had been terminated by Greyhound for failure to report for a medical examination. However, records subpoenaed from Greyhound revealed that the driver was terminated on March 21, 1995, after he tested positive for cocaine in Greyhound's federally mandated random drug testing program.

Title 49 CFR 382.401(b)(1) requires that a motor carrier maintain copies of positive drug test results for a minimum of 5 years. Prospective employers are required by 49 CFR 382.413 to contact each applicant's previous employer to determine whether, in the preceding 2 years, the applicant had failed an alcohol or controlled substance test, had refused to be tested, or had successfully completed return-to-duty requirements after having tested positive for alcohol or a controlled substance. However, release of these records is limited. Title 49 CFR 382.405(f) states that "Records shall be made available to a subsequent employer upon receipt of a written request from a driver. Disclosure by the subsequent employer is permitted only as expressly authorized by the terms of the driver's request." A driver is not obligated to report the positive drug test result to a prospective employer; however, a driver's authorized release of his records as an application requirement provides prospective employers with a viable mechanism for obtaining access to drug test results.

The NTSB previously addressed driver drug testing in its investigation of a May 9, 1999, motorcoach crash in New Orleans, Louisiana, which killed 22 passengers.[107] The motorcoach driver tested positive for tetrahydrocannabinol (THC, the psychoactive substance in marijuana). The driver had been terminated by at least two previous employers on the basis of positive results in random drug testing. When the New Orleans driver applied for the position with the accident carrier, he omitted mention of these two past employers who had terminated him for drug use. He explained the gaps in employment by stating that he had been working as a musician during those periods. Although his employer at the time of the accident had made reference checks with two former employers listed on the driver's application, neither responded. The NTSB concluded that the results of tests for controlled substances performed under the DOT testing guidelines, even when positive, are often not available to prospective employers, making it difficult for them to make well-informed hiring decisions. The NTSB issued Safety Recommendation H-01-25 as a result of the New Orleans investigation, recommending that the FMCSA take the following action:

> Develop a system that records all positive drug and alcohol test results and refusal determinations that are conducted under the U.S. Department of Transportation testing requirements, require prospective employers to query the system before making a hiring decision, and require certifying authorities to query the system before making a certification decision. (H-01-25)

[107] NTSB/HAR-01/01.

As a result of the NTSB's recommendation, in 2004, the FMCSA completed a study of the feasibility and merits of requiring medical review officers and employers to report positive test results to state CDL licensing agencies. The study found that it was feasible to establish a national database of positive drug test results and that it should be operated by the Federal government to ensure consistency and uniformity. The FMCSA is developing rulemaking to establish a National Drug and Alcohol Test Results Database, which would allow Federal and state governments to identify drivers who have refused a DOT drug or alcohol test or have tested positive for drug(s) and/or alcohol under the established DOT drug and alcohol testing regulations. Areas of consideration for the rulemaking include the following: (1) requiring Medical Review Officers to submit confirmed positive controlled substances test results to the FMCSA, including follow-up tests stemming from an initial positive test; (2) having motor carriers submit information on refusals-to-test, positive alcohol test results, and annual summaries of their controlled substances and alcohol testing programs each year; and (3) requiring all laboratories to submit annual reports to the FMCSA.[108]

Safety Recommendation H-01-25 is currently classified "Open—Unacceptable Response" because of the FMCSA's slow response time. The recommendation to develop a database of positive drug and alcohol test results and to establish requirements for use of the system is now 8 years old. Although the FMCSA has increased its enforcement action against commercial motor vehicle drivers who have tested positive for controlled substances and failed to comply with the return-to-duty requirements before performing a DOT safety-sensitive function, and also against motor carriers that use or have used a driver to perform safety-sensitive functions if the motor carrier was aware or should have known that the driver did not comply with return-to-duty requirements, these actions will be the result of investigations and will, therefore, affect only a small percentage of the driver and carrier populations.

The NTSB concludes that if motor carriers cannot check the controlled substance testing backgrounds of prospective employees, they cannot make well-informed decisions when attempting to hire safe drivers. Consequently, the NTSB is reiterating Safety Recommendation H-01-25 to the FMCSA, and the recommendation remains classified "Open—Unacceptable Response."

The state of Texas maintains records on the positive results of controlled substance tests for commercial drivers. In seeking such information concerning the accident driver, the NTSB found it necessary to serve a subpoena upon the TxDPS. (The database contained no records for the driver.)

Information concerning the toxicological and medical condition of vehicle operators is vital to successful accident investigation. The NTSB concludes that the difficulty in obtaining state records in connection with the controlled substance test results for the driver of the accident motorcoach in this case highlights the NTSB's need for investigative access to a national database of positive drug test results. Therefore, in addition to the reiteration of Safety Recommendation H-01-25, the NTSB recommends that the FMCSA establish a regulatory requirement within 49 CFR 382.405 that provides the NTSB, in the exercise of its statutory

[108] This information appears in a letter from the FMCSA, dated June 5, 2009.

authority, access to all positive drug and alcohol test results and refusal determinations that are conducted under the DOT testing requirements.

Tire Failure

The right steer axle tire was a Goodyear G409 MBA radial tire retreaded with a Bandag model T4100 tread. NTSB investigators conducted two independent examinations of the failed tire: one with experts from Goodyear and another with experts from Bridgestone. Both examinations of the right steer axle tire resulted in similar conclusions, which were documented in reports provided by Goodyear and Bridgestone to the NTSB. The tire companies found no defects or dangerous conditions in the design or manufacture of the original tire or the retread. They believed that separation and detachment of the tread and belt pieces occurred as a result of damage caused by overdeflected operation. The overdeflected condition was most likely caused by a puncture or cut in the tire that caused it to lose air, leading to underinflation. Operation of an underinflated tire in an overdeflected condition generates excessive heat, which can cause tread belt separation, the internal separation of the sidewall, belting, and body plies. Numerous exposed rubber surfaces exhibited a blue-tint appearance, indicative of excessive heat generation during operation. Moreover, such heat damage is cumulative and may go undetected by visual inspection. Although it is difficult to state how long the punctured or cut tire may have operated in an underinflated/overdeflected condition, the tread/belt tear patterns and the lack of polishing of the separated surfaces indicate relatively short-term operation in such a condition, most likely for less than 1,000 miles. Thus, it appears that the tire on the right steer axle of the accident motorcoach was punctured and suffered a slow leak, as indicated by a tread rubber hole that was abraded/bruised and torn, which ultimately led to the tire’s failure. Based on the available physical evidence and expert review, therefore, the NTSB concludes that the tire on the accident motorcoach’s right steer axle experienced a puncture, and the resultant gradual pressure loss led to severe overdeflection, which resulted in sidewall, belting, and body ply separations within the tire.

