Bus Loss of Control and Rollover
Dolan Springs, Arizona
January 30, 2009

Highway Accident Report

NTSB/HAR-10/01
PB2010-916201

National
Transportation
Safety Board

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

National Transportation Safety Board. 2010. ***Bus Loss of Control and Rollover, Dolan Springs, Arizona, January 30, 2009.*** **Highway Accident Report NTSB/HAR-10/01. Washington, DC.**

Abstract: On Friday, January 30, 2009, about 4:06 p.m. mountain standard time, a 2007 Chevrolet/Starcraft 29-passenger medium-size bus, operated by DW Tour and Charter and occupied by the driver and 16 passengers, was traveling northbound in the right lane of U.S. Highway 93, a four-lane divided highway, near Dolan Springs, Arizona. The bus was on a return trip from Grand Canyon West to Las Vegas, Nevada, after a day-long tour. As the bus approached milepost 28 at an estimated speed of 70 mph, it moved to the left and out of its lane of travel. The driver steered sharply back to the right, crossing both northbound lanes and entering the right shoulder. The driver subsequently overcorrected to the left, causing the bus to yaw and cross both northbound lanes. The bus then entered the depressed earthen median and overturned 1.25 times before coming to rest on its right side across both southbound lanes. During the rollover sequence, 15 of the 17 occupants (including the driver) were fully or partially ejected. Seven passengers were killed, and nine passengers and the driver were injured.

Major safety issues identified in this investigation were the failure of the bus driver to attend to the road ahead and maintain control of his vehicle; the need for regulatory definitions and classifications for bus body types; the limitations of medium-size buses in retaining and protecting passengers during rollovers; the need for technology to assist commercial drivers in maintaining control of their vehicles; and the need for event data recording in commercial vehicles to aid in accident reconstruction and safety research. As a result of its investigation, the National Transportation Safety Board makes recommendations to the National Highway Traffic Safety Administration.

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Acronyms and Abbreviations

ABA	American Bus Association
ABS	antilock braking system
ADOT	Arizona Department of Transportation
ATA	American Trucking Associations, Inc.
CAMI	Civil Aerospace Medical Institute
CDL	commercial driver's license
CFR	*Code of Federal Regulations*
CSA	Comprehensive Safety Analysis 2010
CVSA	Commercial Vehicle Safety Alliance
DOT	U.S. Department of Transportation
DPS	Arizona Department of Public Safety
DW Tour	DW Tour and Charter
ECE	Economic Commission for Europe
ECM	electronic control module
EDR	event data recorder
EMS	emergency medical services
ESC	electronic stability control
FARS	Fatality Analysis Reporting System
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FMCSRs	*Federal Motor Carrier Safety Regulations*
FMVSSs	*Federal Motor Vehicle Safety Standards*
FR	*Federal Register*
FTA	Federal Transit Administration
GPS	global positioning system
GVWR	gross vehicle weight rating
HVEDR	heavy vehicle event data recorder
IIHS	Insurance Institute for Highway Safety
LDWS	lane departure warning system
LMRFD	Lake Mohave Ranchos Fire District

MCMIS	Motor Carrier Management Information System
MMUCC	Model Minimum Uniform Crash Criteria
MP	milepost
MSBMA	Mid-Size Bus Manufacturers Association
MST	mountain standard time
NHTSA	National Highway Traffic Safety Administration
NPRM	notice of proposed rulemaking
NTSB	National Transportation Safety Board
OOS	out of service
PST	Pacific standard time
RFID	radio frequency identification
RP	Recommended Practice
SAE	SAE International
SAFER	Safety and Fitness Electronic Records (FMCSA)
SUV	sport utility vehicle
UMA	United Motorcoach Association
UMC	University Medical Center, Las Vegas
UMTRI	University of Michigan Transportation Research Institute
US 93	U.S. Highway 93
USDOT	U.S. Department of Transportation (authority number)

Executive Summary

On Friday, January 30, 2009, about 4:06 p.m. mountain standard time, a 2007 Chevrolet/Starcraft 29-passenger medium-size bus, operated by DW Tour and Charter and occupied by the driver and 16 passengers, was traveling northbound in the right lane of U.S. Highway 93, a four-lane divided highway, near Dolan Springs, Arizona. The bus was on a return trip from Grand Canyon West to Las Vegas, Nevada, after a day-long tour. As the bus approached milepost 28 at an estimated speed of 70 mph, it moved to the left and out of its lane of travel. The driver steered sharply back to the right, crossing both northbound lanes and entering the right shoulder. The driver subsequently overcorrected to the left, causing the bus to yaw and cross both northbound lanes. The bus then entered the depressed earthen median and overturned 1.25 times before coming to rest on its right side across both southbound lanes. During the rollover sequence, 15 of the 17 occupants (including the driver) were fully or partially ejected. Seven passengers were killed, and nine passengers and the driver received injuries ranging from minor to serious. At the time of the accident, the roadway was dry and the weather was clear.

The National Transportation Safety Board determines that the probable cause of the January 30, 2009, accident near Dolan Springs, Arizona, was the bus driver's inadvertent drift from the driving lane due to distraction caused by his manipulation of the driver's side door and subsequent abrupt steering maneuver, which led to losing directional control of the vehicle. Contributing to the severity of the accident was the lack of both occupant protection and advanced window glazing standards for medium-size buses.

The following safety issues were identified in this investigation:

- Failure of the bus driver to attend to the road ahead and maintain control of his vehicle,
- Need for regulatory definitions and classifications for bus body types,
- Limitations of medium-size buses in retaining and protecting passengers during rollovers,
- Need for technology to assist commercial drivers in maintaining control of their vehicles, and
- Need for event data recording in commercial vehicles to aid in accident reconstruction and safety research.

As a result of its investigation, the National Transportation Safety Board makes recommendations to the National Highway Traffic Safety Administration.

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Factual

Accident Narrative

On Friday, January 30, 2009, about 4:06 p.m. mountain standard time (MST), a 2007 Chevrolet/Starcraft 29-passenger medium-size bus, operated by DW Tour and Charter (DW Tour) and occupied by the driver and 16 passengers, was traveling northbound in the right lane of U.S. Highway 93 (US 93), a four-lane divided highway, near Dolan Springs, in Mohave County, Arizona. (See figure 1.) The bus was on a return trip from Grand Canyon West to Las Vegas, Nevada, after a day-long tour. As the bus approached milepost (MP) 28 at a speed of 70 mph,[1] it moved to the left and out of its lane of travel. The driver steered sharply back to the right, crossing both northbound lanes and entering the right shoulder. The driver subsequently overcorrected to the left, causing the bus to yaw and cross both northbound lanes. The bus then entered the depressed earthen median and overturned 1.25 times before coming to rest on its right side across both southbound lanes. (See figures 2 and 3.) During the rollover sequence, 15 of the 17 occupants (including the driver) were fully or partially ejected. Seven passengers were killed, and nine passengers and the driver received injuries ranging from minor to serious. At the time of the accident, skies were clear, the temperature was 61° F, and the wind was blowing from the north–northeast at 8 mph.

Appendix A presents background information on the National Transportation Safety Board's (NTSB) launch to the accident site.

[1] This speed was based on readings from a global positioning system (GPS) unit found in the accident vehicle. Skid tests performed on scene resulted in the determination of a vehicle speed of 70–72 mph.

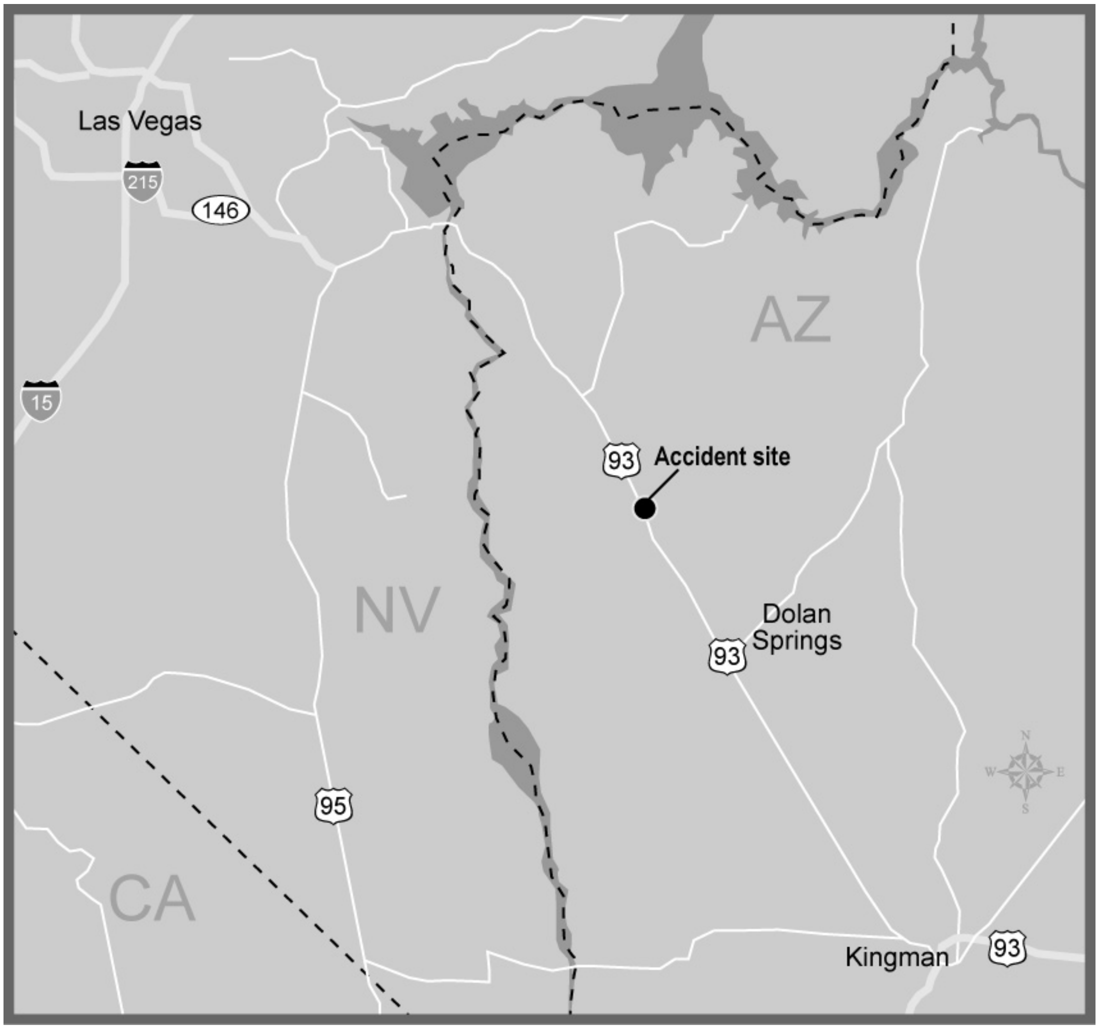

Figure 1. Dolan Springs, Arizona, location map.

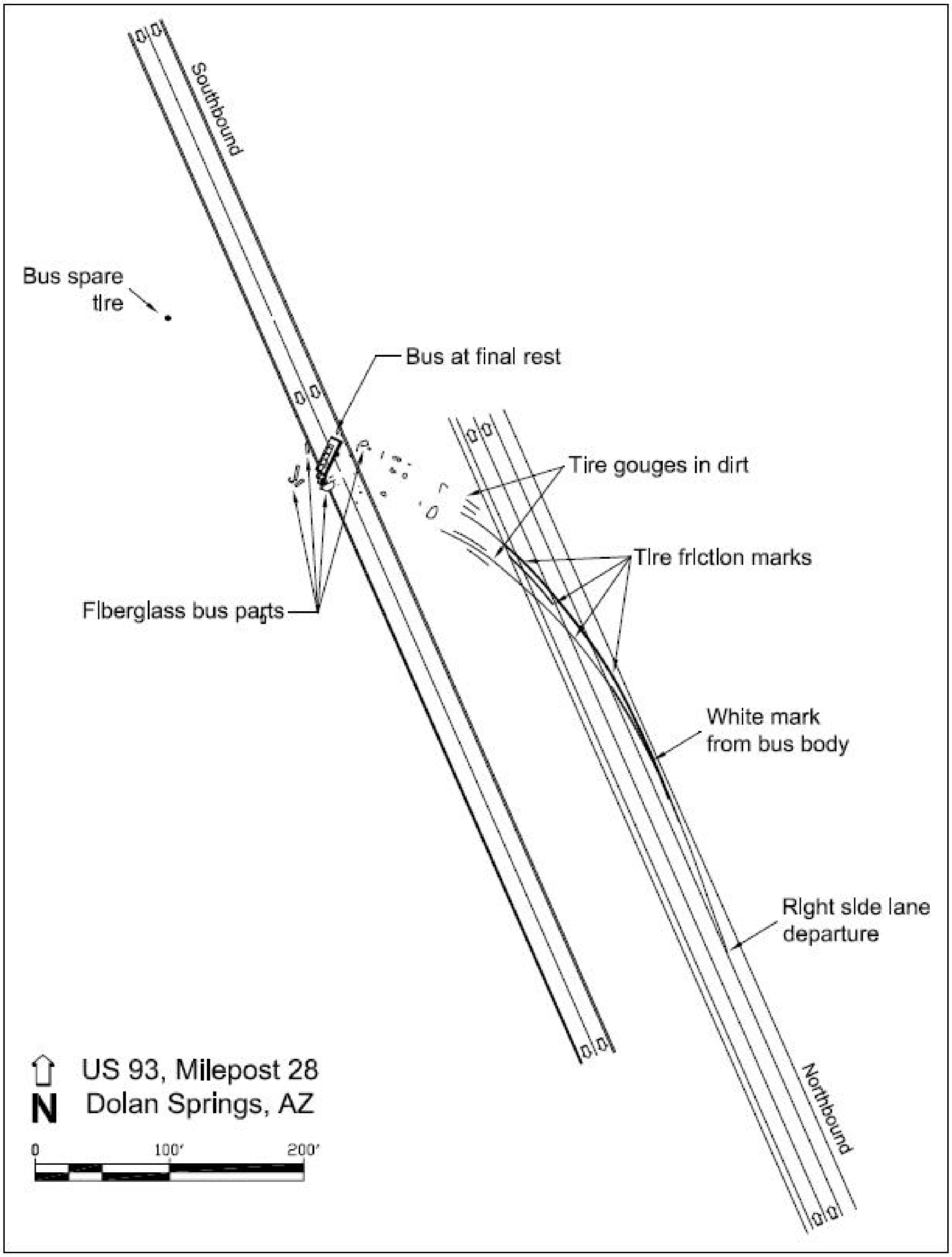

Figure 2. Diagram of Dolan Springs accident scene, showing extent of road marks and gouges leading to final rest position of bus (adapted from Arizona Department of Public Safety diagram). Note: Road marks do not reflect the full accident sequence.

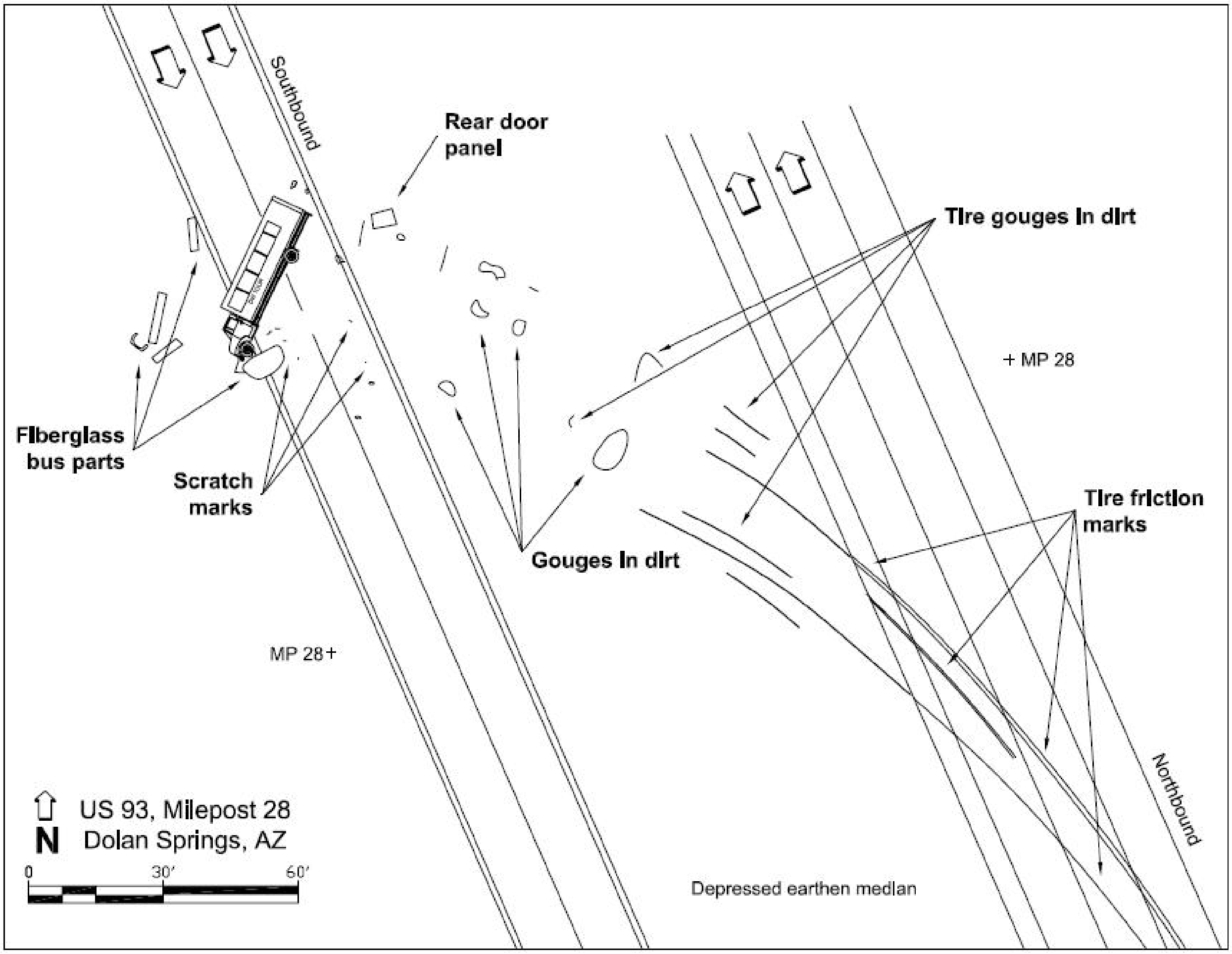

Figure 3. Enlarged view of Dolan Springs accident scene diagram, showing detailed gouge marks and wreckage (adapted from Arizona Department of Public Safety diagram).