Federal regulations at 49 CFR 393.75(d) state that “No bus shall be operated with regrooved, recapped or retreaded tires on the front wheels.” Retreading a tire involves bonding a new tread to the tire body through the application of heat and pressure. The NTSB found good adhesion within the casing and between the casing and the retread on the retreaded tire on the right steer axle, and investigators found no indication that the tire failure was related to the retread. The mechanics of failure in this accident resulted in short, thin strands of tire material separating from the tire, not delamination of the retread. The failure of the tire initiated and resulted from within the original tire casing. The NTSB concludes that although the use of a retreaded, recapped, or regrooved tire on the steer axle of a motorcoach is prohibited, the right steer axle tire’s failure was not associated with its being a retreaded tire.

The failed tire was located on the steer axle on the right side of the motorcoach. Had the tire been mounted on the drive or tag axle and failed, there would have been less lateral and retarding force, so the motorcoach’s departure from the road would have been slower, and the driver might have been able to retain control over it. Therefore, the NTSB concludes that failure of the tire on the steer axle resulted in the loss of control of the motorcoach.

Vehicle Load and Tire Capacity

The GVWR of the accident motorcoach's three axles was 16,500 pounds on the steer axle, 23,000 pounds on the drive axle, and 16,500 pounds on the tag axle. The motorcoach manufacturer's recommended tires for the steer axle were Load Range J size 315/80 R22.5 tires inflated to 120 psi. Load Range J tires with inflation pressures of 120 psi have a maximum working load rating of 8,270 pounds each or 16,540 pounds for the axle. This configuration provides a reserve working limit of only 20 axle-weight pounds per tire. If the motorcoach were to be loaded in such a manner that the weight upon the steer axle was exceeded by as little as 40 pounds (less than 1/2 of 1 percent of the GVWR), the tires would begin to be overloaded.

The tag axle possessed a GAWR of 16,500 pounds. According to the MCI maintenance manual,[109] the tag axle was required to be equipped with Load Range J size 315/80 R22.5 tires mounted on 9.00-inch wheel assemblies, inflated to 105 psi. If such a tire were inflated to 105 psi, the recommended tire would be rated to only 7,440 pounds, providing the tag axle with only 14,880 pounds of load capacity, compared to the required 16,500 pounds. The vehicle specification plate recommended a tag axle tire inflation pressure of 120 psi; the accident motorcoach's tag axle tires as measured after the accident were inflated to 88 psi and 89 psi.

Additionally, the tag axle wheel assemblies on the accident coach were 8.25 inches wide, as opposed to the recommended 9.00-inch wheels. Although an 8.25-inch wheel can be used, the maximum load permitted upon the tire when inflated to 120 psi is reduced to 8,000 pounds. Because the tag axle had a GAWR of 16,500 pounds, the 8.25-inch wheels were not appropriate for use on the motorcoach's tag axle.

Underinflating a tire may dramatically reduce its load capacity. For example, lowering the inflation pressure of a Load Range J tire by only 10 psi reduces its load capacity from 8,270 pounds to 7,610 pounds, or by 8 percent. (See table 6.) In the case of the accident motorcoach, underinflation by less than 1 percent on the steer axle tires would have resulted in an overloading condition if the vehicle were loaded to its GVWR. Therefore, the NTSB concludes that underinflation of tires on commercial motor vehicles by even small margins can result in dangerous overloading of the tires.

Tire Pressure

Following the accident, the pressure of each intact tire was measured. Compared to the recommended tire pressures on the vehicle specification plate, the left steer axle tire pressure was 2 psi below the recommended 120 psi. The pressures of three of the tires on the drive axle were above the recommended 90 psi, by values of 6 psi, 4 psi, and 3 psi.[110] The pressures of the two tires on the tag axle were 31 psi and 32 psi below the recommended 120 psi.

[109] The recommended pressure listed in the MCI maintenance manual differed from the recommended pressure on the vehicle specification plate. This difference is discussed in the next section.

[110] The drive axle had four tires, but the right outer tire on the drive axle was found debeaded as a result of the accident.

Title 49 CFR 392.7 requires commercial drivers to examine the tires of their motor vehicles at the beginning of each trip. The driver of the accident motorcoach reported that he checked the tires, looking for protrusions, wear and tear, and discoloration, and that he kicked the tires prior to departing on the accident trip. According to the regulations, drivers are permitted to visually inspect the tires to determine if they are properly inflated; use of a tire gauge is not mandated. However, it is difficult, if not impossible, to visually determine whether a tire is inflated to the proper pressure.[111] Tires designed to give a smooth ride may always look underinflated, while tires with stiff sidewalls can look properly inflated even at pressures substantially lower than those recommended. The AAMVA model CDL manual recommends that a driver use a tire gauge to check tire inflation; however, it also states that use of a mallet to check inflation is permissible.

Postaccident inspection of the motorcoach indicated that several of the vehicle's tires did not meet recommended inflation levels. The tires on the tag axle were more than 25-percent underinflated when examined. As demonstrated by this accident, underinflation of tires can lead to safety issues such as overloading and tire failures. It is possible that the right steer axle tire that failed, leading to the accident, was underinflated before the trip began. It is also possible that had the pressure in the motorcoach's tires been checked with a tire gauge before the accident trip began, the underinflated tires would have been detected, because a gauge would have given a specific pressure number. The FMCSA regulations and AAMVA guidelines that permit drivers to measure tire pressure by either visually inspecting the tire or "thumping" it with a mallet are not adequate to identify an underinflated tire. Therefore, the NTSB concludes that because underinflated tires can lead to tire failure and because the currently approved methods of visual inspection or "thumping" tires with a mallet are inaccurate, a tire pressure gauge should be used to accurately assess tire pressure. Consequently, the NTSB recommends that the FMCSA require that tire pressure be checked with a tire pressure gauge during pretrip inspections, vehicle inspections, and roadside inspections of motor vehicles. The NTSB also recommends that the AAMVA revise the model CDL manual to stipulate that tire pressure be checked with a tire pressure gauge during pretrip inspections, vehicle inspections, and roadside inspections of motor vehicles.

During the course of the investigation, the NTSB determined that the recommended tire pressure information in the MCI model J4500 motorcoach maintenance manual differed from information on the specification plate on the vehicle, and that the manual was incorrect. The tire inflation chart in the MCI J4500 manual lists the drive axle tire pressure as 85 psi and the tag axle tire pressure as 105 psi. The correct inflation pressures, as listed on the vehicle specification plate, are 90 psi for the drive axle tires and 120 psi for the tag axle tires. Additionally, a note in the manual about the wheels improperly identifies the model and gives the GAWR of the accident motorcoach's steer axle as 16,000 pounds, rather than the correct figure of 16,500 pounds. MCI's only guidance, whether written or electronic, for this motorcoach and others like it remains uncorrected. The most recent MCI manual with corrections does not apply to the earlier or legacy model 4500 motorcoaches, because the applicability of information is stipulated by vehicle identification number ranges. The NTSB concludes that until MCI informs

[111] Goodyear tire photographs in figure 9; and S. Singh, K. Kingsley, and C. Chen, *Tire Pressure Maintenance-A Statistical Investigation*, DOT HS 811 086 (Washington, DC: National Highway Traffic Safety Administration, April 2009).

operators of the inaccuracies in the J4500 motorcoach maintenance manual, operators may be confused as to the proper tire pressures for these motorcoaches. Therefore, the NTSB recommends that MCI correct any inaccurate tire pressure and GAWR information in the maintenance manuals of its J4500 motorcoaches and make electronic versions of the revised manuals readily available on its website; in addition, it should review the maintenance manuals of its other motorcoaches for similar errors and make appropriate corrections.

Tire Pressure Monitoring Systems

TPMSs are designed to monitor and inform the driver of tire pressures and are capable of detecting operating temperatures. Direct TPMSs have the advantage of providing actual tire pressures to the driver in real time while the vehicle is in operation.[112] In this accident, a direct TPMS could have detected the decreasing pressure of the right steer axle tire and alerted the driver before the tire's catastrophic failure.

The TREAD Act, enacted by Congress on November 1, 2000, directed the Secretary of Transportation to conduct rulemaking to require warning systems in new motor vehicles to indicate to the operator when a tire is significantly underinflated. In 2007, NHTSA rulemaking at 49 CFR Part 571[113] established FMVSS 138 for TPMSs to warn the driver when a tire is significantly underinflated. Application of that standard, however, was restricted to light vehicles—specifically to passenger cars, trucks, multipurpose passenger vehicles, and buses with GVWRs of 10,000 pounds or less, except for those vehicles with dual wheels on an axle. Unlike the NHTSA rule, the TREAD Act referred to "new motor vehicles" without restriction regarding vehicle class.[114]

No rule or standard currently requires that large commercial vehicles, including motorcoaches, be equipped with TPMSs. The NTSB notes that the difference between the broad nature of the Congressional language in the TREAD Act and the specific and restrictive regulatory language used in NHTSA's rulemaking leaves large commercial vehicles, including motorcoaches that carry many passengers, unaffected by this important safety requirement. Direct TPMSs have the potential to eliminate failures on commercial vehicles caused by tire underinflation or overloading through their ability to directly measure tire pressure and operating temperatures. Furthermore, direct TPMSs continuously monitor actual tire pressure in real time and can immediately relay information to the operator while the vehicle is en route.

The accident vehicle's tires were substantially underinflated on the tag axle and slightly overinflated on the drive axle. These conditions could have been detected either by a pretrip inspection using a tire gauge or by a TPMS. Moreover, the right steer axle tire experienced a slow leak from a puncture that may have occurred during the accident trip. A TPMS would have detected this critical safety problem en route. The NTSB concludes that if the driver had been aware of the motorcoach's tire pressures, particularly the dangerously low pressure in the

[112] Advanced TPMSs are equipped with central inflation systems that automatically maintain proper tire inflation pressures.

[113] *Federal Register*, vol. 72, no. 133 (July 12, 2007), p. 38017.

[114] See section 13 of Public Law 106-414.

damaged right steer axle tire, then he would have had an opportunity to take corrective action, which might have prevented this accident. A direct TPMS could have provided such a warning. Therefore, the NTSB recommends that NHTSA require all new motor vehicles weighing over 10,000 pounds to be equipped with direct TPMSs to inform drivers of the actual tire pressures on their vehicles.

Bridge Railings

A bridge railing is a longitudinal barrier designed to prevent a vehicle from running off the edge of a bridge. Bridge railings typically differ from roadside barriers in that they are a physically integrated part of the roadway structure. The bridge railing on US-75 at the Post Oak Creek bridge failed to keep the motorcoach on the roadway, allowing it to penetrate the railing completely and to fall 8 feet to the earthen bridge abutment below, where it slid approximately 24 feet on its right side before coming to a stop. Additionally, the 7-inch-high, 18-inch-wide concrete curb above the bridge deck allowed the motorcoach to ramp upward before it struck the railing. A curb should not be used in front of a bridge railing, because it may result in a dynamic jump by the vehicle before it strikes the barrier.[115] The failure of the bridge railing to keep the motorcoach on the roadway contributed to the severity of the accident. Although the Post Oak Creek bridge railing appears to have in the past kept striking passenger cars on the bridge, it has twice failed to retain large, heavy vehicles. The NTSB concludes that a higher performance bridge railing at the accident location might have prevented the motorcoach's departure from the bridge.

Design Guidelines

The design of bridge railings is summarized in AASHTO's *Roadside Design Guide*. More detailed information about the engineering performance and structural requirements for bridge railings is contained in a variety of supporting reference documents, including AASHTO's *Standard Specifications for Highway Bridges*,[116] the *LRFD Bridge Design Specifications*,[117] and the *Manual for Assessing Safety Hardware* (MASH).[118]

The safety performance of a bridge railing is evaluated through crash testing. Since 1986, the FHWA has required that bridge railings used on Federal-aid projects meet full-scale crash-test criteria. A 1997 FHWA policy memorandum stated that all new or replacement safety features on the NHS should be in accordance with NCHRP Report 350, *Recommended Procedures for the Safety Performance Evaluation of Highway Features*, with the minimum acceptable bridge railing being TL-3 (as defined in NCHRP Report 350), unless supported by a rational selection procedure. The FHWA also stated, however, that it does not intend the

[115] *Highway Design and Operational Practices Related to Highway Safety* (Washington, DC: American Association of State Highway and Transportation Officials, 1967), p. 30.

[116] *Standard Specifications for Highway Bridges*, 17th edition (Washington, DC: American Association of State Highway and Transportation Officials, September 1, 2002).

[117] The 2007 *LRFD Bridge Design Specifications* replaced the 1989 *Guide Specifications for Bridge Railings*, which relies on three levels of bridge railing performance (PL-1, PL-2, and PL-3).

[118] The 2009 MASH is intended to replace NCHRP Report 350, *Recommended Procedures for the Safety Performance Evaluation of Highway Features*.

requirement to result in the replacement or upgrading of existing installed features, beyond the course of normal improvements.