Injuries

Table 1 summarizes the injuries resulting from the accident. The injury classifications are based on International Civil Aviation Organization criteria, which the NTSB uses in accident reports for all transportation modes. Although the bus driver's seat was equipped with a seat belt, he was not wearing it at the time of the accident.[2] The passenger seats were not equipped with seat belts.

Table 1. Injuries.

Injuries[a]	Driver	Passengers	Total
Fatal	0	7	7
Serious	1	6	7
Minor	0	3	3
None	0	0	0
Total	1	16	17

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

[2] Title 49 CFR 392.16 states that "a commercial motor vehicle which has a seat belt assembly installed at the driver's seat shall not be driven unless the driver has properly restrained himself/herself with the seat belt assembly." Safety initiatives by the Federal Motor Carrier Safety Administration (FMCSA), the American Trucking Associations, Inc. (ATA), and the Commercial Vehicle Safety Alliance (CVSA) have helped improve seat belt usage rates among commercial drivers from 65 percent in 2007 to 74 percent in 2009. See <http://www.fmcsa.dot.gov/safety-security/safety-belt/exec-summary-2009.aspx>, accessed June 11, 2010.

Medical and Pathological Information

Six passengers were pronounced dead at the scene. A seventh passenger died after arriving by helicopter at the University Medical Center (UMC) in Las Vegas. Six of the seven fatalities were ejected during the accident sequence. Additionally, of the seven bus occupants with serious injuries (including the driver), all were fully or partially ejected. Of the three passengers with minor injuries, two were ejected. According to witness interviews and medical records, four passengers remained in the bus at final rest, two of whom were partially ejected. Of these four, one passenger—who had minor injuries—exited through the roof hatch with the help of an off-duty officer, while the other three were taken out through the roof opening near the driver's seating area and loading door.

All six on-scene fatalities were transported to the Clark County medical examiner's office in Las Vegas, where noninvasive autopsies were performed by the Mohave County, Arizona, medical examiner. Because the passenger who died at UMC in Las Vegas was under Nevada's jurisdiction, the Clark County medical examiner conducted that autopsy. According to the autopsies, six of the seven fatalities sustained multiple head injuries, and six of the seven sustained bilateral rib fractures. Of the 10 surviving bus occupants, seven were hospitalized with serious injuries, and the three with minor injuries were treated and released. According to transport and medical records, six of the seven seriously injured occupants sustained fractures to their extremities. The passenger seated in 4B was partially ejected and sustained crushing injuries to her lower right leg. Another partially ejected passenger, seated in 4E, suffered crushing injuries to her right arm. The three passengers with minor injuries sustained contusions and abrasions to their faces and extremities. Occupant seating positions and injury information are presented in figure 4.

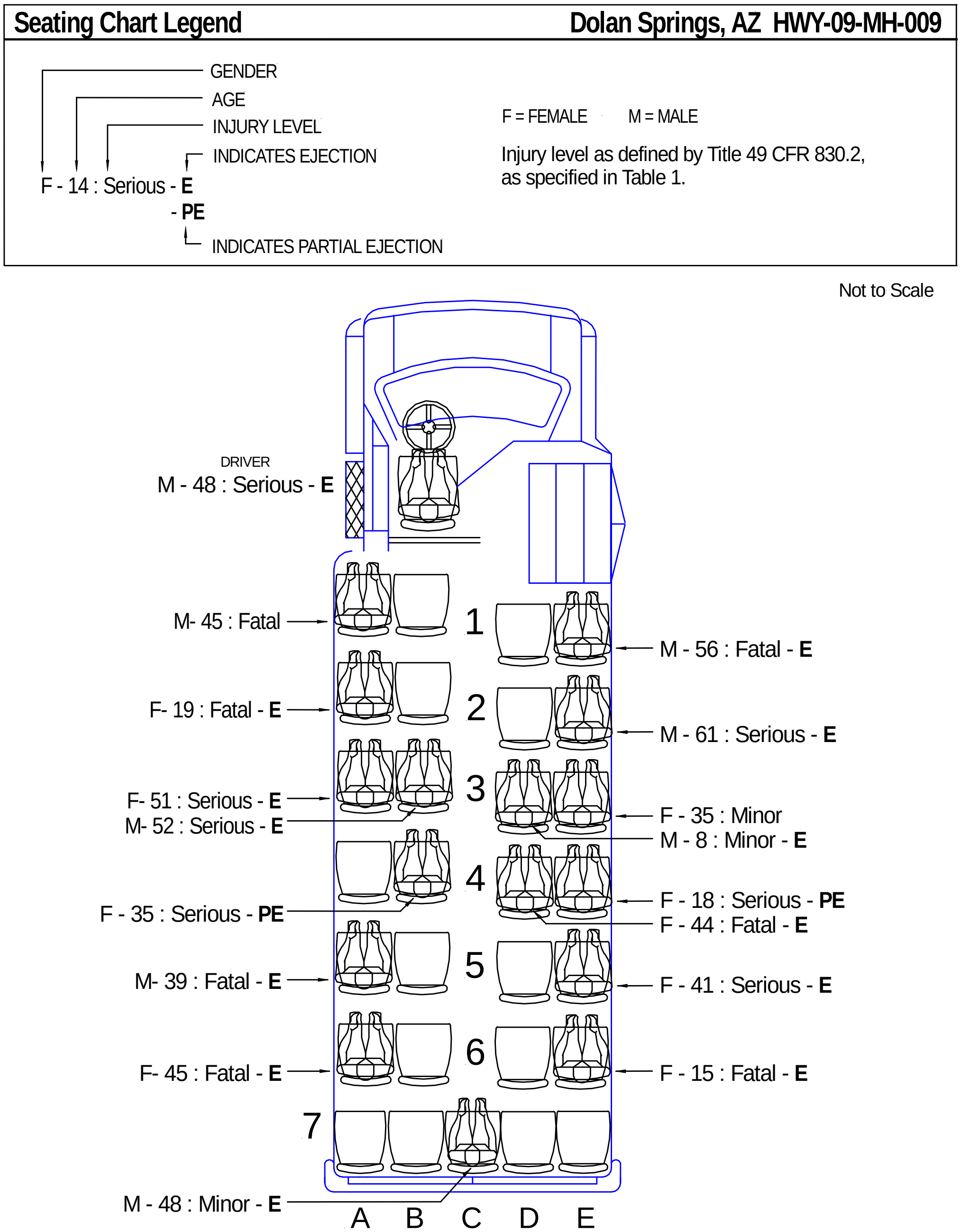

Figure 4. Seating chart reconstruction based on passenger interviews. Fifteen of the 17 bus occupants were ejected, including 6 of the 7 fatally injured passengers.

Emergency Response

The Arizona Department of Public Safety (DPS) dispatcher in Flagstaff was notified of the accident through the 911 system at 4:06 p.m., and the first call from dispatch went out at that time. The closest DPS officer was 27 miles away, and he arrived on scene at 4:22 p.m. The Lake Mohave Ranchos Fire District (LMRFD), located approximately 22 miles south of the accident scene, dispatched extrication units at 4:09 p.m., which arrived on scene at 4:28 p.m. Personnel from the LMRFD assumed incident command in accordance with established protocols.

At 4:23 p.m., the Arizona DPS requested six emergency medical services (EMS) helicopters. The first helicopter arrived on scene at 4:43 p.m., followed by the second at 4:53 p.m. By 5:15 p.m., the sixth helicopter had arrived. The helicopters transported six of the injured occupants. Two ambulances dispatched from the LMRFD arrived at 4:28 p.m. and 4:36 p.m.; these personnel performed triage in preparation for the helicopter transport. Three ambulances from River Medical Inc., in Kingman, Arizona, arrived at 4:56 p.m., 4:58 p.m., and 5:33 p.m. and transported five injured passengers. Dispatch was notified at 5:44 p.m. that all bus occupants had been transported from the scene.

Ten Arizona DPS officers, four DPS accident reconstructionists, and three DPS investigative unit officers responded to the scene. The Arizona Department of Transportation (ADOT) dispatched five trucks to set up traffic control signs. Sixteen National Park rangers in 13 vehicles responded to the scene and were assigned various duties by the incident commander and the medical transport officer. Several other entities responded to the emergency, including the Kingman Fire Department, the Golden Valley Fire Department, and the Hoover Dam Police Department.

The responding agencies held postaccident debriefings on February 5 and 10, 2009. Among the issues discussed were the unfamiliarity of some responders with the equipment used by other agencies, the need for National Incident Management System forms to improve the tracking of patients, the need for larger magnetic mass casualty incident boards, the use of a common radio frequency among responding units, and the need for additional training among responders to prepare for the increased influx of motorcoaches traveling to the Grand Canyon West skywalk. None of these issues resulted in significant delays in transporting the injured. Mohave County[3] has an emergency operations plan for handling disasters and mass fatality incidents that allows the county to seek state assistance. According to the incident commander, the plan was not activated because of the large number of units responding to the accident.

NTSB investigators examined dispatch records and conducted interviews with the surviving bus passengers, witnesses, and first responders. None of the passengers reported any concerns during the triage procedure or transport. The dispatch records indicated that all units responded expeditiously.

[3] According to the U.S. Census Bureau, Mohave County is the fifth largest U.S. county by area. As of the 2000 census, 155,032 people in 62,809 households, representing 43,401 families, resided in the county. The population density was 12 people per square mile. The census reported 80,062 housing units at an average density of 6 per square mile.

Vehicle Damage

NTSB investigators inspected the accident vehicle from February 2–5, 2009, at an ADOT facility in Kingman, Arizona. The bus body sustained damage to the front fenders, hood, side body skirts, front roof area, driver's side door, and passenger loading door area. The fiberglass front fenders and hood were broken away from the frame, exposing the engine compartment. The metal body skirts below the frame were torn away on both sides. Both rear bumper corners had minor damage. Body damage along the exterior roof of the passenger compartment exposed the metal roof cross rails. The fiberglass front fascia above the driver's seating compartment was severely damaged, as shown in figure 5. The square tubular frame of the fascia was bent and twisted. In the right rear roof corner of the bus, the plywood and fiberglass chassis was cracked and displaced. The right edge of the driver's door was slightly misaligned with the frame along the top and bottom. A large opening was created where the passenger loading door completely separated from its mounting. The bottom two steps of the loading stairwell were bent upward. The rear cargo door and the passenger side exterior rearview mirror were broken off.

Figure 5. Bus at final rest, on its right side, showing damage to fiberglass front fascia above driver's compartment.

The left rear axle was shifted forward about 3 inches, thus shortening the wheelbase from 233 inches to about 230 inches on the left side. Further accident-related damage was found in the undercarriage mechanical components, including the rear sway bar, both upper rear shock absorber mounts, and the exhaust pipe. The electrical line to the left rear antilock braking system (ABS) sensor and the hydraulic brake line to the left rear wheel were severed.

The windshield glazing was cracked and remained in place.[4] The A-pillar on the right of the bus was shifted inward to the left approximately 5 inches, causing the windshield to bulge outward. The driver’s door window remained intact. According to a DPS officer, the window had been rolled down postaccident, and it was open at the time of inspection. Along the right side of the bus, all five single-paned solid tempered windows were completely broken out; on the left side, only the first window was intact. On this particular bus model, the first and third windows on each side are designated as emergency exit windows; these windows have red latches on each side and are imprinted with emergency egress instructions.

Apart from the driver’s seating area and loading door, where the front fascia had broken away, interior damage was primarily limited to the overhead luggage racks and the two privacy panels. The overhead luggage rack on the right side of the bus remained attached to the roof at the front two roof attachment points above rows 1 and 3, but it was broken off at the rear two attachment points above rows 4 and 6 and was hanging down just above the seatbacks. In addition, all the screw attachments to the sidewalls had been pulled away. The overhead luggage rack on the left side of the bus remained attached at all of the roof attachment points but the screw attachments to the sidewalls had been pulled away, causing the rack to hang down at an angle over the seatbacks. Numerous occupant contact marks were found on the underside of the overhead luggage racks on both sides of the cabin. According to a Starcraft representative, each luggage rack is attached to the sidewall and roof using 3/8- by 1.5-inch self-tapping hex-head screws. The representative stated that no testing is performed on the weight capacity of the luggage racks.

The privacy panel behind the driver was bent forward approximately 6 inches, and the panel adjacent to the loading door was bent forward 9 inches. The bus was equipped with a Transpec Worldwide roof hatch, which was open at the time of inspection.

The driver’s bucket seat was equipped with a right side armrest, which was broken off. The seat had a three-point lap/shoulder belt but no supplemental restraint system (air bag). At the time of inspection, the seat belt webbing was in the stored position and showed some markings from previous usage. During interviews with law enforcement and NTSB investigators, the bus driver admitted to not wearing his seat belt. As noted earlier, none of the 29 passenger seats in the bus were equipped with seat belts.

Behind the driver’s seat were six rows of two-position seats on each side of the bus and one row of five seats across the rear, for a total of 29 passenger seats. Each passenger seat was equipped with armrests, except for the five seats in the rear. Only the aisle armrests in rows 3 and 4 on the right side were damaged; they were bent outward toward the aisle. At the time of the

[4] Glazing is the clear part of a window that may be made of tempered glass, laminated glass, polycarbonate, or similar materials.

inspection, 27 of the 29 seats were in the upright position.[5] All the seat anchors along the floor and sidewalls remained undamaged and attached.

Driver

At the time of the accident, the 48-year-old driver held a California class “A” commercial driver’s license (CDL), valid from May 2008 until August 2012. His license included a passenger endorsement and had no restrictions. The driver also held a medical card with an expiration date of July 2010. The driver’s CDL record showed one moving violation, occurring in February 2008 in Arizona for operating without required equipment/operating with prohibited equipment. His record revealed no further accidents or violations.

During an interview with NTSB investigators 4 days after the accident, on February 3, while the driver was undergoing treatment in the hospital, he stated that he had attended a driving school to learn to drive both trucks and buses. He indicated that he was familiar with the route to Grand Canyon West and had driven there on previous occasions. He further stated that the bus he was operating at the time of the crash was the vehicle he normally drove.

After obtaining his CDL, the bus driver was hired by AA Express Travel, where he worked until joining DW Tour in November 2008. According to the owner of DW Tour, prior to hiring the driver, she supervised him on a 20-mile road test, during which she had him perform a number of turning skills both in parking lots and on the roadway. According to the driver’s personnel file, he was proficient driving vehicles above 10,000 pounds gross vehicle weight rating (GVWR) and could safely operate a bus carrying 50 or more passengers.

72-Hour History

Table 2 details the bus driver’s activities during the 72 hours preceding the accident. It was constructed through interviews, driver logbook information, video surveillance, radio frequency identification (RFID) information from McCarran International Airport in Las Vegas, and GPS data from the accident vehicle. Figure 6 is a graphic representation of the driver’s duty status from January 27–30. Because most of the driver’s activities were conducted in California and Nevada, the clock times in both the table and the figure—and in this portion of the report text—have been converted to Pacific standard time (PST) for consistency.

[5] The two seats found to be in a reclined position were the window seat in row 6, right side, and the aisle seat in row 1, left side.

Table 2. Activities of Dolan Springs bus driver, January 27–30, 2009.

Time (PST)	Event	Location	Source
Tuesday, January 27			
3:00 p.m.	Logs on duty, not driving	Mission Hills, CA	Logbook
3:15	Begins driving	Mission Hills	Logbook
3:45	Logs on duty, not driving	Los Angeles, CA	Logbook
4:00	Begins driving	Los Angeles	Logbook
4:30	Logs off duty	San Gabriel, CA	Logbook
Wednesday, January 28			
Time (PST)	**Event**	**Location**	**Source**
7:15 a.m.	Logs on duty, not driving	San Gabriel, CA	Logbook
7:30	Begins driving	San Gabriel	Logbook
8:00	Logs on duty, not driving	Los Angeles, CA	Logbook
8:15	Begins driving	Los Angeles	Logbook
10:00	Logs on duty, not driving	Barstow, CA	Logbook
10:15	Logs off duty	Barstow	Logbook
12:45 p.m.	Logs on duty, not driving	Barstow	Logbook
1:00	Begins driving	Barstow	Logbook
3:45	Logs on duty, not driving	Las Vegas, NV	Logbook
4:00	Logs off duty	Las Vegas	Logbook
8:07	Checks into Sahara Hotel	Las Vegas	Hotel records
Thursday, January 29			
Time (PST)	**Event**	**Location**	**Source**
9:45 a.m.	Logs on duty, not driving	Las Vegas, NV	Logbook
10:00	Begins driving	Las Vegas	Logbook
10:13	Enters McCarran airport	Las Vegas	RFID[a]/GPS[b]
10:30	Logs on duty, not driving	Las Vegas	Logbook
10:45	Logs off duty	Las Vegas	Logbook
11:31	Leaves McCarran airport	Las Vegas	RFID
12:00 p.m.	Arrives China Buffet restaurant	Las Vegas	GPS
12:49	Departs China Buffet restaurant	Las Vegas	GPS
3:30	Arrives Riviera Hotel	Las Vegas	Video/GPS
4:31	Receives parking warning at Riviera	Las Vegas	Hotel records
6:30	Logs on duty, not driving	Las Vegas	Logbook
6:50	Leaves Riviera Hotel	Las Vegas	Video
7:15	Logs off duty	Las Vegas	Logbook
Friday, January 30			
Time (PST)	**Event**	**Location**	**Source**
12:00 a.m.	Goes to bed	Las Vegas, NV	Interview
5:30	On duty, not driving	Las Vegas	Logbook
6:00	Leaves Riviera Hotel	Las Vegas	Video
6:40	Crosses Nevada border	Hoover Dam	Video
6:42	Crosses Arizona border	Hoover Dam	Video
8:00	Arrives at “Sky Station”	Meadview, AZ	Interview
8:15	On duty, not driving	Meadview	Logbook
8:30	Off duty, begins nap	Meadview	Logbook/interview
1:30 p.m.	Nap ends	Meadview	Interview
2:13	Leaves “Sky Station”	Meadview	GPS
2:51	Turns onto US 93 northbound	Dolan Springs, AZ	GPS
3:06	Accident occurs	Dolan Springs	

[a] RFID = radio frequency identification information from McCarran International Airport, Las Vegas.
[b] GPS = global positioning system data from the accident vehicle.