The road design of US-75 at the Post Oak Creek bridge, including the bridge railing, was in compliance with the design standards for a principal urban artery at the time of the bridge's construction in 1958. The bridge railing at the accident site was a Type II[119] railing designed in accordance with the 1953 AASHO *Bridge Specifications Manual*. According to TxDOT, the bridge railing design used at the accident site had never been crash-tested; as such, when the accident occurred, the railing did not meet current NHS standards.[120] Approximately one-quarter of the bridges in the NHS have been superseded by structural or test requirements associated with present highway design standards. If the current bridge railing standards were applied to all bridges in the United States (not just those in the NHS), approximately one-half would not meet current design standards.[121]

With over 100,000 bridges in the NHS and nearly 600,000 bridges in the United States, it would be impractical to update them as frequently as design standards improve. Design standards, when they are revised, generally apply to new construction projects and, when practical, to bridge rehabilitation and upgrade projects. Because the accident bridge railing had not undergone a qualifying bridge resurfacing, restoration, or rehabilitation project, it was not required to meet current design standards. Older bridge decks and structures that would not support larger, heavier barriers often have bridge railings with designs based on earlier specifications. Consequently, upgrade projects are postponed until a larger bridge rehabilitation project, such as lane widening and deck replacement, can be planned and funded. If a bridge meets the warrants for higher performance railings, as determined by the FHWA and AASHTO, designers integrate the new designs into rehabilitation or upgrade projects; if the upgraded railings cannot be integrated into a proposed highway improvement project, the FHWA may grant the bridge owner an exception.

Warrants

Bridge owners, usually state departments of transportation, are responsible for determining when bridge railing improvements are needed and what performance level is appropriate for the given location. The various guidance documents available concerning the design and construction of bridge railings, including the AASHTO *Roadside Design Guide* and the *LRFD Bridge Design Specifications*, indicate that the owner should develop the appropriate test level or warrant for the site in question.

TxDOT, the owner of the Post Oak Creek bridge, has developed guidance for retrofit and rehabilitation bridge projects, but it has no selection criteria or warrants for the installation of

[119] "Type II" is an identifying name, not a category, and use of the term does not mean that the design met NCHRP Report 350 TL-2 design requirements.

[120] The 2006 *Roadside Design Guide* states that bridge railing designs predating 1964 typically are considered substandard in that they have not been crash-tested in accordance with either NCHRP Report 230 or NCHRP Report 350 (section 7.7.1, pp. 7-8).

[121] FHWA data from December 31, 2007, showed that the NHS contained 116,144 bridges; of these, 29,579 had bridge railings that did not meet current standards. The total number of bridges on NHS and non-NHS roads was 599,765; of these, 287,469 did not meet current bridge railing standards.

high-performance barriers, including bridge railings. When NTSB investigators asked other state departments of transportation what guidance they use for selecting a barrier system for a specific site, many replied that they use the *LRFD Bridge Design Specifications*; however, that document contains only general guidance and directs state agencies to develop objective guidelines for bridge railing selection.

In 2005, as a result of a multivehicle accident that took place in Fairfield, Connecticut,[122] the NTSB issued Safety Recommendation H-05-31 to AASHTO, asking it to take the following action:

> Establish warrants in the *Roadside Design Guide* regarding the selection and use of high-performance barriers, including 42- and 50-inch-high concrete barriers, that are capable of redirecting heavy trucks. (H-05-31)

In its recommendation response letter, AASHTO indicated that it would consider research on using standard and high-performance barriers for both permanent and temporary application and on providing enhanced barrier guidelines through an update to the *Roadside Design Guide*. The NTSB has classified Safety Recommendation H-05-31 "Open—Acceptable Response."

Recent research activities as part of NCHRP Report 638, *Guidelines for Guardrail Implementation*,[123] have resulted in the development of warrants indicating when some higher performance roadside safety hardware should be used, but bridge railings were not addressed in these activities. The 1989 *Guide Specifications for Bridge Railings* contained criteria for the selection of an appropriate bridge railing design for a specific project location, but their use is not mandatory. Currently, no mandatory warrants indicate when a higher performance bridge railing[124] should be used.

The 2007 *LRFD Bridge Design Specifications* and the 2006 *Roadside Design Guide* advise bridge owners to develop their own bridge railing warrants. Available bridge railing guidance focuses on the performance test level of railing designs, offering only a list of considerations to guide highway engineers in selection of appropriate designs based on location. The NTSB concludes that bridge owners lack warrants to guide them in making high-performance bridge railing selections for specific project applications.

The NTSB recognizes that it may be necessary to conduct research and crash tests to support establishing warrants for higher performance bridge barriers appropriate for motorcoach traffic. For example, experimental tests conducted in 1978–1981 at the Texas Transportation Institute at Texas A&M University showed that a TL-3 (Texas Traffic-202) bridge railing modified with the addition of an aluminum rail to a height of 42 inches was able to redirect 32,000-pound motorcoaches operating at speeds up to 60 mph and encroachment angles up to

[122] NTSB/HAR-05/03.

[123] This research was conducted by the University of Nebraska for the TRB Research Committee.

[124] Higher performance bridge railings would be those that conform to TL-4, TL-5, or TL-6 from NCHRP Report 350, *Recommended Procedures for the Safety Performance Evaluation of Highway Features*.

15 degrees. However, motorcoaches of that period were smaller and lighter than current fleet vehicles.[125]

The NTSB recommends that the FHWA establish, in conjunction with AASHTO, performance and selection guidelines for bridge owners to use to develop objective warrants for high-performance TL-4, TL-5, and TL-6 bridge railings applicable to new construction and rehabilitation projects where railing replacement is determined to be appropriate, and that AASHTO include the guidelines in the *LRFD Bridge Design Specifications*.

Also, the NTSB recommends that AASHTO revise section 13 of the *LRFD Bridge Design Specifications* to state that bridge owners shall develop objective warrants for the selection and use of high-performance TL-4, TL-5, and TL-6 bridge railings applicable to new construction and rehabilitation projects where railing replacement is determined to be appropriate.

Commercial Vehicle Inspections

The FMCSA has certified the state of Texas vehicle inspection program as an "equivalent inspection program." As such, it satisfies the annual commercial motor vehicle inspection requirements of appendix G to subpart B of the FMCSRs through the use of privately owned and operated garages and repair facilities designated by the state as authorized inspection facilities.

The Sherman accident motorcoach was inspected 8 days before the accident; the July 31, 2008, inspection was conducted at 5 Minute Inspections, located in Houston, Texas. The available records from that inspection show omissions and errors that concern the NTSB: specifically, no odometer reading or TxDOT number was entered, and the recorded date of the insurance expiration was incorrect. NTSB investigators visiting the facility noted that it did not have a service pit or a commercial vehicle lift capable of lifting a motorcoach. Without such equipment, it would be very difficult to conduct a thorough inspection of a motorcoach.