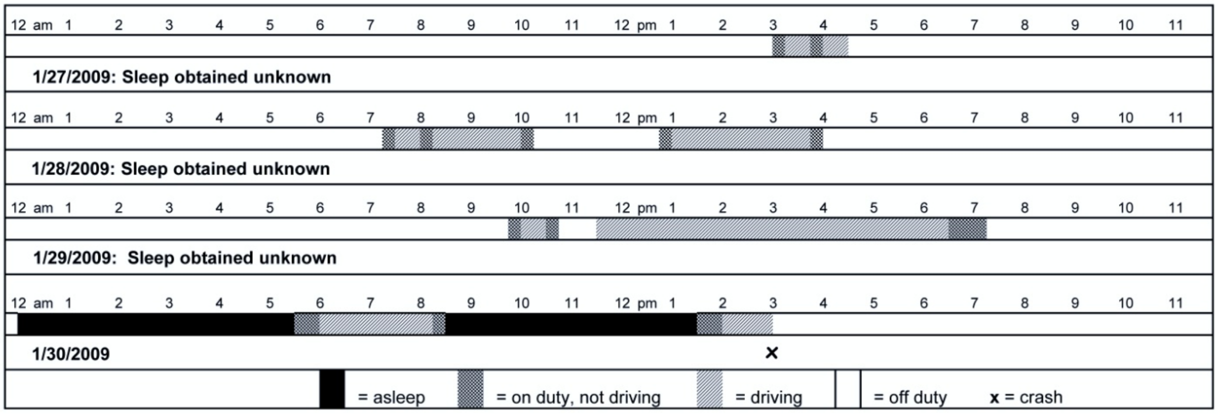

Figure 6. Graphic representation of bus driver's duty status, January 27–30, 2009.

According the driver's logbook, at 7:15 a.m. on January 28, he conducted a 15-minute pretrip inspection and drove 30 minutes from San Gabriel, California, to Los Angeles to pick up a charter group at the airport. He left the airport at 8:15 a.m. and drove 1.75 hours to Barstow, where he stopped for 3 hours to allow the tour group to shop at outlet stores. The driver then drove 2.75 hours to Las Vegas and arrived at 3:45 p.m. He logged 15 minutes of on-duty, not driving, time, from 3:45–4:00 p.m., and was off duty the rest of the day.

The driver's logbook for January 29 indicated that he worked from 9:45–10:45 a.m. and again from 6:30–7:15 p.m. These particular logbook entries differed from statements made by the driver during a postaccident interview with NTSB investigators. During the interview, he stated that on the day prior to the accident, he awoke at approximately 9:30 a.m. and drove to the Las Vegas airport to pick up a tour group arriving at 11:30 a.m. He then took them to a local restaurant for lunch. After lunch, he drove them to several hotels on the Las Vegas strip. Later that evening, he drove the tour group to dinner and a night tour of Las Vegas. According to the driver, he stayed with the tour group at the Riviera for most of the night and went to bed about midnight. As shown in table 2, video surveillance records, RFID records from McCarran International Airport, and GPS data from the accident vehicle supported the driver's statements.

On January 30, the day of the accident, the driver logged in as on duty, not driving, at 5:30 a.m. and began driving to Grand Canyon West around 5:45 a.m. He arrived at the Grand Canyon West bus terminal[6] about 8:15 a.m. and logged off duty at 8:30 a.m. According to the driver, he took a nap in the bus while he waited for the tour group to return from the canyon. He stated that his nap ended about 1:30 p.m., and he left Grand Canyon West at 2:13 p.m. The accident occurred 53 minutes later, on the return trip to Las Vegas.

[6] Only buses operated by the Hualapai Nation are allowed to operate within Grand Canyon West. A bus terminal is located 1.5 miles outside the entrance to Grand Canyon West to accommodate the transfer of passengers.

Driver's Health

In an interview with NTSB investigators, the bus driver stated that he felt fine on January 30, the day of the accident. He reported not having health problems. The driver stated that he did not use prescription or over-the-counter medications, apart from an herbal supplement.[7] When asked about his sleeping habits, the driver told investigators that he normally sleeps 7–8 hours a night. He went on to describe the quality of his sleep as "good."

When admitted to UMC in Las Vegas, following the crash, the driver indicated no significant medical history with the exception of a thoracotomy (chest surgery) for unspecified trauma.

In the driver's most recent commercial driver fitness examination, he denied any significant medical history. His visual acuity was recorded as 20/20 with the left, right, and both eyes; and his horizontal field of vision was noted as 80° with both the right and left eyes. The performing physician indicated that the driver could distinguish red, green, and amber colors. The driver was able to hear a forced whispered voice at 6 feet with both his left and right ears. The performing physician found no abnormalities in any body system and qualified the driver for a period of 2 years.

Toxicology

The Civil Aerospace Medical Institute (CAMI), in Oklahoma City, Oklahoma, performed a toxicological examination of the driver's blood.[8] The results were negative for alcohol and 12 legal and illegal drugs of abuse.[9]

Workload/Distraction

The NTSB investigation determined that the bus driver owned a cellular telephone and had it in his possession during the trip. However, records from the driver's cellular carrier indicated that he was not using his phone at the time of the accident. Likewise, none of the passengers interviewed reported seeing the driver use his cell phone.

The bus driver described the traffic volume at the time of the accident as light and the roadway as flat with good surfaces. During a postaccident interview, the driver stated that he had been traveling in the right lane of US 93 the entire time and did not know how long he had been on the highway when the accident occurred. The driver estimated his speed at 65 mph, which was the legal speed limit; he later stated that the vehicle's cruise control was set to 65 mph and

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[7] The name of the Chinese herbal supplement was translated into English as "six taste yellow earth pills." Further investigation suggested that the supplement was likely "Liu Wei Di Huang Wan."

[8] On January 30, 2009, at UMC Las Vegas, three partial vials of blood were drawn from the driver (at 4:45 p.m., 10:00 p.m., and 10:05 p.m.) and two partial vials of serum (both at 4:45 p.m.). These times are Pacific standard (PST); the accident occurred in Arizona at 4:06 p.m. MST. CAMI tested the blood and serum samples drawn at 4:45 p.m. PST.

[9] The examination tested for amphetamines, opiates, marijuana, cocaine, phencyclidine, benzodiazepines, barbiturates, antidepressants, antihistamines, meprobamate, methaqualone, and nicotine.

engaged at the time of the accident. According to the driver, as he approached the area where the accident occurred, near MP 28, he saw an object in the middle of the road, on the dashed lines between the northbound lanes. He described the object as a rock or rag, and stated that it was similar in size to an intravenous bag but with an irregular shape.[10] He said that he steered to the right to avoid the object and went off the right edge of the highway, causing a "rumbling" noise. Upon hearing the noise, the driver steered left, then right, and lost control of the vehicle. When asked why he lost control, the driver stated that he was making a rightward steering input and went off the road to the right. When he steered in the opposite direction, he lost control of the bus.

The driver stated that there were no interior distractions from the passengers or other sources prior to the accident. When the driver was told that a passenger (seated at 4E) had stated that he was busy opening and closing the driver's door prior to losing control of the vehicle, he insisted that it was impossible for his door to have been open. He did state that wind noise and wind were coming through the door and that he had pulled on the door to tighten the seal. The driver went on to state that he was not sure how much time he spent trying to seal the door.

A motorcyclist traveling in the right lane of southbound US 93 at the time of the accident stated that his attention was drawn to the northbound lanes of travel by what he described as a "puff of dust." He estimated his distance from the bus at 0.5–0.75 mile and could not recall which lane the bus was in when he first observed it. As he watched, the bus veered toward the median. The witness slowed his motorcycle as the bus leaned toward the driver's side, rolled once, began to roll again, and went into the air. At that point, the witness thought he would be hit by the bus. He steered away from the median and placed his motorcycle onto its side in an effort to avoid being hit. According to the witness, he and his motorcycle slid to final rest, remaining in the right lane. He stated that he heard the bus sliding across the pavement, and then the noise stopped. He estimated that the bus came to rest about 8 feet from his location.

Motor Carrier

DW Tour and Charter was an interstate, authorized-for-hire carrier of passengers. The company operated under U.S. Department of Transportation (USDOT) authority number 1379776 and motor carrier number 526301. About 50 percent of DW Tour's business was interstate travel. At the time of the accident, DW Tour met all of the requirements for intrastate operations with the California Public Utilities Commission and the Federal requirements for interstate operations. The company was also properly insured. DW Tour ceased operations following the accident.

[10] The bus driver was a hospital patient when interviewed by NTSB investigators.

DW Tour's fleet consisted of three motorcoaches[11] and the accident bus, which had been purchased in November 2007 from Bus West in Carson, California. DW Tour employed four company drivers. The drivers were paid by the hour and received a meal allowance depending on the number of hours assigned for the day.

Records from the FMCSA's Motor Carrier Management Information System (MCMIS)[12] accessed after the accident indicated that DW Tour had no recordable accidents, resulting in a zero accident rate. The FMCSA has determined that motor carriers with an accident rate[13] of 1.50 or greater are deficient in the accident category of the compliance review.

DW Tour entered the FMCSA's new entrant program on June 3, 2005,[14] and the FMCSA conducted a safety audit on October 19, 2005.[15] The company was cited for two critical violations[16]—one for the inability to produce carrier maintenance files and the other for not conducting a periodic inspection on all of its own vehicles. The safety audit noted that the owner agreed to correct the critical items. In determining the overall safety management controls of a company, the FMCSA assesses a one-point value for each violation. A new entrant with three or more points would fail the safety audit process, and its operating authority would be revoked if corrective action was not taken within 45 days of being notified of the failure.[17] DW Tour exited the new entrant program and was granted operating authority on December 4, 2006.[18]

DW Tour had received two compliance reviews prior to the Dolan Springs accident.[19] A compliance review on February 2, 2007, resulted in a conditional rating because the company

[11] "Motorcoach" is not defined in Federal law. The American Bus Association (ABA) equates a motorcoach with an over-the-road bus. According to section 3038 of Public Law 105-178, Title 49 United States Code section 5310, an over-the-road bus is a bus characterized by an elevated passenger deck located over a baggage compartment.

[12] MCMIS contains information on the safety fitness of commercial motor carriers and hazardous material shippers subject to the *Federal Motor Carrier Safety Regulations* (FMCSRs) and the *Hazardous Materials Regulations*.

[13] Accident rate is determined by the number of annual miles traveled versus the number of recordable accidents based on million miles traveled.

[14] The new entrant program is a process to help new motor carriers comprehend and follow the FMCSRs. Any new interstate motor carrier is considered a new entrant for 18 months after it registers with the FMCSA and receives a USDOT identification number. New entrant carriers are required to undergo and pass a safety audit within this period of time.

[15] The new entrant safety audit examines six management areas: general factors, driver, operations, vehicle, hazardous materials, and accident rate.

[16] A critical violation relates to management or operational controls. An acute violation requires immediate corrective action, regardless of the overall safety posture of the motor carrier. See 49 CFR Part 385 appendix B, subpart VII, "List of acute and critical regulations."

[17] Title 49 CFR 385.319 indicates that motor carriers with commercial motor vehicles transporting 16 or more passengers have 45 days from the time of notification to correct inadequate safety management controls.

[18] The FMCSA published a final rule, on December 16, 2008 (73 *Federal Register* [FR] 76472), that amended the new entrant program to raise the standard of compliance for passing the safety audit.

[19] A compliance review is an onsite examination of six management areas (general factors, driver, operations, vehicle, hazardous materials, and accident rate) to determine the degree to which a carrier complies with the FMCSRs.

had allowed a driver to operate a vehicle prior to receiving a negative preemployment controlled substance test result (critical violation) and had failed to implement a controlled substance testing program (acute violation). DW Tour received a $2,140 fine for these violations. A followup compliance review conducted on August 13, 2007, noted no critical or acute violations, resulting in a satisfactory rating.

The FMCSA conducted a postaccident compliance review of DW Tour on February 2, 2009. The review noted one critical violation for using a driver before receiving a negative preemployment controlled substance test result (the accident driver) and another critical violation because two of its commercial motor vehicles had not been periodically inspected. The accident vehicle was one of the two that had been inspected.[20] The postaccident compliance review resulted in a satisfactory rating.

NTSB investigators accessed DW Tour's carrier profile from the FMCSA Safety and Fitness Electronic Records (SAFER)[21] system and found that—in the 24 months prior to the accident—the carrier had three vehicles and one driver inspected, with no out-of-service (OOS) determinations. The national OOS rate at the time was 23.14 percent for inspected vehicles and 6.80 percent for drivers.

Vehicle

The accident vehicle was a 2007 Starcraft model XLT 29-passenger bus with a curb weight of 15,077 pounds,[22] a GVWR[23] of 19,500 pounds, and an overall length of 32 feet. It was powered by a Duramax 6.6L, 300-horsepower V-8 diesel engine, with an Allison model PTS 1000 five-speed automatic transmission. The odometer registered 63,734 miles.

The accident bus was built in two stages.[24] A 2007 Chevrolet two-axle, rear wheel drive C-5500 Series chassis, manufactured by General Motors, was delivered to Starcraft Bus, a Division of Forest River Incorporated and owned by Berkshire Hathaway, on October 24, 2006. As the final stage manufacturer, Starcraft installed a bus body onto the chassis in January 2007 and shipped the bus to the dealer on February 22, 2007. Starcraft attached a certification plate to the vehicle indicating that it was in compliance with the *Federal Motor Vehicle Safety Standards*

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[20] The California Highway Patrol performed a full inspection of the accident bus on June 16, 2008, and no violations were discovered.

[21] The SAFER website offers company safety data and related services to industry and the public. See <http://safer.fmcsa.dot.gov/>, accessed January 29, 2009.

[22] Curb weight is the total weight of a vehicle with all standard equipment, oil, coolant, and fuel, while not loaded with passengers or cargo.

[23] GVWR refers to the maximum allowable total weight of a vehicle when loaded, including the weight of the vehicle itself plus fuel, passengers, and cargo.

[24] Federal regulations (49 CFR Parts 555, 567, 568, and 571) refer to a bus that is built in two or more stages as a multistage vehicle. The bus industry refers to these types of buses as "cutaway vehicles." The NTSB's bus crashworthiness report referred to them as "specialty buses." (See *Bus Crashworthiness*, Highway Special Investigation Report NTSB/SIR-99/04 [Washington, DC: National Transportation Safety Board, 1999].)

(FMVSSs), the Federal regulations to which manufacturers of motor vehicles must conform and certify compliance.

The ADOT facility in Kingman, Arizona, conducted a postaccident inspection of the bus from February 2–5, 2009. Participating in the inspection were personnel from the Arizona DPS Highway Patrol, the Arizona DPS fleet service, and the NTSB. Starcraft and General Motors personnel were on scene and provided technical assistance.

Tires

NTSB investigators inspected the tires on the accident bus and found no signs of damage except to the right rear dual tires. One nail was found in the outside right rear tire, and two nails were found in the inside right rear tire. Further inspection revealed the nails to be about 0.5-inch long, with none penetrating into the tire liners. Both right rear dual tires were deflated because of tire bead separation from the rim.

The tires were inflated to the manufacturer-recommended 95 pounds per square inch, and a soap solution was used to detect air leaks. No leaks were found in the area of the nails or where the tire bead contacted the rim. Maintenance records indicated that the bus was last serviced about 1 week prior to the accident, and the service included a tire rotation, which typically involves checking tire pressure and inflating all tires to the recommended level.

Brake System

The accident bus was equipped with a power hydraulic brake system with a four-channel ABS. All wheel positions were equipped with disc brakes. The wheel bearings appeared smooth and without noticeable wear. The brake pads were measured to be above the 4/32-inch minimum required by the CVSA North American Out-of-Service Criteria. The brake rotors were measured to be above the minimum thickness specification of 36.1 millimeters set by the brake manufacturer.[25] The rear rotors showed small hairline cracks, known as heat checking, which was considered normal. The left rear caliper pistons showed heat cracks on the inside of the pistons, but there were no indications that this affected operation of the brakes.

Steering System

The accident bus was equipped with a ZF model 8014 integral power steering gearbox. NTSB investigators directed examination of the steering gearbox and steering linkage, and the inspection revealed that neither had been damaged by the rollover event. The steering linkage was intact with no free play noted. With the front of the vehicle raised, the steering wheel was rotated left and right, from axle stop to axle stop, and it rotated freely and smoothly with no impediments felt or observed. The power steering reservoir fluid level was checked without the engine running, and it was about 0.5 inch above the full mark.

[25] There are no CVSA OOS criteria for minimum rotor thickness.

Examination of the warranty claims for the accident bus revealed that the steering gearbox had been replaced twice during the approximate 2-year life of the vehicle. When the owner of DW Tour was asked about these warranty repairs, she did not appear to be aware of them. The steering gearbox and pump were removed and sent to the ZF Lenksysteme GmbH facility in St. Thomas, Ontario, where they were inspected by ZF Lenksysteme and NTSB investigators to determine if the parts had any faults that would account for the frequent replacement. No damage, leaks, or corrosion were found during the bench test, and the steering pump and gear performed within tolerances. The manufacturing dates of the parts closely matched the manufacturing date of the GM chassis, both being made in October 2006; all parties in attendance at the testing concluded that the steering gearbox and pump were the original equipment for the accident bus and had not been replaced during the life of the vehicle.

Suspension

The rollover caused substantial damage to the suspension system and undercarriage of the accident bus. The rear sway bar was stripped away from both mounts, and the right mount was bent outward. Both upper rear shock absorber mounts were fractured, disconnecting the shocks from the mounts. The left side of the suspension dampener was bent forward. The tailpipe was found disconnected at a joint just behind the right rear wheel.

Driver’s Side Door

In addition to having a passenger loading door, the accident bus was equipped with a driver’s side door. The NTSB examined the driver’s side door as part of its postaccident inspection because a passenger had stated that the driver was manipulating the door just prior to the accident. The door was equipped with an interior release handle, which was located adjacent to the door lock switch and the manual window handle. The armrest in the door, located rearward of the interior release handle, also served as a grab point to close or open the door. Manipulating the door by means of the armrest required the person in the driver’s seat to reach down and behind with a slight twisting of the torso to the left. (See figure 7.) The door of the bus was found to open and close normally and smoothly. When closed, the door latched securely. NTSB investigators noticed that light entered through a small gap at the bottom of the door frame.

Engine Electronic Control Module

The Chevrolet engine on the accident bus was equipped with an electronic control module (ECM) that functioned as the engine computer, controlling fuel injection, timing, and various diagnostics. Because the engine ECM was not designed to be an accident data recorder and was not capable of recording parameters such as vehicle speed, engine rpm, brake use, or percent throttle, it provided no information to assist with the accident investigation.

Figure 7. Layout of driver's side door, showing armrest located near seatback and interior door release handle adjacent, to the right.

Highway

US 93 is a four-lane asphalt paved roadway, with the dual northbound and southbound lanes separated by a depressed 81-foot-wide earthen median. Both the northbound and southbound median slopes are relatively flat and free of roadside fixed objects. Each travel lane is approximately 12 feet wide and is delineated by dashed white pavement stripes and raised reflectors. On the northbound side of the highway, a solid white pavement stripe delineates the travel lanes from the 10-foot-wide paved right shoulder. A solid yellow pavement stripe delineates the travel lanes from the 4-foot-wide paved median shoulder. The northbound lanes were resurfaced in 2001, and rumble strips were added on the right and median shoulders to alert errant motorists of lane departures.

The highway is straight and level at the accident site. The speed limit is 65 mph. Commercial vehicles account for about 8 percent of the average daily traffic of 7,000 vehicles. US 93 has no controlled access, but numerous median crossover areas provide access to roadside businesses.

ADOT provided a 5-year accident history for US 93 along a 2-mile segment that included the accident location. From 2004–2008, 26 other accidents occurred along this portion of the roadway: 10 property damage accidents, 15 injury accidents, and one fatal accident. Most of the accidents (69 percent) were single-vehicle accidents, and nine involved a vehicle rollover. None of the accidents involved a bus, and none involved a vehicle traversing the median.

The Arizona DPS mapped the accident scene and located the first visible evidence of tire marks, from the right front bus tire, on the right-hand shoulder. (See figure 8.) Evaluation of the tire marks revealed that the bus had overturned on the depressed earthen median, not on the pavement. Impact marks in the median and on the bus showed that the vehicle overturned 1.25 times during the rollover sequence.

Figure 8. Aerial view of two northbound lanes of US 93, showing tire marks extending from right shoulder, across highway, and onto earthen median.

Meteorological Factors

The accident occurred during daylight, and the pavement was dry. When interviewed by NTSB investigators, the bus driver stated that the sun was in his eyes at the time of the accident, limiting his sight distance. Information from the U.S. Naval Observatory indicated that, at the time and location of the accident, the sun was 20.7° above the horizon and 228.4° east of true north.[26] Personal observations by NTSB investigators at the same time of day as the accident (4:00 p.m.) indicate that—in the direction of travel—the sun would have been to the left and slightly behind the driver.

[26] To compare this measurement with the driver's compass heading of NW (315°), apply the magnetic declination 12.2° east, which results in a vehicle heading of 327.2° from true north. Next, subtract 100° to account for the visual observation that the sun was to the left and slightly behind the driver. The result is 227.2° from true north, a value generally consistent with U.S. Naval Observatory data.

Additional Information

Classification of Medium-Size Buses

The accident bus had traveled from Los Angeles to Las Vegas before being used on a day tour to Grand Canyon West. Both the intercity travel and the subsequent day tour required the bus to traverse rural high speed roads. During a visit to the Grand Canyon West bus terminal on February 5, 2009, NTSB investigators observed two medium-size buses—similar in size to the accident bus—parked alongside motorcoaches. Medium-size buses are generally associated with travel within cities and towns—such as for shuttle and commuter service—and not with long-distance tour or charter service. The use of the accident bus for both intercity and tour travel prompted the NTSB to seek information on medium-size bus travel and accident characteristics, as well as to examine current occupant protection requirements.

The NTSB refers to the accident bus as a "medium-size bus" because it was built on a medium-duty truck chassis[27] and met the FMVSS definition of "bus" (at 49 CFR 571.3) in that it was configured to carry more than 10 people. The Federal regulations do not contain one standard definition for a bus, nor do they specify a category of "medium-size bus." For example, the regulations that govern transportation services for individuals with disabilities, at 49 CFR 37.3, define a bus as any of several types of self-propelled vehicles, generally rubber-tired, intended for use on city streets, highways, and busways. The Federal Transit Administration (FTA) bus testing requirements, at 49 CFR 665.5, define a bus as a rubber-tired automotive vehicle used for the provision of mass transportation service by or for a recipient. The FMCSRs, established at 49 CFR 390.5, define a bus as any motor vehicle designed, constructed, or used for the transportation of passengers, including taxicabs. Unlike the FMVSS definition, these bus definitions do not specify a minimum passenger threshold.

The FMVSSs do not classify different bus body types other than to define them as either a bus or a school bus. The National Highway Traffic Safety Administration's (NHTSA) Fatality Analysis Reporting System (FARS)[28] further distinguishes between bus body types, classifying them as intercity/cross-country bus, school bus, transit bus, other bus, or unknown bus. The FARS database also contains nine attributes for a bus, based on usage. Under the FARS classification scheme, medium-size buses could be categorized as belonging to four of the five bus body types and six of the nine bus usage categories.

[27] "Medium duty" is a designation given by the manufacturer and coincides with categories established by the Federal Highway Administration (FHWA) of light duty being class 1 and 2 vehicles, all vehicles under 10,000 pounds GVWR; medium duty being class 3 through 5 vehicles, ranging from 10,001–19,500 pounds GVWR; and heavy duty being class 6 and higher vehicles, or vehicles over 19,501 pounds GVWR.

[28] FARS was established in 1975 and contains police accident report data on fatal traffic crashes in the 50 states, the District of Colombia, and Puerto Rico. To be included in FARS, a crash must involve a motor vehicle traveling on a road open to the public and result in the death of a person within 30 days of the crash.

Medium-Size Bus Characteristics and Usage

The accident bus was a 32-foot medium-size multistage vehicle, with seating for the driver and 29 passengers. A 2007 FTA report on multistage vehicles[29] described a typical medium-size bus as 25–35 feet long, with a GVWR of 10,000–30,000 pounds, and seating for 16–40 passengers. By comparison, the typical motorcoach is 45 feet long and seats about 55 passengers. Costs for a new medium-size multistage bus ranged from $50,000–$175,000 in 2007, compared to an average $450,000 for a new motorcoach.[30]

According to the Mid-Size Bus Manufacturers Association (MSBMA),[31] the production volume of medium-size buses reported by its members is 10,200–13,600 units per year. By comparison, an estimated 1,600 motorcoaches were produced for the North American market in 2009. Public transit agencies account for just over half (53 percent) of the annual sales for medium-size buses. The buses are primarily used for paratransit services.[32] The remainder of the medium-size bus production goes to private market sales. The MSBMA estimates that 20 percent of these buses are sold to churches, schools, and communities for use as activity buses; 10 percent are sold to businesses such as hotels and rental car companies to be used as shuttle buses; and 10 percent are sold to tour and charter bus companies.

According to representatives of the United Motorcoach Association (UMA)[33] and the ABA,[34] medium-size buses are a growing trend in the passenger transportation arena due to their ability to generate high revenues, their lower retail costs as compared to motorcoaches, and their passenger capacity. The ABA representative also noted that the current economic downturn has resulted in smaller groups of people traveling shorter distances, for which medium-size buses are the economical choice.

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[29] *Evaluation of the Market for Small-to-Medium-Sized Cutaway Buses*, Report MI-26-7280.07.1 (Washington, DC: U.S. Department of Transportation, Federal Transit Administration, December 2007).

[30] *The Economic Impacts and Social Benefits of the U.S. Motorcoach Industry* (Arlington, Virginia: Nathan Associates, 2008), p. 14.

[31] The MSBMA is an affiliate division of the National Truck Equipment Association and was established in 1993. Its 16 bus manufacturers represent the majority of medium-size bus production throughout the United States and Canada. Starcraft is a member of the MSBMA.

[32] Paratransit services are public or private transportation options, typically vans and small buses, for senior citizens and persons with special needs. The Americans With Disabilities Act of 1990 (Public Law 101336) requires paratransit services to be available for "individuals with disabilities who are unable to use fixed route transportation systems." See 49 CFR 37.3.

[33] The UMA includes over 875 motorcoach company members and 215 motorcoach manufacturers, suppliers, and related businesses as associate members. The UMA membership includes manufacturers that produce small- and medium-size buses.

[34] The ABA represents approximately 900 motorcoach and tour companies. Another 2,300 member organizations represent suppliers of bus products and services. Included in the ABA membership are motor carrier operators that provide passenger transportation on motorcoaches as well as medium-size buses.

Fatal Accidents Involving Medium-Size Buses

The NTSB used FARS data in its analysis of fatal accidents involving medium-size buses. Because bus usage data were added to FARS in 2000, the analysis was restricted to data from 2000–2008. This analysis defined a medium-size bus as

- A bus used in tours and charters, in scheduled service, in commuter service, or as a shuttle,
- A bus with a GVWR greater than 10,000 pounds, configured to carry more than 15 passengers, and with only two axles, and
- Not a conventional bus (rear engine, flat front), transit or city bus, or motorcoach.

As such, the NTSB analysis relied on FARS criteria related to bus use, bus body type, GVWR, vehicle configuration, and number of axles.

During this 9-year period, medium-size buses were involved in 83 fatal accidents, resulting in 106 fatalities and 270 injuries. Thirty-three of these fatalities and 187 of the injuries involved bus occupants,[35] for an average of 4 occupant fatalities and 21 nonfatal injuries per year. Overall, bus occupants accounted for 31 percent of medium-size bus fatalities. This number is substantially higher than the percentage of fatally injured bus occupants found in the NTSB's analysis of large bus accidents, which indicated that only 15 percent of fatalities were bus occupants.[36] From FARS data, rural accidents accounted for a third of all fatal accidents involving medium-size buses and a disproportionate number of occupant fatalities (64 percent) and injuries (48 percent). These findings are similar to those for large buses, where 20 percent of fatal accidents occur on rural roads and account for 57 percent of occupant fatalities and 49 percent of injuries.[37]

The accident bus had rolled over on the earthen median before coming to rest on southbound US 93. In the past 10 years, the NTSB has investigated six motorcoach accidents involving rollovers, which resulted in a total of 42 fatalities.[38] All were single-vehicle accidents that occurred on rural roads. In three of the five accidents, the motorcoach ran off the road prior to rolling over.

[35] Nonoccupant fatalities include those outside of the bus, such as pedestrians and occupants of other vehicles.

[36] *Motorcoach Rollover Near Mexican Hat, Utah, January 6, 2008*, Highway Accident Report NTSB/HAR-09/01 (Washington, DC: National Transportation Safety Board, 2009), table B-2.

[37] NTSB/HAR-09/01, table B-2.

[38] (a) *Motorcoach Rollover on U.S. Highway 59, Near Victoria, Texas, January 2, 2008*, Highway Accident Report NTSB/HAR-09/03 (Washington, DC: National Transportation Safety Board, 2009). (b) *Motorcoach Run-Off-the-Bridge and Rollover, Sherman, Texas, August 8, 2008*, Highway Accident Report NTSB/HAR-09/02 (Washington, DC: National Transportation Safety Board, 2009). (c) NTSB/HAR-09/01. (d) *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). (e) *Motorcoach Run-Off-the-Road Near Canon City, Colorado, December 21, 1999*, Highway Accident Brief NTSB/HAB-02/19 (Washington, DC: National Transportation Safety Board, 2002). (f) *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).

From 2000–2008, rollover accidents involving vehicles of all types accounted for almost 30 percent of all fatal accidents. For motorcoaches, approximately 29 percent of all fatal crashes involve rollovers, with ejection accounting for 56 percent of occupant fatalities.[39]

Of the 83 fatal medium-size bus accidents reported in FARS for 2000–2008, four involved a rollover. (See table 3.) These four accidents are similar to the Dolan Springs accident in terms of location, occurrence, sequence of events, and resulting casualties—all were single-vehicle accidents, and three of the four accidents occurred on a rural highway. As in Dolan Springs, two of the four buses ran off the road to the left before rolling over. For the other two buses, one rolled over on the highway and one hit an animal before departing the roadway to the left and rolling over. Of the 54 occupants in these 4 buses, 18 passengers were ejected during the rollovers, resulting in 3 fatalities and 15 injuries. Appendix B discusses the limitations that should be considered when interpreting these findings.

Table 3. Fatalities, injuries, and ejections for medium-size bus rollover accidents, 2000–2008.

Rollover Accidents	Total Occupants	Total Fatalities	Total Injuries	Ejections	
				Fatalities	Injuries
2005 shuttle bus (rural interstate)	13	2	11	2	1
2005 shuttle bus (urban interstate)	9	1	8	0	0
2007 commuter bus (rural interstate)	27	1	26	1	14
2008 tour bus (rural arterial road)	5	3	1	0	0
Total	54	7	46	3	15
SOURCE: NHTSA FARS data.					

[39] *NHTSA's Approach to Motorcoach Safety*, NHTSA Docket 2007-28793 (Washington, DC: U.S. Department of Transportation, National Highway Traffic Safety Administration, August 2007).

NTSB Medium-Size Bus Investigations

Apart from Dolan Springs, the NTSB has investigated at least six other accidents involving medium-size buses since 1990, three of which involved a rollover.[40] (See table 4 and figure 9.) Most recently, on February 22, 2010, the NTSB launched to Lake Placid, Florida, on an accident involving a 2001 Ford/Krystal 32-passenger medium-size bus occupied by the 68-year-old driver and 30 passengers. The bus was traveling northbound in the right lane of U.S. Highway 27, a four-lane divided roadway with an earthen center median. As the bus approached the Lake Saint Francis/Lykes Road intersection, a 2010 Mercury Sable approaching from the west, occupied by the 81-year-old driver, made a left turn into the northbound lanes of the highway and maneuvered into the right lane, striking the bus on the left side behind the driver's door. The right front wheel of the Mercury contacted the left outside rear wheel of the bus. The bus driver swerved to the right, and the bus began to rotate in a clockwise direction, crossing an acceleration lane and entering an earthen area. The bus rolled onto its roof, ejecting eight passengers, three of whom were killed. The bus came to rest on its roof facing east, and the Mercury came to rest in the acceleration lane facing north.

The fiberglass roof of the Lake Placid accident bus sustained significant damage from the rollover. Along the left side, the roof was shifted approximately 30 inches to the right, exposing the seatbacks through the large window wells. The fiberglass fascia above the driver's seat and the right front passenger seating compartments was broken open, revealing the square tubular frame; additionally, the roof was crushed downward and intruded into the compartments of the driver and front passenger. At the rear of the bus, a portion of the fiberglass body was cracked open vertically along the left rear corner and pulled away from the rest of the bus body, resulting in a 60- by 23-inch-wide gap that revealed the square steel tubular frame. The rear cargo door was torn out from the locking mechanism and was hanging open. All the left side windows (1,017.5 square inches each) were completely broken out, while five of the seven windows on the right side remained intact. Within the bus, the fiberglass luggage rack on the driver's side remained attached to the roof, but all of the middle fiberglass supports were broken. The luggage rack on the left was also crushed to a point just above the seatbacks. Three-point lap/shoulder belts and air bags were available at the driver and right front passenger seating areas only.

[40] (a) Adirondack, New York, investigation DCA-94-MH-005. (b) *Pupil Transportation in Vehicles Not Meeting Federal School Bus Standards*, Highway Special Investigation Report NTSB/SIR-99/02 (Washington, DC: National Transportation Safety Board, 1999). (c) *Single Vehicle Run-Off-Road Rollover, U.S. Route 101, San Miguel, California, January 2, 2001*, Highway Accident Brief NTSB/HAB-02/01 (Washington, DC: National Transportation Safety Board, 2002). (d) *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). (e) Broward County, Florida, investigation HWY-07-FH-005. (f) Lake Placid, Florida, investigation HWY-10-FH-009.

Table 4. NTSB medium-size bus accident investigations.

Year and Location	Bus	Total Occupants	Total Fatalities	Total Injuries	Rollover (degrees)	Ejections (Including Partial)	
						Fatalities	Injuries
1994 Adirondack, New York	1992 Ford/Goshen 21-passenger	23	1	22	450	1	13
1998 Lenoir City, Tennessee	1990 Oshkosh/ National Coach 25-passenger	25	2	23	0	1	0
2001 San Miguel, California	2000 Ford/Krystal 31-passenger	6	2	6	270	2	0
2003 Hampshire, Illinois	1999 Ford/Goshen 25-passenger	21	8	12	0	8	0
2006 Broward, Florida	2005 Navistar 33-passenger	29	0	29	0	0	0
2009 Dolan Springs, Arizona	2007 Chevrolet/Starcraft 29-passenger	17	7	10	450	6	9
2010 Lake Placid, Florida	2001 Ford/Krystal 32-passenger	32	3	28	180	3	5

Figure 9. Photographs from NTSB-investigated medium-size bus accidents. Left to right, from top: Adirondack, New York; Lenoir City, Tennessee; San Miguel, California; Hampshire, Illinois; Broward, Florida; and Lake Placid, Florida.

Occupant Protection

Crashworthiness Standards. The Dolan Springs accident bus was built on a General Motors C5500 medium-duty chassis. The body structure of the bus—including the floor, sidewalls, windows, roof, and rear wall—was mounted to the chassis. Multistage vehicles such as the accident bus are required to meet applicable FMVSSs prior to use.