Although investigators cannot be sure of the condition of the motorcoach when the inspection took place, the motor carrier purchased four new Ling Long tires for the motorcoach on July 29, just 2 days before the annual inspection. It seems likely that they were installed for the purpose of the inspection and that any tire rotation would have been done when the new tires were mounted, prior to the inspection. Thus, it appears that the retread tire was probably on the right steer axle when the inspection took place and that it was not identified as a retread during the inspection. As has been noted earlier in this report, Federal regulations prohibit the use of a retreaded tire on the steer axle of a motorcoach, and a thorough inspection should have detected this problem. The serious underinflation of the tag axle tires and the undersized wheel assemblies on the tag axle also indicate that tire pressure measurements probably were not conducted during the inspection. Moreover, postaccident examination of the left axle brake drum and shoes found significant grease contamination with considerable buildup and caking, a condition that most likely had been in effect for much longer than 8 days but that was not identified during the inspection.

[125] The Sherman motorcoach had a 54,000-pound GVWR.

The 5 Minute Inspections station inspected and passed another motorcoach owned by the accident motor carrier in early August 2008. The day after it was certified by 5 Minute Inspections, that motorcoach underwent a MCSAP-sponsored inspection conducted by the Missouri Highway Patrol and was placed out of service due to numerous violations. Vehicle violations found during the MCSAP inspection that should have been identified during the annual inspection included the following items: an out-of-adjustment brake on the right steer axle and general poor condition of the left steer axle brake, general poor condition of the right tag axle brake, and a missing or defective automatic brake adjuster.

In March 2009, at the request of NTSB staff, the TxDPS Houston Regional Office visited the 5 Minute Inspections station and interviewed the inspector who had inspected the Sherman accident motorcoach. The TxDPS took no corrective action against 5 Minute Inspections.

The NTSB concludes that the commercial vehicle inspections conducted by the 5 Minute Inspections station failed to identify safety deficiencies, and the TxDPS review of the station did not identify any problems with its processes; therefore, at least in this instance, the state of Texas vehicle inspection program for commercial motor vehicles did not provide adequate oversight of the private garages it authorizes to conduct safety inspections. The NTSB is concerned that other states may have similar problems with oversight of their inspection programs. The NTSB recommends that the FMCSA require those states that allow private garages to conduct FMCSA inspections of commercial motor vehicles to have a quality assurance and oversight program that evaluates the effectiveness and thoroughness of those inspections.

Occupant Protection

Safety Standards

Seventeen people died and many more were seriously injured in this accident. In the event of an accident, the vehicle's occupant protection system serves to mitigate the crash forces that cause injury. A comprehensive occupant protection system considers many aspects of the vehicle, including roof strength, window glazing, seat strength, and restraint systems and their anchorage strengths—all working together to protect occupants should a crash occur. Generally, the NTSB has found that passengers who remain in their seating compartments sustain fewer injuries, while ejected passengers are more likely to be killed. NHTSA motorcoach testing using crash test dummies has confirmed NTSB findings, showing that a lap/shoulder-belted dummy on the far side of an impact had a much lower risk of sustaining injuries than an unrestrained dummy on the far side of an impact.

Differences in the drop heights between the United Nations Economic Commission for Europe Regulation 66 (ECE R66) test (800 mm or about 2.6 feet) and this accident (8 feet) most likely would not change the improved injury results seen with lap/shoulder belts. If the energy is properly managed, passengers can survive an 8-foot fall, and in this accident, many passengers, especially those on the far side of the impact, survived the fall. A simplified analysis[126] showed

[126] The analysis is simplified in that it assumes the same motorcoach mass, but it neglects the longitudinal velocity, the roll velocity, and the asymmetry in the impact configuration.

that the vertical impact velocity in this accident scenario would be less than two times the impact velocity in the ECE R66 crash test. In this accident, the motorcoach also had some forward velocity (29 mph) at the time of the fall from the bridge. This forward velocity would enable an occupant in a shoulder belt to engage the belt, providing better occupant restraint for a lap/shoulder-belted passenger than was seen for the restrained dummies in the ECE R66 test. Although the ECE R66 test requires a drop from only about 2.6 feet, similar improved results for lap/shoulder-belted passengers would be expected in an 8-foot drop, as experienced by the accident motorcoach passengers.

With respect to this accident, interviews with first responders and passengers confirmed that some passengers in the accident motorcoach were ejected as a result of the accident. However, due to the circumstances of the accident, the NTSB could not determine the exact number of fully and partially ejected passengers.[127]

The FMVSSs contain 22 standards on vehicle crashworthiness. Most of these standards exempt motorcoaches with GVWRs over 10,000 pounds, and no Federal regulations require that motorcoaches in the United States be equipped with an occupant protection system for passengers. Although motorcoaches must comply with FMVSS 217, which establishes minimum requirements for motorcoach window retention and release; FMVSS 205, which covers windshields and glazing; and FMVSS 302, which establishes standards for the flammability of interior materials,[128] motorcoaches do not have to comply with the many other FMVSSs concerning occupant protection standards that apply to school buses[129] and passenger cars.

In 1994, the ECE initiated a project to improve safety by fitting seat belts on motorcoaches.[130] 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,[131] concluded that wearing either a lap or a lap/shoulder belt 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. Since 1997, EU member states have required

[127] Some of those passengers who were partially ejected were trapped under the vehicle, making it difficult for witnesses to identify how many passengers had been ejected. Also, first responders' records of ejections were inconclusive because other passengers rendered immediate assistance to the injured, who were moved away from the motorcoach as quickly as possible due to passengers' fears of a postcrash fire.

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

[129] Title 49 *United States Code* §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. In 2007, Texas enacted legislation requiring school buses to be equipped with 3-point lap/shoulder seat belts.

[130] 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).

[131] 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).

2-point lap belts and energy-absorbing seats or 3-point lap/shoulder belts on all M3 motorcoaches.[132]

Australia applies a set of design rules in addition to ECE requirements.[133] 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.[134] Since 1994, Australian Design Rule 68/00 has required that all newly manufactured motorcoaches have lap/shoulder belt systems.

Despite the lack of U.S. Federal requirements, manufacturers are proceeding to introduce lap/shoulder belt seats into the U.S. market,[135] and states such as Texas are beginning to require lap/shoulder belt-equipped seats for motorcoach transport of students.[136]

In 1999, the NTSB conducted a bus crashworthiness special investigation and issued a series of safety recommendations to improve occupant protection in the event of an accident.[137] In that report, the NTSB concluded that one of the primary causes of preventable injury in motorcoach accidents involving a rollover, ejection, or both, is occupant motion out of the seat during a collision when no intrusion into the seating area occurs. Safety Recommendations H-99-47, 48, -50, and -51 asked NHTSA to take the following actions:

> 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)

[132] 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. 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.