Table 5 summarizes the applicable crashworthiness standards for the passenger compartments of four typical bus body types: small school bus, large school bus, motorcoach, and medium-size bus. Standards that apply to the driver's area only are not included in the table. The labeling/designation of bus body types is based either on bus use or body type. Exemplars of these bus body types are shown in figure 10.

Table 5. Required crashworthiness FMVSSs for passenger compartments of selected bus body types.

49 CFR Part 571, FMVSS Number	Small School Bus (GVWR ≤ 10,000 lb)	Large School Bus (GVWR > 10,000 lb)	Medium-Size Bus (GVWR > 10,000 lb)[a]	Motorcoach[a]
201 Occupant Protection in Interior Impact	●			
205 Glazing Materials	●	●	●	●
207 Seating Systems	●[b]			
208 Occupant Crash Protection	●			
209 Seat Belt Assemblies	●			
210 Seat Belt Assembly Anchorages	●			
213 Child Restraint Systems	●[c]	●[c]	●[c]	●[c]
214 Side Impact Protection	●			
217 Bus Emergency Exits and Window Retention	●	●	●	●
220 School Bus Rollover Protection	●	●		
221 School Bus Body Joint Strength	●	●		
222 School Bus Seating and Crash Protection	●	●		
225 Child Restraint Anchorage Systems	●			

[a] Medium-size buses and motorcoaches are not so distinguished in the FMVSSs; these bus body type categories are included in the table for purposes of comparison.
[b] Applies to small school buses (GVWR of 10,000 pounds or less) manufactured after October 21, 2011.
[c] Applies to vehicles if equipped with a built-in child restraint system.

Figure 10. Images of selected bus body types (not to scale).

Starcraft provided NTSB with documentation showing that both it and Chevrolet/General Motors complied with current applicable crashworthiness regulations and that its window glazing complied with FMVSS 205[41] for this specific bus model. Starcraft representatives stated that the company voluntarily subjects this bus model to FMVSS 207[42] for all seating positions and to FMVSS 210[43] for seat belt assembly anchorages because it can be equipped with lap belts at the passenger positions.

[41] Title 49 CFR 571.205 specifies glazing materials and establishes requirements for reducing injuries from impact to glazing surfaces to minimize the possibility of motor vehicle occupants being thrown (ejected) through vehicle windows as a result of collisions.

[42] Title 49 CFR 571.207 establishes requirements for seats, their attachment assemblies, and their installation to minimize the possibility of failure by forces acting on them as a result of vehicle impact.

[43] Title 49 CFR 571.210 establishes requirements for seat belt anchorages to ensure their proper location for effective occupant restraint and to reduce the likelihood of failure.

Roof Strength. Several FMVSSs specifically apply to school bus certification, including FMVSS 220 for rollover protection/roof strength, FMVSS 221 for joint strength, and FMVSS 222 for occupant safety. Medium-size buses are not required to meet any of these school bus-specific standards. Some of the final stage manufacturers of medium-size buses have voluntarily tested their vehicles to FMVSSs 220 and 221. Some transportation agencies have specified that the buses they purchase must meet or exceed the rollover protection requirements of FMVSS 220.[44] As a result, some FMVSS 220 and 221 test data are available for medium-size multistage buses.

Table 6 presents the results of roof strength tests conducted by NHTSA in 2008 on two motorcoaches, a large school bus, and two medium-size multistage buses, based on FMVSS 220. The two motorcoaches were chosen by NHTSA to represent existing buses in the motorcoach fleet due to the differences in their window spacing (58 and 40 inches). The tests required the roof of each vehicle to withstand 1.5 times the unloaded vehicle weight while not exceeding a downward vertical movement of 130 millimeters (5.1 inches) at any point on the application plate. The two motorcoaches failed the test because their roofs exceeded the downward vertical movement threshold. The large school bus and both medium-size buses passed FMVSS 220.

Table 6. Comparison of FMVSS 220 roof strength test data for two motorcoaches, a school bus, and two medium-size buses.

Test Parameter	1992 MCI MC-12 Motorcoach	1991 Prevost LeMirage Motorcoach	2003 Bluebird School Bus	1997 GC II Goshen Medium-Size Bus	2001 Starcraft 190 WB E450 Medium-Size Bus
Gross vehicle weight rating	37,800 lb	40,000 lb	36,200 lb	14,050 lb	14,050 lb
Unloaded vehicle weight	28,000 lb	29,500 lb	19,925 lb	9,420 lb	9,000 lb
Target load	42,000 lb	44,250 lb	29,888 lb	14,130 lb	13,500 lb
Test value	0.91	1.17	1.5	1.5	1.5
Maximum deflection	25.7 in.	21.4 in.	3.57 in.	2.5 in.	3.5 in.
Pass/fail	Fail	Fail	Pass	Pass	Pass
SOURCE: NHTSA Docket 2007-28793.					

[44] Missouri, Pennsylvania, Minnesota, Wisconsin, Tennessee, Michigan, Utah, Alabama, and California, along with the FTA, require compliance with FMVSS 220. See *Federal Motor Vehicle Safety Standards, Roof Crush Resistance*, NHTSA Docket 2005-22143 (Washington, DC: U.S. Department of Transportation, National Highway Traffic Safety Administration, August 2005).

The accident bus was not specifically designed to meet FMVSS 220. With the exception of the luggage racks, the fiberglass roof above the passenger area sustained relatively minor damage during the rollover. (See figure 11.) Several small areas of the roof along the left side were torn away, revealing the metal roof cross rails. The bus body remained intact, and the integrity of the interior was not compromised by crush. Damage was more severe in the front fascia area above the driver's seating compartment, where the fiberglass was broken away. (See figure 12.) All that remained in the area of the driver's seating compartment and the loading door was the square tubular frame, which was bent and twisted. At the left rear corner of the bus, the fiberglass chassis was cracked and displaced.

Figure 11. Right side of accident bus roof.

Figure 12. Front fascia area above driver's seating compartment and loading door.

The Insurance Institute for Highway Safety (IIHS) recently correlated roof strength to the level of driver injury in passenger cars and sport utility vehicles (SUV).[45] The IIHS study found that vehicles with stronger roofs had lower rates of serious injury, ejection, and injury for nonejected drivers. Even minor increases in roof strength were found to significantly decrease serious injuries in rollover crashes. The IIHS cautioned, however, that occupant protection research should not be limited to roof strength.

The NTSB arrived at similar findings in its bus crashworthiness report,[46] in which the Board recommended that NHTSA develop motorcoach standards for both roof strength and occupant protection, recognizing that only a systems approach would result in the best protection for motorcoach occupants. Bus rollovers—such as the Canon City, Colorado, motorcoach accident and the Milton, Florida, large school bus accident—highlight both the failures and the successes of the bus structure in protecting occupants.[47]

[45] (a) M. Brumbelow and others, "Roof Strength and Injury Risk in Rollover Crashes," *Traffic Injury Prevention*, vol. 10, no. 3 (2009), pp. 252–265. (b) M. Brumbelow and E. Teoh, "Roof Strength and Injury Risk in Rollover Crashes of Passengers Cars and SUVs," *21st International Technical Conference on the Enhanced Safety of Vehicles, Stuttgart, Germany, June 2009.*

[46] NTSB/SIR-99/04.

[47] (a) NTSB/HAB-02/19. (b) *School Bus Loss of Control and Rollover on Interstate 10, Near Milton, Florida, May 28, 2008*, Highway Accident Brief NTSB/HAB-09/03 (Washington, DC: National Transportation Safety Board, 2009).

Occupant Restraint Systems. The interior configuration of the Starcraft XLT medium-size bus is similar to the interior of many motorcoaches. (See figures 13 and 14.) Rows of high-backed seats are located on each side of the aisle. Overhead luggage racks with some form of entertainment system are also common. Unlike school buses, however, medium-size buses and motorcoaches in the United States are not required to meet any occupant protection standards, either active or passive, except for the driver's position. Seat belts are not typically provided, though a variety of manufacturers currently have seat belt-equipped seats available for motorcoaches and other buses.[48,49]

Figure 13. Interior photograph showing seatbacks, televisions, and overhead luggage racks on exemplar Starcraft XLT bus. Note: The accident bus did not have video displays or luggage rack doors.

[48] According to Starcraft representatives, the model bus involved in the Dolan Springs accident offers the option of lap belts at the occupant positions.

[49] (a) See <http://www.imminet.com/news/pressreleases/motorcoachpress_0409_1.htm>, accessed June 15, 2009. (b) NTSB/HAR-06/03. The bus involved in the Hampshire crash was voluntarily equipped with lap belts at all passenger seating positions.

Figure 14. Interior photograph showing seats on exemplar Starcraft XLT bus.

Window Size. The purpose of FMVSS 217 is to establish minimum requirements for the following:

- Bus window retention and release to reduce the likelihood of passenger ejection in crashes, and
- Emergency exits to facilitate passenger off-loading.

All buses in the United States are required to meet this standard, which sets a minimum window size. In 1999, the NTSB's report on bus crashworthiness noted that there were no restrictions on maximum window size in buses and expressed concern with respect to a potential decrease in roof strength due to fewer vertical support posts.[50] The report recorded motorcoach window sizes, representing only the area of the transparent glazing itself and not the window frame, as averaging 2,040 square inches. The average window width was 60 inches, and the average window height was 34 inches.

The Dolan Springs accident bus was equipped with five tempered glass windows along each side of the passenger compartment, as described below:

- The first three windows from the front measured 45 inches wide by 34 inches high (1,530 square inches each).
- The fourth window was 36 inches wide by 34 inches high (1,224 square inches).
- The fifth window was 24 inches wide by 34 inches high (816 square inches).

[50] NTSB/SIR-99/04.

By comparison, a school bus window typically measures about 24.5 inches wide by 21.25 inches high, though a 0.75-inch sash splits the window into two separate panes. As a result, one window typically consists of two separate glazing areas, each measuring 24.5 inches wide by 10.25 inches high, equating to a window area of 251 square inches. Including both portions of the window as a single unit would result in a window area of 520 square inches.[51] Table 7 compares the glazing area for three bus body types.

Table 7. Typical side window glazing area for selected bus body types.

Bus Body Type	Window Glazing Area (square inches)
Motorcoach	2,040
Medium-size accident bus	816–1,530
School bus	520–669

Simulation of Accident

Using commercially available vehicle dynamics software (TruckSim), NTSB investigators conducted a computer simulation based on tire marks and other physical evidence found at the accident scene. The primary focus of the simulation study was to understand the initial loss of control and determine whether a stability control system might have influenced the outcome of the accident.

The physical evidence found at the accident scene included several feet of tire marks, indicating the path of the bus as it traveled onto the right shoulder of the road, back across the two travel lanes, and into the center median before overturning. Because no physical evidence was found indicating the path of the bus prior to the beginning of the tire marks, the NTSB conducted a series of simulations to determine its most likely path. The results of the simulations indicated that the bus most likely underwent all or part of a sinusoidal motion[52] prior to traveling onto the right shoulder and losing control.

[51] School bus windows can be wider. For example, the NTSB investigated an accident involving a school bus in Holyoke, Colorado, and found that two of its windows had a width of 35 inches, including the window frame. (The other windows were 28 inches wide, which corresponds to the glazing dimensions above.) Assuming a similar frame dimension, this glazing size would have been approximately 31.5 by 21.25 inches, resulting in a window area of 669 square inches when including both the upper and lower glazing areas. (See NTSB/SIR-99/04.)

[52] "Sinusoidal" refers to an oscillation, such as a back-and-forth sideways motion.

Accident scenarios that closely matched the physical evidence had the bus traveling in the right lane before drifting into the left lane, followed by a hard steering maneuver to the right, causing the bus to veer sharply back to the right. As the bus veered across the northbound lanes toward the right shoulder of the road, another hard steering maneuver was made to the left to avoid going off the right edge of the roadway. As the bus traveled from the right shoulder back into the roadway, heading toward the median, the simulations indicated that it began to develop a rapid counterclockwise rotation that could not be arrested even with rapid countersteers to the right. The rollover was not modeled in the simulations because the vehicle dynamics software was not capable of modeling such an event.

Motorcoach Safety Action Plan

In November 2009, the U.S. Department of Transportation (DOT) published its motorcoach action plan,[53] an integrated strategy to reduce crashes involving motorcoaches. According to the action plan, an average of 19 motorcoach occupants die annually. Although motorcoach accidents are rare events, even one accident can result in a significant number of fatalities or serious injuries.

The action plan addresses driver errors resulting from fatigue, distraction, medical conditions, and inexperience; crash avoidance technologies; vehicle maintenance and safety; carrier compliance; and measures to protect occupants in the event of a crash, such as seat belts, roof strength, fire safety, and emergency egress. The DOT determined from the data that driver fatigue, vehicle rollover, occupant ejection, and operator maintenance issues contributed to the majority of motorcoach accidents. Consequently, seven priority action items were identified to have the greatest impact on reducing motorcoach accidents, fatalities, and injuries. Among these action items are three related to

- Evaluating and developing roof crush performance requirements to enhance structural integrity,
- Initiating rulemaking to require the installation of seat belts on motorcoaches to improve occupant protection, and
- Developing performance requirements and assessing the safety benefits for stability control systems to reduce rollover events.

According to the action plan, NHTSA would

- By the fourth quarter of 2009, (1) develop and evaluate roof crush performance requirements, and (2) develop performance requirements and assess the safety benefits of stability control systems on motorcoaches and heavy trucks;

[53] *Motorcoach Safety Action Plan*, DOT HS 811 177 (Washington, DC: U.S. Department of Transportation, November 2009).

- In the first quarter of 2010, initiate rulemaking for the installation of seat belts; and
- In 2010, accelerate research on improved glazing and window retention techniques.

NTSB staff met with NHTSA in May 2010 to discuss the status of these initiatives, and NHTSA is currently preparing a formal response.

Analysis

Following a brief discussion of the factors and conditions that the NTSB has excluded as neither causing nor contributing to the accident, the analysis portion of this report discusses the safety issues specific to the investigation:

- Failure of the bus driver to attend to the road ahead and maintain control of his vehicle,
- Need for regulatory definitions and classifications for bus body types,
- Limitations of medium-size buses in retaining and protecting passengers during rollovers,
- Need for technology to assist commercial drivers in maintaining control of their vehicles, and
- Need for event data recording in commercial vehicles to aid in accident reconstruction and safety research.

Exclusions

At the time of the accident, on January 30, 2009, skies were clear with an 8-mph wind from the north–northeast. The bus driver had stated to investigators that the sun was in his eyes immediately prior to the crash, limiting how far ahead he could see. However, astronomical data—along with direct observation of the roadway at the same time of day as the crash—indicated that the sun would have been to the left and slightly behind the driver. Given the sun's position relative to the bus and the driver's line of sight, the NTSB concludes that the sun did not limit the driver's forward vision.

According to the bus driver, his health was generally good, and he had not experienced any acute medical events immediately prior to the crash. His most recent CDL medical exam did not indicate any chronic medical conditions or the likelihood of any acute medical issues. Additionally, the exam indicated that the driver had good hearing and no visual problems. Therefore, the NTSB concludes that the bus driver's health did not cause or contribute to the accident.

Toxicological testing performed by CAMI on the driver's blood was negative for alcohol and illicit drugs. Furthermore, police officers responding to the accident did not observe any indications that the driver might have been under the influence of alcohol at the time of the crash. During a postaccident interview, the driver stated that he used a traditional Chinese herbal supplement. The NTSB has noted in a prior investigation[54] that the lack of empirical data on the contents of herbal supplements makes it difficult to determine their possible effects on the

[54] *Motorcoach Run-Off-the-Road Accident, Tallulah, Louisiana, October 13, 2003,* Highway Accident Report NTSB/HAR-05/01 (Washington, DC: National Transportation Safety Board, 2005).

driving task. The limited information available on the driver's herbal supplement suggests that it would not have affected his ability to operate the vehicle. The NTSB concludes that the bus driver was not under the influence of drugs or alcohol at the time of the accident.

The driver was properly licensed to operate the medium-size bus. He stated to investigators that he was familiar with both his vehicle and the route to and from Grand Canyon West. The NTSB concludes that the bus driver was properly licensed and was familiar with both the route and the accident vehicle.

According to both the bus driver and his passengers, he was neither using nor in the process of using his cellular telephone prior to the accident—which was confirmed by a check of cellular phone records. Therefore, the NTSB concludes that the bus driver was not using his cellular telephone at the time of the accident.

The accident vehicle was inspected after the accident, and no preexisting defects were found. The damage to the hydraulic and electrical brake lines, suspension, and undercarriage was caused by the accident. The nails found in the tires did not penetrate the inside of the tire liners and did not cause a loss of tire pressure. The NTSB concludes that the bus had no preexisting mechanical defects that could have caused or contributed to the accident.

The pavement on the roadway was dry and in good condition when the accident occurred. Delineation markings on the pavement were visible and in good condition. The northbound lanes included rumble strips on the right and median shoulders. The median slope was relatively flat and traversable, its width exceeded design requirements for a median barrier, and there was no history of median crossover accidents in this area. Therefore, the NTSB concludes that neither the design nor the maintenance of the highway contributed to the accident.

With a total area of 13,470 square miles, Mohave County, Arizona, is the fifth largest county in the United States. According to the U.S. Census Bureau, the population density in 2000 was 12 people per square mile. The subject accident occurred on a rural stretch of US 93, about 49 miles from Kingman, Arizona, the closest city. Despite travel distances, the first DPS patrolman arrived 16 minutes after the accident, followed shortly by LMRFD units and several other emergency response agencies. Ambulances were on scene within 30 minutes of the initial request by DPS, and EMS helicopters were on scene within 40 minutes.

A debriefing/critique held by the responding agencies after the accident noted some problems with communication and equipment, but it was determined that those issues caused no significant delays in transportation of the injured. The Mohave County mass fatality incident plan was not executed because the incident commander believed that the widespread emergency response yielded sufficient resources. The incident command system was implemented, however, allowing the incident commander to coordinate all activities. NTSB investigators conducted an emergency response assessment based on dispatch information and interviews with passengers, witnesses, and first responders, and found no evidence of prolonged response times or lack of cooperation among responders. Therefore, the NTSB concludes that the emergency response was timely, especially considering the isolated location of the accident scene.