[133] Australia requires 3-point seat belts and 20-g seats.

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

[135] In January 2009, American Seating and SafeGuard introduced lap/shoulder belt-equipped seats on Prevost motorcoaches. In April 2009, Greyhound ordered 140 Prevost X3-45 motorcoaches with lap/shoulder belt-equipped seats.

[136] The state of Texas has required that, by September 1, 2014, all charter (motorcoach) buses used by Texas schools to transport school children be equipped with 3-point lap/shoulder belts for passengers.

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

> In 2 years, develop performance standards for motorcoach roof strength that provide maximum survival space for all seating positions and that take into account current typical motorcoach window dimensions. (H-99-50)
>
> Once performance standards have been developed for motorcoach roof strength, require newly manufactured motorcoaches to meet those standards. (H-99-51)

All of these recommendations are classified "Open—Unacceptable Response." Safety Recommendations H-99-47 and -50 are on the NTSB Most Wanted List of Transportation Safety Improvements.

All four recommendations have been reiterated to NHTSA as a result of several motorcoach accident investigations over the last decade and as recently as this year in conjunction with the NTSB's investigation of a motorcoach rollover accident near Mexican Hat, Utah.[138] The Sherman accident motorcoach experienced multiple collisions, including a rollover with an 8-foot drop. Previous NTSB motorcoach investigations concluded that passengers would be safer with an occupant protection system and sufficient roof strength. Recent NHTSA crash testing showed that injury risk was much lower for lap/shoulder-belted dummies than for unrestrained dummies. The NTSB concludes that if NHTSA had implemented the requirements for motorcoach occupant protection systems following the issuance of Safety Recommendations H-99-47, -48, -50, and -51, fewer injuries and fatalities might have occurred because more occupants might have been retained within the accident motorcoach. Once again, the NTSB reiterates these safety recommendations, and they remain classified "Open—Unacceptable Response."

In 2008, NHTSA briefed the NTSB regarding its plans to publish a Notice of Proposed Rulemaking in 2009 that would require motorcoach occupant restraints. Following the NTSB Board Meeting on the Mexican Hat accident investigation, the Secretary of Transportation on April 30, 2009, ordered a full departmental review of motorcoach safety. The Secretary established a Departmental Motorcoach Safety Action Group to develop an action plan. NHTSA, the FMCSA, the FHWA, and the Pipeline and Hazardous Materials Safety Administration have participated in creating the plan. The Secretary indicated that the report was expected to be completed and released by summer 2009. The Motorcoach Safety Action Group gave the NTSB a status briefing on October 16, 2009. During the briefing, action group representatives indicated that the group's report was under review by the DOT's Office of the Secretary.

Luggage Rack Failure

The 36-foot-long right side luggage rack was attached to the ceiling and sidewall by nine cast aluminum brackets. Each bracket was secured to the ceiling using two 1/2-inch bolts and secured to the sidewall using two inline 1/2-inch bolts. The overhead luggage rack on the right side of the motorcoach sustained failure damage at the anchorage points, became completely

[138] (a) *Motorcoach Rollover Near Mexican Hat, Utah, January 6, 2008*, Highway Accident Report NTSB/HAR-09/01 (Washington, DC: National Transportation Safety Board, 2009); (b) NTSB/HAR-08/01; (c) *Motorcoach Run-Off-The-Road and Overturn, Victor, New York, June 23, 2002*, Highway Accident Report NTSB/HAR-04/03 (Washington, DC: National Transportation Safety Board, 2004).

detached, and fell diagonally across the aisle onto the passengers. The fallen structure blocked the aisle near rows 3 and 4 as well as the right side emergency window exits. The fallen overhead luggage rack obstructed the evacuation route of those who were ambulatory and, based on interview evidence, impeded the efforts of first responders to evacuate injured passengers. The NTSB concludes that the failure of the luggage rack on the accident motorcoach impeded egress and rescue efforts. The NTSB recommends that NHTSA develop performance standards for newly manufactured motorcoaches to require that overhead luggage racks remain anchored during an accident sequence.

The majority of the seriously and fatally injured passengers incurred blunt force trauma to the head, neck, chest, and spine. There was evidence that several passengers' heads contacted the luggage rack and, although investigators were unable to determine exactly when in the accident sequence passenger injuries took place, it is possible that serious head or neck injury resulted from the interactions between the passengers and the luggage rack. In addition, recent motorcoach rollover testing performed by NHTSA using crash test dummies has demonstrated the potential for serious head injury to unrestrained dummies due to passenger interactions with luggage racks. Lap/shoulder-belted dummies showed low risk for head injury and were retained within the seating compartment. Currently, there are no U.S. standards for luggage rack design that would help to reduce potential injuries during a motorcoach crash sequence. The NTSB concludes that the Sherman accident and recent motorcoach testing indicate that the lack of standards for overhead luggage racks on motorcoaches leaves passengers at risk of serious injury from interaction with luggage racks in case of a crash. The NTSB recommends that NHTSA develop performance standards for newly manufactured motorcoaches that prevent head and neck injuries from overhead luggage racks.

Motor Carrier Oversight

New Entrant Program

Iguala BusMex applied for authority to operate as a new entrant interstate passenger carrier on July 27, 2008,[139] about a month after Angel Tours lost its authority to operate due to an unsatisfactory compliance review rating and its failure to submit a corrective action plan in a timely manner. The FMCSA issued a USDOT number to Iguala BusMex but advised the carrier that its authority to operate was pending because it did not fulfill the FMCSA's requirement to prove financial responsibility; that is, it did not prove that it had proper insurance coverage. Consequently, at the time of the accident, Iguala BusMex's operating authority was pending. However, because it had a valid USDOT number, the motor carrier was able to complete the required Texas vehicle inspection, which enabled it to obtain a Texas Commercial Vehicle Inspection Certificate sticker.

In December 2008, the FMCSA published a final rule raising the standards of compliance for new entrant motor carriers. The rule requires that any carrier that attempts to register as a new

[139] Records indicate that prior to making that application, Iguala BusMex improperly conducted operational trips in June 2008.

entrant and evade an enforcement action or an out-of-service order is subject to revocation of its new entrant registration and/or civil penalties.

The NTSB is aware that the FMCSA has taken several steps since this accident to improve new entrant registration processes to increase its ability to identify a carrier, such as Iguala BusMex, that is attempting to evade FMCSA enforcement actions by becoming a reincarnated carrier. The FMCSA's New Applicant Screening Program uses data to identify newly registered carriers that may have a history of enforcement problems. The screening process seeks matches between new registrants and information provided by previously registered motor carriers.