Motor Carrier Issues

On June 3, 2005, DW Tour entered the new entrant program, and the FMCSA audited DW Tour on October 19, 2005. The company passed the safety audit but was cited for two critical violations that required corrective action, one of which was for not conducting a periodic inspection on all of its own vehicles. On December 16, 2008, the FMCSA published a final rule that amended the new entrant program to raise the standard of compliance for passing the safety audit.[55] The agency identified 16 requirements, at 49 CFR 385.321, as essential elements of safety management controls necessary to operate in interstate commerce. Failure to comply with any one of these requirements would result in a failure of the audit. Included among the 16 essential elements, at 49 CFR 396.17(a), is a requirement that carriers provide proof of periodic vehicle inspection to pass the new entrant safety audit.

Although the FMCSA rated DW Tour as "satisfactory" during a postaccident compliance review, the company was again cited for not conducting a periodic inspection on two of four of its vehicles. However, the accident vehicle was among the buses that DW Tour had made available for inspection during the California inspection in 2007, and a postaccident inspection by NTSB revealed no preexisting defects that could have caused or contributed to the accident. Therefore, although DW Tour's safety management program was lacking in terms of periodic inspections, the NTSB concludes that the condition of the vehicle did not cause or contribute to the accident.

In the investigation of a May 2001 collision between a school bus and a tractor-semitrailer near Mountainburg, Arkansas, which killed three students, the NTSB described the ease with which carriers avoid vehicle inspections.[56] In that report, the NTSB issued the following safety recommendation to the FMCSA:

<u>H-02-16</u>

Require that vehicle inspections of a motor carrier's fleet be conducted during compliance reviews.

Safety Recommendation H-02-16 is currently classified "Open—Unacceptable Response" because of the lack of concrete action by the FMCSA. According to the FMCSA, it is evaluating the compliance review process as part of the Comprehensive Safety Analysis (CSA) 2010 initiative, and this recommendation is among the issues being considered. According to the CSA 2010 website,[57] the FMCSA expects to complete the operational model test by June 2010. The University of Michigan Transportation Research Institute (UMTRI) will then evaluate the program's potential for improving safety and its impact on available resources. The FMCSA expects to have CSA 2010 fully implemented by 2011. The NTSB will continue to monitor the FMCSA's progress in improving motor carrier oversight and compliance with the FMCSRs.

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[55] See 73 FR 76472 (December 16, 2008). Full compliance with this final rule was required beginning December 16, 2009.

[56] *Collision Between Truck Tractor-Semitrailer and School Bus Near Mountainburg, Arkansas, May 31, 2001,* Highway Accident Report NTSB/HAR-02/03 (Washington, DC: National Transportation Safety Board, 2002).

[57] For further information, see <http://csa2010.fmcsa.dot.gov>, accessed February 23, 2010.

Driver Issues

Fatigue

According to the bus driver, he usually obtained 7–8 hours of sleep a night, which is consistent with typical sleep requirements. The driver also described the quality of his sleep as "good." The driver stated that he obtained 5–6 hours of sleep on the night of January 29, 2009, which is about 2 hours less than he normally obtains. Studies have shown reduced performance associated with reductions in sleep.[58] However, the driver told investigators that he took a nap on the bus after dropping off his passengers at Grand Canyon West, which provided the opportunity for as much as 5 hours of rest before passengers returned to the vehicle.

The accident occurred about 1.5 hours after the driver would have awakened from his nap, making it unlikely that he was suffering from sleep inertia.[59,60] As discussed below, a witness stated that she observed the driver opening and closing his door prior to the accident, indicating that he was awake at the time of the crash. The NTSB thus concludes that the bus driver was not impaired by fatigue at the time of the accident.

Distraction

During postaccident interviews, one passenger stated that the driver's door had been open just prior to the crash. When investigators asked the driver about the door, he stated that it had not been open. He explained that he had heard wind noise coming through the door and had only manipulated the door in an attempt to tighten the seal. NTSB investigators examined the driver's door postaccident and found it to be closed and latched normally. Investigators observed a small gap between the door and the frame, which—if it had existed prior to the occurrence of the accident—would have allowed light and possibly wind to come through.

The driver was unsure how much time he spent trying to tighten the door. Regardless of whether the door was open, however, the driver had been engaged in some form of activity involving the door prior to the crash. Distraction from the driving task is a serious problem; NHTSA has estimated that driver inattention or distraction is responsible for 25–30 percent of police-reported crashes, or approximately 1.2 million crashes per year.[61] Distraction is defined as occurring when a driver is delayed in the recognition of information needed to safely accomplish

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[58] (a) R. Wilkinson and others, "Performance Following a Night of Reduced Sleep," *Psychonomic Science*, vol. 5 (1966), pp. 471–472. (b) J. Connor and others, "Driver Sleepiness and Risk of Serious Injury to Car Occupants: Population Based Case Control Study," *British Medical Journal*, vol. 324, no. 7346 (2002), p. 1125.

[59] Sleep inertia is a physiological state that occurs immediately following an abrupt awakening. It typically lasts 15–30 minutes and is characterized by a decline in motor dexterity and a subjective feeling of grogginess.

[60] G. Hofer-Tinguely and others, "Sleep Inertia: Performance Changes After Sleep, Rest, and Active Waking," *Brain Research: Cognitive Brain Research*, vol. 22, no. 3 (March 22, 2005), pp. 323–331.

[61] (a) M. Sundeen, *Along for the Ride: Reducing Driver Distractions*, Final Report of the Driver Focus and Technology Forum (Denver, Colorado: National Conference of State Legislatures, 2002). (b) L. Shelton, Statement before the Subcommittee on Highways and Transit, Committee on Transportation and Infrastructure, U.S. House of Representatives, May 9, 2001. See <http://www.nhtsa.dot.gov/nhtsa/announce/testimony/distractiontestimony.html>, accessed February 4, 2010.

the driving task because some event, activity, object, or person within or outside the vehicle compels or induces the driver's attention away from driving.[62] The bus driver said that he was attending to the door to tighten the seal. A preoccupation with the door would explain the driver's statement that the sun was in his eyes at the time of the accident. The NTSB concludes that the bus driver shifted his gaze and attention to the left to attend to the driver's side door.

In a postaccident interview, the driver reported seeing an object in the middle of the road and swerving right to avoid it, which caused the bus to travel off the right edge of the roadway. He subsequently steered left and then right before losing control of the bus. If the driver's statements are accurate and he had, in fact, found it necessary to initiate an evasive maneuver to avoid an object the size of an intravenous bag in the middle of the road, two scenarios can be postulated:

- The driver had not noticed the object until he was almost upon it, surprising him and necessitating an evasive maneuver sharp enough to cause him to lose control of the bus; and
- The bus had drifted left, toward the middle of the road, necessitating an evasive maneuver to avoid the object in the middle of the road.

A preoccupation with the door would explain the driver's inattention to the primary task of driving and his delayed response to the object on the road. It would also explain the vehicle's drift toward the left lane. Had the driver's attention and gaze been on the door to his left, he may have inadvertently caused the vehicle to drift toward the left lane. Both anecdotal evidence[63] and research[64] have shown that driver steering tends to follow the direction of gaze.

Simulations of the accident based on physical evidence from the roadway suggested that the vehicle underwent all or part of a sinusoidal motion prior to traveling onto the right shoulder and losing control. This finding is consistent with the steering pattern described by the bus driver. The final right steering motion described by the driver may have been an attempt to avoid going into the roadway median. The vehicle motion modeled by the simulation is also consistent with an inattentive driver reacting with surprise to the leftward drift of his vehicle and overcorrecting to the right, subsequently losing control. When all evidence and testimony are considered together, the following scenario emerges:

- Because the driver heard wind noise coming through the door, suggesting to him that it was not properly closed, he turned toward the door in an attempt to tighten the seal, inadvertently turning the steering wheel slightly to the left as he did so.

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[62] J. Stutts and others, *The Role of Driver Distraction in Traffic Crashes* (Washington, DC: AAA Foundation for Traffic Safety, 2001).

[63] (a) R. Bondurant and J. Blakemore, *Bob Bondurant on High Performance Driving* (Osceola, Wisconsin: Motorbooks International, 1998). (b) *Evaluating, Coaching, and Range Management Instructor's Guide* (Irvine, California: Motorcycle Safety Foundation, 1992).

[64] W. Readinger and others, "Gaze-Eccentricity Effects on Road Position and Steering," *Journal of Experimental Psychology: Applied*, vol. 8, no. 4 (2002), pp. 247–258.

- At some point, he turned his attention back to the direction of travel and either steered sharply to avoid an object in the roadway or made a startled response when he noticed the drift of his vehicle.

The common factor in both movements is driver inattention caused by a preoccupation with the driver's side door, resulting in a rapid and exaggerated steering response. The NTSB concludes that the bus driver was distracted by the driver's side door, causing the vehicle to drift leftward, which triggered the subsequent accident sequence.

It has been estimated that 20 percent of all police-reported accidents involve vehicles running off the road, leading to 41 percent of all vehicle fatalities.[65] A majority of these accidents occur on straight roadways (76 percent) and in good weather conditions (73 percent). Lane departure warning systems (LDWS) are forward-looking video-based systems that warn the driver if the vehicle drifts from the lane. Most such systems are activated only when the vehicle is traveling over a certain speed (generally 35 mph) and when the driver initiates a lane departure without signaling the intent to do so.[66]

In a field operation test sponsored by NHTSA, an LDWS—when compared with baseline driving without this technology—was found to increase turn signal usage per mile driven by 9 percent, to decrease lane position deviation, and to cause drivers to more quickly return to their travel lane after being issued an imminent alert.[67] Researchers predict that LDWSs could reduce heavy truck road departure crashes by 17–24 percent, though the effectiveness of these systems has varied along with such factors as field testing environment, driving population, and test design.[68] The FMCSA has already developed voluntary standards for LDWS functional, data, hardware and software, driver–vehicle interface, and maintenance and support requirements for vehicles above 10,000 pounds GVWR.[69]

In its investigative report on a 2005 motorcoach collision with an overturned truck in Osseo, Wisconsin, the NTSB described LDWSs as a tool to warn drivers about unintended lane shifts, regardless of whether they are impaired by fatigue, distraction, poor driving, or other

[65] D. Pomerleau and others, *Run-Off-Road Collision Avoidance Using IVHS Countermeasures*, DOT HS 809 170 (Washington, DC: National Highway Traffic Safety Administration, 1999).

[66] P. Rau, "Drowsy Driver Detection and Warning System for Commercial Vehicle Drivers: Field Operational Test Design, Data Analyses, and Progress," *Proceedings, 19th International Technical Conference on the Enhanced Safety of Vehicles*, DOT HS 809 825 (Washington, DC: National Highway Traffic Safety Administration, June 2005).

[67] D. LeBlanc and others, *Road Departure Crash Warning System Field Operational Test: Methodology and Results*, UMTRI 2006-9-1 (Ann Arbor, Michigan: University of Michigan Transportation Research Institute, June 2006).

[68] S. Johnson, *Human Factors Study of Driver Assistance Systems to Reduce Lane Departures and Side Collision Accidents* (Fayetteville, Arkansas: Mack–Blackwell National Rural Transportation Study Center, 2008).

[69] A. Houser and others, Concept of Operations and Voluntary Operational Requirements for Lane Departure Warning Systems (LDWS) On-Board Commercial Motor Vehicles, FMCSA-MCRR-05-005 (Washington, DC: Federal Motor Carrier Safety Administration, 2005).

conditions.[70] Furthermore, LDWSs can help prevent single-vehicle roadway departures, lane change/merge incidents, and head-on crashes. The NTSB concludes that, had the accident bus been equipped with an LDWS, the driver would have been alerted to the leftward drift of the bus, which might have provided an opportunity to take corrective action in a timely manner, thus avoiding the severe steering maneuver to the right that initiated the accident sequence. Because standards have already been established for vehicles above 10,000 pounds GVWR and several LDWS field tests have predicted steep reductions in accidents such as the one that killed seven passengers in Dolan Springs, the NTSB recommends that NHTSA require new commercial motor vehicles with a GVWR above 10,000 pounds to be equipped with LDWSs.

Regulatory Definition of Buses

Federal regulations do not provide a standard definition of a bus; and even among DOT agencies, the term "bus" may refer to vastly different types of vehicles, from taxis to motorcoaches. The FMVSSs do not differentiate among bus body types other than to distinguish between school bus and "not a school bus." Consequently, the bus body type classifications used by NHTSA for its accident databases and guidelines are not always consistent or well defined and do not have a regulatory basis.

An example of the vague and confusing nature of current bus definitions is illustrated by the term "motorcoach," which is used prominently in the DOT's recently published motorcoach safety action plan.[71] "Motorcoach" is not defined in Federal regulations, though it is commonly interpreted to mean a large bus characterized by an elevated passenger deck located over a baggage compartment. Although all 15 bus photographs in the action plan fit the common interpretation, the action plan itself does not define motorcoach. In FARS, a motorcoach would generally be classified as an intercity/cross-country bus. Multistage vehicles such as the Dolan Springs accident bus would generally be categorized as "other" or "unknown" bus body types, along with trolley buses, amphibious buses ("ducks"), and a variety of other bus configurations. However, because the Dolan Springs accident bus was being used for intercity travel, it could also be classified, along with motorcoaches, in the intercity/cross-country bus category. In addition, several multistage medium-size buses are sold in the United States with the appearance and features of traditional motorcoaches, such as rear engines, lavatories, video systems, and baggage compartments over an elevated passenger deck,[72] and some are even marketed as small motorcoaches.

The ability to classify buses of different manufacture, weight, and range of passenger capacity under more than one FARS bus body attribute creates ambiguity in the data and

[70] *Truck-Tractor Semitrailer Rollover and Motorcoach Collision With Overturned Truck, Interstate Highway 94 Near Osseo, Wisconsin, October 16, 2005*, Highway Accident Report NTSB/HAR-08/02 (Washington, DC: National Transportation Safety Board, 2008).

[71] DOT HS 811 177.

[72] Stallion Bus Industries and Ciao North America are two companies that build multistage medium-size buses for the U.S. market with the appearance and features of traditional large motorcoaches.

weakens the meaning of each attribute. Consequently, the statistical analyses presented in this report on medium-size bus characteristics, usage, and fatal accident involvement do not rely solely on bus body type classifications to identify medium-size buses but instead use multiple FARS criteria, combined with make, model, and vehicle identification number.

The NTSB first examined the lack of standard bus definitions and classifications in its 1999 bus crashworthiness special investigation,[73] discussing many of the same issues described in this report. The NTSB expressed particular concern that FARS did not include a separate category for specialty buses (multistage vehicles) and van-based vehicles. As a result of its findings, the NTSB issued two recommendations to the DOT:

> H-99-43
>
> In 1 year and in cooperation with the bus manufacturers, complete the development of standard definitions and classifications for each of the different bus body types, and include these definitions and classifications in the *Federal Motor Vehicle Safety Standards*.
>
> H-99-44
>
> Once the standard definitions and classifications for each of the different bus body types have been established in the *Federal Motor Vehicle Safety Standards*, in cooperation with the National Association of Governors' Highway Safety Representatives, amend the Model Minimum Uniform Crash Criteria's bus configuration coding to incorporate the FMVSS definitions and standards.

In April 2000, the NTSB added both Safety Recommendations H-99-43 and -44 to its Most Wanted List of Transportation Safety Improvements. In November 1999, the DOT had formed the "One DOT" task force to develop a plan of action for addressing the lack of a standard bus definition. The task force focused primarily on the classification of multistage vehicles and determined that because bus use varied considerably and often changed, the DOT should base its classification on basic descriptive information, such as length and seating configuration. The task force also determined that descriptive information could be encoded on the final stage manufacturer's certification label, in addition to the vehicle identification number. In 2005, NHTSA published a notice of proposed rulemaking (NPRM) to add encoded descriptive information on the final stage manufacturer's certification label for multistage vehicles, but the rulemaking was terminated in 2007 so that NHTSA could pursue a solution that would not unnecessarily burden bus manufacturers and would be more cost-effective for the states to implement. As an alternative measure, NHTSA worked with an expert panel, including NTSB representatives, to modify the Model Minimum Uniform Crash Criteria (MMUCC)[74] guidelines to ensure that police reports include information that identifies vehicles manufactured in multiple stages. In 2006, the NTSB removed Safety Recommendations H-99-43 and -44 from the Most

[73] NTSB/SIR-99/04.

[74] First published in 1998, the MMUCC is a set of national guidelines developed by NHTSA and used by state law enforcement to code vehicle crashes into accident reports.

Wanted List, classifying them as "Open—Acceptable Alternate Response" and "Open—Acceptable Response," respectively.

Although NHTSA has made substantial progress in encouraging the states to base their police accident reports on the MMUCC guidelines, inconsistencies among the most basic regulatory definitions and descriptions for buses undermine the reliability and validity of the data collected. The 2008 version of the MMUCC distinguishes bus body types in a similar manner as FARS, with the only difference being the characterization of intercity/cross-country buses as motorcoaches. The MMUCC website provides users with more detailed descriptions of categories and attributes, along with illustrations of cars, buses, and trucks. The website and accompanying photographs are helpful for distinguishing among more traditional bus body configurations but do not clarify the body type distinctions between motorcoaches and some multistage medium-size buses. Finally, the MMUCC defines a bus as a motor vehicle with seating to transport 9 or more people (including the driver), which is consistent with FARS but inconsistent with the FMVSS definition of a bus as a vehicle that seats more than 10 people.

Regulatory definitions strongly influence the nature and scope of public policy decisions. Definitions provide the parameters from which classifications are based; and classifications determine the accident data to be gathered, how the data are analyzed, and how the results are interpreted. The interpretation of these results affects how research funding is allocated and, ultimately, what regulations are enacted. Therefore, the absence of uniform and unambiguous definitions can affect all aspects of regulatory decision-making—from the way issues are framed to the way solutions are implemented.