The NTSB notes that the FMCSA is developing verification procedures intended to ensure that unfit operators do not receive operating authority; however, these measures were not in place at the time of the accident. Therefore, the NTSB concludes that at the time Iguala BusMex applied as a new entrant motor carrier, the FMCSA processes were inadequate to identify the carrier as a company that evaded enforcement action.

The NTSB has reviewed information provided by the FMCSA concerning its new entrant screening program.[140] The FMCSA material described how information about carriers is used to develop a score for a "suspect" carrier, but it provides no description of a performance evaluation process designed to indicate whether the program is effectively preventing carriers with a history of evading safety requirements from continuing to operate. The GAO's recent report on reincarnated carriers also makes no assessment of the new entrant screening program. Information available to the FMCSA, in the form of safety audits, compliance reviews, and roadside inspection results, could be used to identify unfit operators that were not targeted by the New Applicant Screening Program. This information could then be used to evaluate any limitations or shortcomings in the program's ability to identify unfit carriers. The NTSB concludes that until the New Applicant Screening Program of the FMCSA contains a performance evaluation component capable of showing the program's effectiveness in identifying carriers with a history of enforcement evasion and preventing them from operating, the screening program's value cannot be accurately assessed. Therefore, the NTSB recommends that the FMCSA develop an evaluation component to determine the effectiveness of its New Applicant Screening Program.

Revocation of Operating Authority

Not only did Iguala BusMex begin operations without obtaining operating authority, but also a review of Angel Tours's driver logs showed that several of the carrier's drivers continued to operate after Angel Tours was placed out of service. In 2006, following the investigation of a multivehicle accident in Hampshire, Illinois,[141] the NTSB issued Safety Recommendation H-06-17, which called for the FMCSA to

[140] *Summary of Methodology for New Applicant Screening*, FMCSA, June 16, 2009.

[141] *Multivehicle Collision on Interstate 90, Hampshire-Marengo Toll Plaza, Near Hampshire, Illinois, October 1, 2003*, Highway Accident Report NTSB/HAR-06/03 (Washington, DC: National Transportation Safety Board, 2006).

> Establish a program to verify that motor carriers have ceased operations after the effective date of revocation of operating authority. (H-06-17)

Although the motorcoach in the Hampshire accident was rear-ended and thus did not initiate the accident, the NTSB reviewed the motor carrier's operations as part of the investigation. The review revealed that the motorcoach carrier had operated on revoked interstate authority at least eight times before the accident occurred. In the Hampshire accident report, the NTSB pointed out that after a carrier is deemed inactive per an out-of-service order, the FMCSA no longer targets that carrier for compliance review because it is not registered as an active carrier.

In the Hampshire report, the NTSB described the FMCSA Performance and Registration Information Systems Management (PRISM) project. PRISM links FMCSA records on motor carrier safety with a state's vehicle registration system so that a motor carrier with revoked authority will have its license plates revoked. Forty-seven states are participating in PRISM to some degree.[142] In addition to PRISM, the FMCSA, in its August 3, 2006, response to the NTSB regarding the status of Safety Recommendation H-06-17, said that it was increasing its enforcement efforts upon motor carriers that have been issued out-of-service orders or that have had their operating authority revoked. The FMCSA issued memorandums on August 25, 2003, and April 6, 2005, directing FMCSA field administrators and division administrators to monitor motor carriers and to take appropriate enforcement action when evidence indicates a violation of an out-of-service order. Additionally, on May 24, 2006, the FMCSA issued a policy memorandum initiating a new procedure for Federal and state MCSAP inspectors to verify motor carrier operating and insurance status during roadside inspections. Safety Recommendation H-06-17 is classified as "Open—Acceptable Response," pending full implementation of the PRISM program or another comparable program by all states to prevent unauthorized motor carriers from operating.

The NTSB encourages the FMCSA to complete its actions with regard to improving oversight to identify and remove from operation unauthorized motor carriers. Further, the NTSB notes that the FMCSA took some effective oversight actions with respect to the Sherman accident motor carrier. Before the accident, Angel Tours was identified as an unsafe carrier as a result of an FMCSA compliance review and was placed out of service, and the FMCSA identified Iguala BusMex as a new applicant with pending operating authority that required proof of insurance coverage to obtain active authority. Also, as a result of the postaccident compliance review, the FMCSA issued an imminent hazard shutdown order to Iguala BusMex. Further, because of Iguala BusMex's use of another motor carrier's operating authority, the FMCSA conducted a compliance review of that carrier and placed it out of service until it developed and enacted a corrective action plan.

[142] As of July 2009, only 25 states have implemented PRISM to the extent that they can identify out-of-service carriers.

Conclusions

Findings

1. The weather did not cause or contribute to the accident.

2. The accident notification and emergency response by surface and air resources were timely and adequate.

3. With the exception of the right steer axle tire, the mechanical condition of the motorcoach did not contribute to the cause or severity of the accident.

4. The driver’s diabetes, high blood pressure, and high cholesterol were not factors in the accident.

5. The driver used cocaine and alcohol either during or shortly before starting the trip, and he may have been impaired by aftereffects from either or both drugs.

6. Fatigue was not a factor in the accident and, based on event timing in the accident reconstruction analysis, even a well-rested, completely alert driver could not have reacted in time to affect the accident sequence.

7. If motor carriers cannot check the controlled substance testing backgrounds of prospective employees, they cannot make well-informed decisions when attempting to hire safe drivers.

8. The difficulty in obtaining state records in connection with the controlled substance test results for the driver of the accident motorcoach in this case highlights the National Transportation Safety Board’s need for investigative access to a national database of positive drug test results.

9. The tire on the accident motorcoach’s right steer axle experienced a puncture, and the resultant gradual pressure loss led to severe overdeflection, which resulted in sidewall, belting, and body ply separations within the tire.

10. Given the limited distance between the roadway and the bridge curb and the lack of recovery time, there is no evidence that the actions of the driver caused or contributed to the tire failure, and it is unlikely that the driver had sufficient time to respond to the tire failure and avoid the loss of control, the collision with the bridge railing, and the subsequent departure of the motorcoach from the bridge.

11. Although the use of a retreaded, recapped, or regrooved tire on the steer axle of a motorcoach is prohibited, the right steer axle tire’s failure was not associated with its being a retreaded tire.

12. Failure of the tire on the steer axle resulted in the loss of control of the motorcoach.

13. Underinflation of tires on commercial motor vehicles by even small margins can result in dangerous overloading of the tires.

14. Because underinflated tires can lead to tire failure and because the currently approved methods of visual inspection or “thumping” tires with a mallet are inaccurate, a tire pressure gauge should be used to accurately assess tire pressure.

15. Until Motor Coach Industries, Inc., informs operators of the inaccuracies in the J4500 motorcoach maintenance manual, operators may be confused as to the proper tire pressures for these motorcoaches.

16. If the driver had been aware of the motorcoach’s tire pressures, particularly the dangerously low pressure in the damaged right steer axle tire, then he would have had an opportunity to take corrective action, which might have prevented this accident.

17. A higher performance bridge railing at the accident location might have prevented the motorcoach’s departure from the bridge.

18. Bridge owners lack warrants to guide them in making high-performance bridge railing selections for specific project applications.

19. The commercial vehicle inspections conducted by the 5 Minute Inspections station failed to identify safety deficiencies, and the Texas Department of Public Safety review of the station did not identify any problems with its processes; therefore, at least in this instance, the state of Texas vehicle inspection program for commercial motor vehicles did not provide adequate oversight of the private garages it authorizes to conduct safety inspections.

20. If the National Highway Traffic Safety Administration had implemented the requirements for motorcoach occupant protection systems following the issuance of Safety Recommendations H-99-47, -48, -50, and -51, fewer injuries and fatalities might have occurred because more occupants might have been retained within the accident motorcoach.

21. The failure of the luggage rack on the accident motorcoach impeded passenger egress and rescue efforts.

22. The Sherman accident and recent motorcoach testing indicate that the lack of standards for overhead luggage racks on motorcoaches leaves passengers at risk of serious injury from interaction with luggage racks in case of a crash.

23. At the time Iguala BusMex, Inc., applied as a new entrant motor carrier, the Federal Motor Carrier Safety Administration processes were inadequate to identify the carrier as a company that evaded enforcement action.

24. Until the New Applicant Screening Program of the Federal Motor Carrier Safety Administration contains a performance evaluation component capable of showing the program’s effectiveness in identifying carriers with a history of enforcement evasion and preventing them from operating, the screening program’s value cannot be accurately assessed.

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the right steer axle tire, due to an extended period of low-pressure operation, which resulted in sidewall, belting, and body ply separation within the tire, leading to loss of vehicle control. Contributing to the severity of the accident was the failure of the bridge railing to redirect the motorcoach and prevent it from departing the bridge. The lack of an adequate occupant protection system contributed to the severity of the passenger injuries.

Recommendations

New Recommendations

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

To the Federal Highway Administration:

Establish, in conjunction with the American Association of State Highway and Transportation Officials, performance and selection guidelines for bridge owners to use to develop objective warrants for high-performance Test Level Four, Five, and Six bridge railings applicable to new construction and rehabilitation projects where railing replacement is determined to be appropriate. (H-09-17)

To the Federal Motor Carrier Safety Administration:

Establish a regulatory requirement within 49 *Code of Federal Regulations* 382.405 that provides the National Transportation Safety Board, in the exercise of its statutory authority, access to all positive drug and alcohol test results and refusal determinations that are conducted under the U.S. Department of Transportation testing requirements. (H-09-18)

Require that tire pressure be checked with a tire pressure gauge during pretrip inspections, vehicle inspections, and roadside inspections of motor vehicles. (H-09-19)

Require those states that allow private garages to conduct Federal Motor Carrier Safety Administration inspections of commercial motor vehicles to have a quality assurance and oversight program that evaluates the effectiveness and thoroughness of those inspections. (H-09-20)

Develop an evaluation component to determine the effectiveness of your New Applicant Screening Program. (H-09-21)

To the National Highway Traffic Safety Administration:

Require all new motor vehicles weighing over 10,000 pounds to be equipped with direct tire pressure monitoring systems to inform drivers of the actual tire pressures on their vehicles. (H-09-22)

Develop performance standards for newly manufactured motorcoaches to require that overhead luggage racks remain anchored during an accident sequence. (H-09-23)

Develop performance standards for newly manufactured motorcoaches that prevent head and neck injuries from overhead luggage racks. (H-09-24)

To the American Association of State Highway and Transportation Officials:

Work with the Federal Highway Administration to establish performance and selection guidelines for bridge owners to use to develop objective warrants for high-performance Test Level Four, Five, and Six bridge railings applicable to new construction and rehabilitation projects where railing replacement is determined to be appropriate, and include the guidelines in the *Load and Resistance Factor Design (LRFD) Bridge Design Specifications*. (H-09-25)

Revise section 13 of the *Load and Resistance Factor Design (LRFD) Bridge Design Specifications* to state that bridge owners shall develop objective warrants for the selection and use of high-performance Test Level Four, Five, and Six bridge railings applicable to new construction and rehabilitation projects where railing replacement is determined to be appropriate. (H-09-26)

To the American Association of Motor Vehicle Administrators:

Revise the model *Commercial Driver's License Manual* to stipulate that tire pressure be checked with a tire pressure gauge during pretrip inspections, vehicle inspections, and roadside inspections of motor vehicles. (H-09-27)

To Motor Coach Industries, Inc.:

Correct any inaccurate tire pressure and gross axle weight rating information in the maintenance manuals of your J4500 motorcoaches and make electronic versions of the revised manuals readily available on your website; in addition, review the maintenance manuals of your other motorcoaches for similar errors and make appropriate corrections. (H-09-28)

Previously Issued Recommendations Reiterated in This Report

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

To the Federal Motor Carrier Safety Administration:

Develop a system that records all positive drug and alcohol test results and refusal determinations that are conducted under the U.S. Department of Transportation testing requirements, require prospective employers to query the system before making a hiring decision, and require certifying authorities to query the system before making a certification decision. (H-01-25)

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)

> In 2 years, develop performance standards for motorcoach roof strength that provide maximum survival space for all seating positions and that take into account current typical motorcoach window dimensions. (H-99-50)

> Once performance standards have been developed for motorcoach roof strength, require newly manufactured motorcoaches to meet those standards. (H-99-51)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

DEBORAH A.P. HERSMAN
Chairman

ROBERT L. SUMWALT
Member

CHRISTOPHER A. HART
Vice Chairman

Adopted: October 27, 2009

Appendix A

Investigation

The National Transportation Safety Board (NTSB) received notification of this accident on August 8, 2008. The NTSB launched a team of investigators to address motor carrier, survival factors, human factors, vehicle, vehicle recorder, and highway issues. The NTSB team also included staff from the public affairs and transportation disaster assistance offices. Board Member Deborah A.P. Hersman (now NTSB Chairman) and her assistant took part in the on-scene investigation.

Parties to the investigation were the Federal Motor Carrier Safety Administration; the Texas Department of Public Safety; the Texas Department of Transportation; the Sherman, Texas, Police Department; Motor Coach Industries, Inc.; and Bridgestone Americas, Inc.

No public hearing was held in connection with this accident.