The DOT's motorcoach action plan is an ambitious document that provides the status of ongoing bus safety research and rulemaking, as well as a roadmap of future initiatives. Most of the activities described in the action plan are based on a strong body of research that spans passenger vehicle and truck safety as well as bus safety. The DOT has taken a systems approach to address motorcoach safety, evaluating the role of both the driver and the vehicle in crash and injury causation. However, because the DOT lacks standard bus definitions and classifications, and because "motorcoach" is a commonly used but ambiguous term, the scope of the research and rulemaking described in the action plan remains unclear. As a result, though many of the occupant protection and technology initiatives described in the action plan could prevent or ameliorate crash outcomes such as those in Dolan Springs, it is difficult to assess whether and to what extent the initiatives address medium-size buses and other multistage vehicles. Whether the action plan includes other bus body types has repercussions not only for the passengers who ride in these vehicles, but also for the bus manufacturers, carriers, technology vendors, and other stakeholders that supply and operate them. Finally, the DOT states in the action plan that it intends to improve safety through improved technological methods of data collection and analysis, as described later in this report. The NTSB is supportive of this initiative but believes that more basic regulatory changes are needed before any data can be effectively analyzed, interpreted, and used to improve safety.

To eliminate data ambiguity and foster more transparent and accurate public policy decisions, NHTSA and its sister agencies need to collaborate to create uniform regulatory definitions for different bus body types and to base their data systems and other products on these definitions. Little has been done within the DOT to standardize definitions since the NTSB published its bus crashworthiness report 11 years ago. Bus definitions still differ among the FMCSA, the FTA, and NHTSA; and even within agencies, there is confusion as to what a bus is and what distinguishes one bus from another. Therefore, the NTSB concludes that, in the 11 years since the NTSB issued its initial safety recommendations calling for the development of standard regulatory definitions and classifications for the different bus body types, the DOT still does not have standard regulatory definitions. The NTSB recommends that NHTSA, to maintain consistency in bus body classifications and to clarify the scope of bus safety initiatives, develop regulatory definitions and classifications for each of the different bus body types that would apply to all DOT agencies and promote use of the definitions among the bus industry and state governments. This recommendation replaces Safety Recommendations H-99-43 and -44, which the NTSB classifies “Closed—Unacceptable Action/Superseded.”

Vehicle Crashworthiness and Occupant Protection

Roof Strength, Occupant Protection, and Window Glazing

The accident bus had been traveling as a tour bus on a rural road when it rolled over and ejected 15 of its 17 occupants. Medium-size bus bodies and interiors are built with configurations similar to motorcoaches, including large windows with tempered glass glazing, luggage racks that may have protruding video displays, and high-backed seats usually lacking occupant restraints. The accident bus had large window glazing areas that ranged in size from 816–1,530 square inches. Nine of the 10 windows on the bus were broken out during the accident sequence and were a means by which unrestrained passengers were ejected. As with motorcoaches, no Federal regulations or standards require medium-size buses sold or operated in the United States to be equipped with active or passive occupant protection, except at the driver’s position.

In addition, the Federal standards on window glazing do not account for advanced glazing materials and bonding techniques for reducing the likelihood of the windows breaking and providing a pathway for ejection. A NHTSA–Transport Canada research program initiated in 2003 to improve glazing and window retention and prevent motorcoach ejections created test procedures to evaluate the effectiveness of glazing materials and bonding techniques. However, it was determined that “significant improvement in roof strength and the structural integrity of windows” was required before realizing the benefits of advanced glazing materials.[75]

The roof of a medium-size bus is not required to meet any Federal regulations regarding roof strength, which is also the case for motorcoaches. In the Dolan Springs accident, the roof above the driver’s area was severely damaged and left an opening from which the unbelted driver was likely ejected. However, the roof crush above the passenger compartment was minimal, and there was no intrusion to compromise survivable space, which suggests that fewer fatalities and serious injuries would have occurred had the passengers stayed within their seating areas and not been ejected out the window openings.

[75] DOT HS 811 177, p. 33.

In its 1999 bus crashworthiness report, the NTSB concluded that a primary cause 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 occurs into the seating area.[76] The NTSB further concluded that the overall injury risk to occupants in motorcoach accidents involving rollover and ejection may be significantly reduced by retaining the occupant in the seating compartment throughout the collision.

The medium-size bus involved in the 2010 Lake Placid, Florida, rollover accident sustained severe roof deflection and crush above both the passenger and driver compartments, resulting in several ejections and three deaths among the unrestrained passengers.[77] The NTSB has found that bus or motorcoach occupants have a better chance of survival in a crash when the vehicle remains intact and retains survivable space, and when the occupants remain within their seating compartments throughout the accident sequence.[78]

The NTSB has issued numerous recommendations regarding occupant protection for motorcoaches, several of which originated from the bus crashworthiness special investigation:

> <u>H-99-47</u>
>
> 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.
>
> <u>H-99-48</u>
>
> 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.
>
> <u>H-99-49</u>
>
> Expand research on current glazing to include its applicability to motorcoach occupant ejection prevention, and revise window glazing requirements for newly manufactured motorcoaches based on the results of this research.

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[76] NTSB/SIR-99/04.

[77] NTSB investigation HWY-10-FH-009.

[78] NTSB/SIR-99/04.

H-99-50

In 2 years, issue 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-99-51

Once performance standards have been developed for motorcoach roof strength, require newly manufactured motorcoaches to meet those standards.

Safety Recommendations H-99-47 and -50 are currently on the NTSB's Most Wanted List of Transportation Safety Improvements. Safety Recommendation H-99-49 is classified "Open—Acceptable Response" based on correspondence with NHTSA regarding its joint research program with Transport Canada on improving glazing retention and structural integrity requirements for motorcoach-type buses.

In 2008, NHTSA briefed the NTSB on its plans to publish an NPRM on motorcoach occupant restraints. On April 21, 2009, the NTSB reclassified Safety Recommendations H-99-47, -48, -50, and -51 "Open—Unacceptable Response" following a Board meeting on the Mexican Hat, Utah, accident investigation.[79] These same four recommendations were reiterated to NHTSA on October 27, 2009, following the NTSB's investigation of a motorcoach run-off-the-bridge and rollover accident in Sherman, Texas, in August 2008, that killed 17 passengers.[80] In that investigation, the NTSB concluded that had NHTSA implemented the requirement for motorcoach occupant protection systems in a timely manner following the issuance of Safety Recommendations H-99-47, -48, -50, and -51, more occupants might have been retained within the motorcoach, improving survivability and reducing injuries.

On April 30, 2009, the Secretary of Transportation ordered a full departmental review of motorcoach safety. In November 2009, the DOT published a motorcoach safety action plan,[81] which described a systems-oriented approach for enhancing motorcoach safety. Three of the plan's seven action items—on roof strength, seat belts, and crash avoidance technology—focus on the prevention or amelioration of rollovers. The action plan addresses a range of other crash avoidance and crash mitigation initiatives, including reduction of driver errors resulting from fatigue, distraction, medical condition, and inexperience; vehicle maintenance and safety; carrier compliance; and occupant protection measures in the event of a crash.

A principal objective of the motorcoach safety action plan is to address outstanding NTSB recommendations on occupant protection, most of which apply to motorcoaches. It is not clear whether the scope of the action plan includes medium-size buses. If the initiatives detailed in the action plan are restricted to motorcoaches, nonschool-related buses with GVWRs in the approximate range of 10,001–26,000 pounds would remain the only class of bus without

[79] NTSB/HAR-09/01.

[80] NTSB/HAR-09/02.

[81] DOT HS 811 177.

occupant protection standards. Additionally, though some Federal and state agencies already require the paratransit buses they purchase to comply with the roof strength standards detailed in FMVSS 220, it appears that most do not, thereby placing many of those people who use paratransit at higher risk for injury during accidents. Transit bus passengers may be similarly at risk. In the Washington, D.C., metropolitan area, for example, transit buses are used on urban expressways to transport commuters and those traveling to local airports. A survey of metropolitan transit maps for Los Angeles, Miami, Dallas, and Boston suggests that transit buses are also used on high speed roads in these cities. Because the use of transit buses has expanded from local secondary roads to high speed roads, where crash forces can be greater, the occupant safety standards that apply to these buses should also be improved. The NTSB concludes that because of the lack of Federal standards for occupant protection, roof strength, and advanced window glazing, occupants of motorcoaches and medium-size buses are similarly at risk of ejection during rollover accidents. Therefore, the NTSB recommends that NHTSA, in its rulemaking to improve motorcoach roof strength, occupant protection, and window glazing standards, include all buses with a GVWR above 10,000 pounds, other than school buses.

Luggage Racks

During the accident sequence, the overhead luggage racks on the left and right sides of the bus detached from their anchorages. The luggage rack on the right side was found detached from the roof above rows 4 and 6. In addition, all the screw attachments to the sidewalls had been pulled away. The roof attachments for the luggage rack on the left side remained attached, but the rack was completely detached from the sidewalls.

The NTSB also documented luggage rack failures in a 2008 rollover accident in Sherman, Texas, in which the overhead luggage rack on the right side of the motorcoach failed at the anchorage points and became completely detached.[82] The luggage rack fell diagonally across the aisle onto the passengers and blocked the aisle adjacent to the third and fourth rows of seats as well as the right side emergency window exits. The fallen overhead luggage rack obstructed the evacuation route for those who were ambulatory and, based on interview evidence, impeded the efforts of first responders to evacuate injured passengers. As a result, the NTSB made the following recommendations to NHTSA on October 27, 2009:

> H-09-23
>
> Develop performance standards for newly manufactured motorcoaches to require that overhead luggage racks remain anchored during an accident sequence.
>
> H-09-24
>
> Develop performance standards for newly manufactured motorcoaches that prevent head and neck injuries from overhead luggage racks.

[82] NTSB/HAR-09/02.

On March 15, 2010, NHTSA formally responded to these recommendations and reiterated the agency's commitment to improving motorcoach safety. NHTSA described roof crush and rollover tests it has performed on motorcoaches since 2008 in preparation for possible rulemaking on new roof strength and occupant protection standards. NHTSA maintained that Safety Recommendations H-09-23 and -24 would be suitably addressed in its current research and rulemaking plans.

In the Dolan Springs accident, there was no indication that the detached luggage racks impeded evacuation of the injured. However, as in the Sherman accident, NTSB investigators found evidence of occupant contact marks on the undersides of the overhead luggage racks on both sides of the cabin. During NHTSA's 2008 rollover tests on four motorcoaches, luggage rack failure exposed sharp metal edges, presenting additional sources of passenger injury.[83] In the July 2009 tests, unprotected racks caused head injuries to the unrestrained dummy.

As is the case with motorcoaches, there are currently no performance standards for overhead luggage racks on medium-size buses. It is evident from both the Sherman and Dolan Springs accidents that the strength of luggage rack anchors should be considered as part of any systematic evaluation of bus occupant safety. Although it is not specifically known when the luggage racks on the accident bus failed, it is important to note that they failed despite minimal deformation to the roof structure. It is clear from the way the luggage racks were mounted above the seatbacks that—had the occupants been restrained in their seats—the failure of the racks might have resulted in head injuries and hampered egress from the vehicle. The NTSB concludes that the detachment of overhead luggage racks presents a potential injury source for both restrained and unrestrained bus passengers. Because of this potential hazard, the NTSB recommends that NHTSA develop performance standards for all newly manufactured buses with a GVWR above 10,000 pounds to require that overhead luggage racks are constructed and installed to prevent head and neck injuries and remain anchored during an accident sequence. This recommendation replaces Safety Recommendations H-09-23 and -24, both of which the NTSB classifies "Closed—Superseded."

[83] *NHTSA ECE Regulation 66-Based Research Test of Motorcoach Roof Strength*, Final Report, ECE66-MGA2007-001 (Washington, DC: National Highway Traffic Safety Administration and Economic Commission for Europe, May 2008).

Crash Mitigation Technology

The physical evidence at the accident scene included several feet of tire marks indicating the motion of the bus as it traveled off of the roadway onto the right shoulder, back across the roadway, and into the center median. The NTSB conducted a series of computer simulations based on these marks to study vehicle dynamics and better understand the circumstances that led to the accident. The simulations suggested the following order of events:

- First, the accident bus likely underwent all or part of a sinusoidal motion prior to traveling on the right shoulder. This movement is consistent with a scenario in which a bus traveling in the right lane drifts or is steered into the left lane, then is steered back hard to the right, causing it to veer onto the right shoulder; and it is also consistent with the driver's statement that he was initially traveling in the right lane.
- Second, as the bus was steered back toward the roadway from the right shoulder, it approached the limits of its cornering capability, which changed its handling characteristics. The bus began to develop a rapid counterclockwise rotation, or spinout, which the driver could not arrest even with rapid countersteering to the right as the bus reentered the roadway. The development of this spinout immediately preceded the bus's departure from the left side of the road into the center median.
- Finally, the rollover was caused by a combination of the bus sliding sideways as it entered the center median and the tires digging into the sandy soil.

Of particular interest in the simulations were the handling changes and the subsequent spinout of the bus as it traveled on the right shoulder of the roadway—a situation that could make vehicle recovery difficult for all but the most skilled drivers. The challenge in controlling a vehicle as it approaches the limits of tire/road friction is that its response can change, tending toward oversteer (spinout) or understeer (plowing); and the lag time of the vehicle's response can lengthen, leading to a situation where the driver's learned responses to normal driving situations do not apply. When a driver encounters these changes during a panic situation, it adds to the likelihood that he or she will lose control of the vehicle.

Stability control systems use automatic braking to help prevent directional and roll instabilities. For commercial vehicles over 10,000 pounds GVWR, stability control systems are generally divided into two types:

- Roll stability control, which is primarily designed to prevent on-road rollover; and
- Yaw stability control, which is primarily designed to address directional instability.

Roll stability control systems work by monitoring lateral acceleration to determine when rollover is imminent and applying braking to reduce the lateral acceleration. Yaw stability control systems use driver steering input and measured yaw rate as well as lateral acceleration to determine the proper differential braking[84] to reduce directional instabilities, thereby reducing

[84] Differential braking applies braking to individual wheels.

the tendency of a vehicle to understeer or oversteer during an emergency maneuver as it approaches the limits of its traction.

Several studies have shown stability control systems to be highly effective in preventing single-vehicle accidents involving automobiles and SUVs,[85] and NHTSA requires that all vehicles with GVWRs of 10,000 pounds or less be equipped with stability control systems by the 2012 model year.[86,] NHTSA estimates that the installation of stability control systems will reduce all single-vehicle crashes of passenger cars by 34 percent and single-vehicle crashes of SUVs alone by 59 percent, with a much greater reduction in rollover crashes. Once all light vehicles are equipped, the agency estimates that stability control systems could save 5,300–9,600 lives per year and prevent 156,000–238,000 injuries in all types of crashes.[87]

The NTSB simulated stability control systems on the accident bus to determine whether they might have allowed the driver to maintain control. Inclusion of stability control in the simulation reduced the changes in vehicle handling as the bus traveled over the right shoulder of the road—which might have made it easier for the driver to maintain control of the bus as he steered away from the right shoulder. The simulations further indicated that braking by the stability control systems would have slowed the bus, which would have given the driver slightly more time to react to the situation and lowered lateral acceleration. Based on accident simulations, the NTSB concludes that the likelihood of the driver losing control and crashing would have been lower had the accident bus been equipped with a stability control system.

The NTSB has advocated the study and implementation of technology to aid commercial vehicle drivers in maintaining control of their vehicles since the multiple-fatality incident that occurred near Slinger, Wisconsin, in 1997.[88] In that accident, a doubles truck traveling northbound on U.S. Route 41 in hazardous weather conditions crossed over the median into the southbound lanes. This incursion initiated a series of collisions that resulted in eight fatalities. As a result of this accident, the NTSB issued the following recommendation to NHTSA:

> <u>H-98-15</u>
>
> Work, together with the Federal Highway Administration, the American Trucking Associations, the International Brotherhood of Teamsters, and the Motor Freight Carrier Association, to conduct laboratory and truck fleet testing to assess the

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[85] (a) J. Dang, *Statistical Analysis of the Effectiveness of Electronic Stability Control (ESC) Systems*, Final Report, DOT HS 810 794 (Washington, DC: U.S. Department of Transportation, July 2007). (b) P. Green and J. Woodrooffe, *The Effect of Stability Control on Motor Vehicle Crash Prevention*, UMTRI-2006-12 (Ann Arbor, Michigan: University of Michigan Transportation Research Institute, April 2006).

[86] (a) *Federal Motor Vehicle Safety Standards (FMVSS) and Electronic Stability Control (ESC) Systems, Controls and Displays*, Final Rule, Docket No. NHTSA-2007-27662 (Washington, DC: U.S. Department of Transportation, National Highway Traffic Safety Administration, April 2007). (b) *Federal Regulatory Impact Analysis: FMVSS No. 126, Electronic Stability Control Systems*, Office of Regulatory Analysis and Evaluation, National Center for Statistics and Analysis (Washington, DC: National Highway Traffic Safety Administration, March 2007).

[87] FMVSS, ESC Final Rule.

[88] *Multiple Vehicle Crossover Accident, Slinger, Wisconsin, February 12, 1997,* Highway Accident Report NTSB/HAR-98/01 (Washington, DC: National Transportation Safety Board, 1998).

safety benefits of adding traction control devices to antilock brake systems and report your findings to the National Transportation Safety Board.

The NTSB revisited the potential benefits of vehicle control technology in its investigation of a 2005 multiple-fatality accident near Osseo, Wisconsin.[89] As a result of this investigation, the NTSB made the following recommendation to NHTSA:

<u>H-08-15</u>

Determine whether equipping commercial vehicles with collision warning systems with active braking and electronic stability control systems will reduce commercial vehicle accidents. If these technologies are determined to be effective in reducing accidents, require their use on commercial vehicles.

Both Safety Recommendations H-98-15 and H-08-15 are classified "Open—Acceptable Response."

As indicated in the motorcoach safety action plan, the DOT is currently conducting research and testing to evaluate how stability control systems work for heavy trucks and motorcoaches, to assess the potential safety benefits, and to develop objective performance standards. According to NHTSA, it has conducted statistical research on stability control systems for large-platform buses (above 10,000 pounds GVWR),[90] and there are plans to test a medium-size bus with a GVWR of at least 26,000 pounds, but the agency has so far been unable to identify such a vehicle already equipped with a stability control system. NHTSA officials indicated to the NTSB that the exclusion of medium-size buses in vehicle tests thus far does not preclude them from any potential rulemaking and that stability control could be required on the buses if supported by other research.

According to both General Motors and Starcraft, stability control systems were not offered as options on the accident bus at the time of its manufacture. After contacting NHTSA and several manufacturers of braking systems and stability control systems, the NTSB identified only one bus/van between 10,000–33,000 pounds GVWR sold in the United States and equipped with a stability control system.[91] Two major manufacturers of stability control systems for vehicles equipped with air brakes stated that their systems could be adapted for use in medium-size buses.

Research has already demonstrated that stability control is highly effective in reducing rollover and single-vehicle crashes in passenger vehicles and SUVs. The NTSB recognizes that specific vehicle characteristics could affect the overall effectiveness of these systems; however,

[89] NTSB/HAR-08/02.

[90] M. daSilva and others, *Crash Problem Definition and Safety Benefits Methodology for Stability Control for Single-Unit Medium and Heavy Trucks and Large-Platform Buses*, DOT HS 811 099 (Washington, DC: National Highway Traffic Safety Administration, 2009).

[91] The Sprinter van, a vehicle with a GVWR of 11,030 pounds and equipped with hydraulic brakes, is sold with a stability control system. It is manufactured by Mercedes Benz. Bosch sells a stability control system in Europe for a vehicle with a GVWR of 14,030 pounds that is equipped with hydraulic brakes.

the results of simulations suggest that there are potential benefits in equipping vehicles, such as medium-size buses, with stability control systems. The motorcoach safety action plan indicates that the agency's goal is to develop performance standards for large trucks and motorcoaches if this objective is supported by research. The NTSB supports this goal but is concerned that the development of stability control systems and standards for medium-size buses is currently lagging behind that for other commercial vehicles. Therefore, the NTSB recommends that NHTSA develop stability control system performance standards applicable to newly manufactured buses with a GVWR above 10,000 pounds. Once the performance standards have been developed, require the installation of stability control systems in all newly manufactured buses in which this technology could have a safety benefit.

Event Data Recorders

The Chevrolet engine on the accident bus was equipped with an ECM that functioned as the engine computer; but, it was not designed to be a data recorder and was not capable of recording parameters such as vehicle speed, engine rpm, brake use, or percent throttle. The bus was not equipped with any form of event data recorder (EDR), a device or function that records dynamic time series data prior to (such as vehicle speed versus time) and during (such as delta V versus time) a crash event. Because event data were unavailable, the NTSB had to rely on simulation-based estimates of steering wheel angle, lateral acceleration, vehicle speed, and yaw rate to determine the stability of the bus throughout the accident sequence. Although the NTSB's computer model appeared to correlate well with the physical evidence, a more robust reconstruction, based on fewer estimates, would have been possible with the retrieval of event data. The NTSB concludes that the availability of recorded event data would have resulted in a more complete account of the preaccident events leading to the rollover of the accident bus.

In its bus crashworthiness report, the NTSB described the importance of event data in the reconstruction of accidents and the continued development of bus occupant protection systems, and issued the following recommendations to NHTSA:[92]

> <u>H-99-53</u>
>
> Require that all school buses and motorcoaches manufactured after January 1, 2003, be equipped with on-board recording systems that record vehicle parameters, including, at minimum, lateral acceleration, longitudinal acceleration, vertical acceleration, heading, vehicle speed, engine speed, driver's seat belt status, braking input, steering input, gear selection, turn signal status (left/right), brake light status (on/off), head/tail light status (on/off), passenger door status (open/closed), emergency door status (open/closed), hazard light status (on/off), brake system status (normal/warning), and flashing red light status (on/off) (school buses only). For those buses so equipped, the following should also be recorded: status of additional seat belts, airbag deployment criteria,

[92] NTSB/SIR-99/04.

airbag deployment time, and airbag deployment energy. The on-board recording system should record data at a sampling rate that is sufficient to define vehicle dynamics and should be capable of preserving data in the event of a vehicle crash or an electrical power loss. In addition, the on-board recording system should be mounted to the bus body, not the chassis, to ensure that the data necessary for defining bus body motion are recorded.

H-99-54

Develop and implement, in cooperation with other government agencies and industry, standards for on-board recording of bus crash data that address, at a minimum, parameters to be recorded, data sampling rates, duration of recording, interface configurations, data storage format, incorporation of fleet management tools, fluid submersion survivability, impact shock survivability, crush and penetration survivability, fire survivability, independent power supply, and ability to accommodate future requirements and technological advances.

Several positive developments have occurred since the issuance of these recommendations, among which are the following:

- Establishment of a truck and bus EDR working group by NHTSA in 2000;[93]
- Publication of IEEE Standard P1616, "Standard for Motor Vehicle Event Data Recorders," in 2005 and the SAE International (SAE) Recommended Practice (RP) J1698 in 2003 to establish a common format for displaying and presenting postdownloaded crash-related data recorded and stored within electronic components currently installed in many light-duty vehicles;
- Publication of SAE RP J1698/1 in 2003 to provide definitions for event-related data items;
- Publication of SAE RP J1698/2 in 2004 to define a common method for extracting event data;[94]
- Publication of RP 1214 by the ATA in 2004 to provide guidelines for the collection, storage, and retrieval of event-related data from electronic control units in commercial vehicles;[95] and

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

[94] (a) *IEEE Standard* for *Motor Vehicle Event Data Recorders*, IEEE Standard 1616-2004 (Los Alamitos, California: IEEE, February 2005). (b) *Vehicle Event Data Recorder Interface, Output Data Format*, SAE Recommended Practice J1698/1 (Warrendale, Pennsylvania: SAE International, December 2003).

[95] *American Trucking Associations Technology and Maintenance Council Guidelines for Event Recording: Collection, Storage, and Retrieval*, Recommended Practice 1214 (Alexandria, Virginia: American Trucking Associations, January 2004).

- Publication of requirements for EDR components, hardware, software, sensors, and databases by the FHWA in 2004 as part of the FMCSA's Commercial Vehicle Safety Technology Diagnostics and Performance Enhancement Program.[96]

In June 2010, the SAE Truck and Bus Event Data Recorder Committee completed RP J2728, which serves as a base standard for heavy vehicle event data recorders (HVEDR) and applies to heavy-duty vehicles[97] over 10,000 pounds that are designed or required to comply with the FMVSSs. RP J2728 provides design and performance requirements necessary to comply with the development of a "tier 1" (minimum capabilities) HVEDR. Subsequent documents are envisioned to significantly expand on the tier 1 capabilities. These devices will be referred to as "tier 2" and "tier 3" HVEDRs. NHTSA anticipates making a regulatory decision on HVEDRs in the near future. According to NHTSA, it will determine at that time whether it will apply to motorcoaches, to school buses, or to all heavy vehicles.[98]

Despite the work that has been done since the NTSB first issued Safety Recommendations H-99-53 and -54, there is still no requirement for the installation and use of EDRs on motorcoaches and school buses. The NTSB reiterated these recommendations in the investigation of a 2007 motorcoach ramp override accident in Atlanta, Georgia, that killed seven passengers.[99] In that accident, the NTSB determined that EDR data would have yielded information on vehicle parameters and driver actions prior to the accident, as well as on vehicle dynamics throughout the accident sequence—which would have been valuable in reconstructing and evaluating occupant kinematics, injury exposure, and the potential benefits of occupant protection devices and systems. These two recommendations were again reiterated in the NTSB's 2009 special investigation of pedal misapplication in heavy vehicles, a report that focused primarily on school buses.[100] The NTSB concluded that the presence of EDRs in heavy vehicles would provide essential and specific information regarding the causes and mechanisms of pedal misapplication and unintended acceleration; Safety Recommendations H-99-53 and -54 were reclassified "Open—Unacceptable Response" due to NHTSA's failure to require the use of EDRs on buses.

Safety Recommendation H-99-53 specifies that EDRs be required for school buses and motorcoaches. However, as illustrated by the Dolan Springs accident, EDR data would also be useful in the reconstruction of preaccident events and crash dynamics for medium-size buses. Because SAE RP J2728 is designed to address the application of EDRs in vehicles over 10,000 pounds GVWR, it should be possible for NHTSA to include all buses above 10,000 pounds GVWR in any regulatory requirements based on RP J2728. The NTSB concludes

[96] See <http://www.itsdocs.fhwa.dot.gov/JPODOCS/REPTS_TE/14146_files/14146.pdf>, accessed April 14, 2010.

[97] The term "heavy-duty vehicle" refers to vehicles equipped with one or both of the SAE J1708/J1587 or SAE J1939 communication networks.

[98] E-mail correspondence to the NTSB from the Acting Director, Office of Strategic Planning, NHTSA, March 19, 2010.

[99] NTSB/HAR-08/01.

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

that having EDRs on all buses above 10,000 pounds GVWR would greatly increase the understanding of crash causation and be helpful in further establishing design requirements for crashworthiness and occupant protection systems. As a result, the NTSB recommends that NHTSA require that all buses above 10,000 pounds be equipped with on-board recording systems that: (1) record vehicle parameters, including, at minimum, lateral acceleration, longitudinal acceleration, vertical acceleration, heading, vehicle speed, engine speed, driver's seat belt status, braking input, steering input, gear selection, turn signal status (left/right), brake light status (on/off), head/tail light status (on/off), passenger door status (open/closed), emergency door status (open/closed), hazard light status (on/off), brake system status (normal/warning), and flashing red light status (on/off; school buses only); (2) record status of additional seat belts, airbag deployment criteria, airbag deployment time, and airbag deployment energy; (3) record data at a sampling rate sufficient to define vehicle dynamics and be capable of preserving data in the event of a vehicle crash or an electrical power loss; and (4) are mounted to the bus body, not the chassis, to ensure recording of the necessary data to define bus body motion. This recommendation replaces Safety Recommendation H-99-53, which the NTSB classifies "Closed—Unacceptable Action/Superseded."

Conclusions

Findings

1. Given the sun's position relative to the bus and the driver's line of sight, the sun did not limit the driver's forward vision.
2. The bus driver's health did not cause or contribute to the accident.
3. The bus driver was not under the influence of drugs or alcohol at the time of the accident.
4. The bus driver was properly licensed and was familiar with both the route and the accident vehicle.
5. The bus driver was not using his cellular telephone at the time of the accident.
6. The bus had no preexisting mechanical defects that could have caused or contributed to the accident.
7. Neither the design nor the maintenance of the highway contributed to the accident.
8. The emergency response was timely, especially considering the isolated location of the accident scene.
9. Although DW Tour and Charter's safety management program was lacking in terms of periodic inspections, the condition of the vehicle did not cause or contribute to the accident.
10. The bus driver was not impaired by fatigue at the time of the accident.
11. The bus driver shifted his gaze and attention to the left to attend to the driver's side door.
12. The bus driver was distracted by the driver's side door, causing the vehicle to drift leftward, which triggered the subsequent accident sequence.
13. Had the accident bus been equipped with a lane departure warning system, the driver would have been alerted to the leftward drift of the bus, which might have provided an opportunity to take corrective action in a timely manner, thus avoiding the severe steering maneuver to the right that initiated the accident sequence.
14. In the 11 years since the National Transportation Safety Board issued its initial safety recommendations calling for the development of standard regulatory definitions and classifications for the different bus body types, the U.S. Department of Transportation still does not have standard regulatory definitions.

15. Because of the lack of Federal standards for occupant protection, roof strength, and advanced window glazing, occupants of motorcoaches and medium-size buses are similarly at risk of ejection during rollover accidents.

16. The detachment of overhead luggage racks presents a potential injury source for both restrained and unrestrained bus passengers.

17. Based on accident simulations, the likelihood of the driver losing control and crashing would have been lower had the accident bus been equipped with a stability control system.

18. The availability of recorded event data would have resulted in a more complete account of the preaccident events leading to the rollover of the accident bus.

19. Having event data recorders on all buses above 10,000 pounds gross vehicle weight rating would greatly increase the understanding of crash causation and be helpful in further establishing design requirements for crashworthiness and occupant protection systems.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the January 30, 2009, accident near Dolan Springs, Arizona, was the bus driver's inadvertent drift from the driving lane due to distraction caused by his manipulation of the driver's side door and subsequent abrupt steering maneuver, which led to losing directional control of the vehicle. Contributing to the severity of the accident was the lack of both occupant protection and advanced window glazing standards for medium-size buses.

Recommendations

New Recommendations

To the National Highway Traffic Safety Administration:

Require new commercial motor vehicles with a gross vehicle weight rating above 10,000 pounds to be equipped with lane departure warning systems. (H-10-1)

To maintain consistency in bus body classifications and to clarify the scope of bus safety initiatives, develop regulatory definitions and classifications for each of the different bus body types that would apply to all U.S. Department of Transportation agencies and promote use of the definitions among the bus industry and state governments. (H-10-2) (This recommendation supersedes Safety Recommendations H-99-43 and -44 and is classified "Open—Unacceptable Response.")

In your rulemaking to improve motorcoach roof strength, occupant protection, and window glazing standards, include all buses with a gross vehicle weight rating above 10,000 pounds, other than school buses. (H-10-3)

Develop performance standards for all newly manufactured buses with a gross vehicle weight rating above 10,000 pounds to require that overhead luggage racks are constructed and installed to prevent head and neck injuries and remain anchored during an accident sequence. (H-10-4) (This recommendation supersedes Safety Recommendations H-09-23 and -24.)

Develop stability control system performance standards applicable to newly manufactured buses with a gross vehicle weight rating above 10,000 pounds. (H-10-5)

Once the performance standards from Safety Recommendation H-10-5 have been developed, require the installation of stability control systems in all newly manufactured buses in which this technology could have a safety benefit. (H-10-6).

Require that all buses above 10,000 pounds gross vehicle weight rating be equipped with on-board recording systems that: (1) record vehicle parameters, including, at minimum, lateral acceleration, longitudinal acceleration, vertical acceleration, heading, vehicle speed, engine speed, driver's seat belt status, braking input, steering input, gear selection, turn signal status (left/right), brake light status (on/off), head/tail light status (on/off), passenger door status (open/closed), emergency door status (open/closed), hazard light status (on/off), brake system status (normal/warning), and flashing red light status (on/off; school buses only); (2) record status of additional seat belts, airbag deployment criteria, airbag deployment time, and airbag deployment energy;

(3) record data at a sampling rate sufficient to define vehicle dynamics and be capable of preserving data in the event of a vehicle crash or an electrical power loss; and (4) are mounted to the bus body, not the chassis, to ensure recording of the necessary data to define bus body motion. (H-10-7) (This recommendation supersedes Safety Recommendation H-99-53 and is classified "Open—Unacceptable Response.")

Previously Issued Recommendations Classified in This Report

The National Transportation Safety Board classifies the following previously issued recommendations:

- Safety Recommendation H-99-43 to the U.S. Department of Transportation (previously classified "Open—Acceptable Alternate Response") is classified "Closed—Unacceptable Action/Superseded" (replaced by Safety Recommendation H-10-2) in the "Regulatory Definition of Buses" section of this report.
- Safety Recommendation H-99-44 to the U.S. Department of Transportation (previously classified "Open—Acceptable Response") is classified "Closed—Unacceptable Action/Superseded" (replaced by Safety Recommendation H-10-2) in the "Regulatory Definition of Buses" section of this report.
- Safety Recommendation H-99-53 to the National Highway Traffic Safety Administration (previously classified "Open—Unacceptable Response") is classified "Closed—Unacceptable Action/Superseded" (replaced by Safety Recommendation H-10-7) in the "Event Data Recorders" section of this report.
- Safety Recommendation H-09-23 to the National Highway Traffic Safety Administration (previously classified "Open—Initial Response Received") is classified "Closed—Superseded" (replaced by Safety Recommendation H-10-4) in the "Luggage Racks" section of this report.
- Safety Recommendation H-09-24 to the National Highway Traffic Safety Administration (previously classified "Open—Initial Response Received") is classified "Closed—Superseded" (replaced by Safety Recommendation H-10-4) in the "Luggage Racks" section of this report.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

DEBORAH A.P. HERSMAN
Chairman

ROBERT L. SUMWALT
Member

CHRISTOPHER A. HART
Vice Chairman

Adopted: June 22, 2010

Appendix A: Investigation

The National Transportation Safety Board (NTSB) received notification of this accident on January 30, 2009. The NTSB launched a team of investigators to address motor carrier, survival factors, human factors, vehicle, and highway issues. The NTSB team also included staff from the transportation disaster assistance office. No Board member was present on scene. Parties to the investigation were the Federal Motor Carrier Safety Administration, Arizona Department of Public Safety, DW Tour and Charter, Starcraft Bus, and General Motors Corporation. No public hearing was held in connection with this accident, and no depositions were taken.

Appendix B: Data Limitations

A number of limitations should be considered when interpreting the findings on medium-size bus accidents, injuries, and fatalities using the National Highway Traffic Safety Administration's Fatality Analysis Reporting System (FARS).

FARS data analyses include only those accidents with at least one fatality. FARS is a census of all fatal crashes within the United States, the District of Columbia, and Puerto Rico; a candidate crash is included if it involves a motor vehicle traveling on a public roadway and if the death of a vehicle occupant or nonmotorist occurs within 30 days of the accident. Consequently, crashes that result in property damage, result in nonfatal injuries, or occur on private roadways are not included in FARS data.

Fatal accidents account for a very small proportion of the total number of highway accidents in any given year. Although fatal accidents can be viewed as the most severe type of crash, they may not adequately represent the kinds of accidents where nonfatal but serious injuries occur. In addition, fatal rural accidents involving medium-size buses represent a very small proportion of all fatal rural accidents. Given that almost 60 percent of all fatal accidents occur on rural roads, the magnitude of rural road travel risk may be substantially higher than is shown in this report.

The calculation of accident rates to characterize accident risk is dependent on well-defined populations of study, as well as accurate measures of activity on which to base exposure measures, such as vehicle miles traveled or number of passengers. Accident rates are missing from this report because accurate estimates of bus activity are not readily available or reported.