Truck-Tractor Double Trailer Median Crossover Collision With Motorcoach and Postcrash Fire on Interstate 5
Orland, California
April 10, 2014

Accident Report

NTSB/HAR-15/01
PB2015-104149

National Transportation Safety Board

NTSB/HAR-15/01
PB2015-104149
Notation 8590A
Adopted July 14, 2015

Highway Accident Report

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National Transportation Safety Board

490 L'Enfant Plaza SW
Washington, DC 20594

National Transportation Safety Board. 2015. ***Truck-Tractor Double Trailer Median Crossover Collision With Motorcoach and Postcrash Fire on Interstate 5, Orland, California, April 10, 2014.*** **Highway Accident Report NTSB/HAR-15/01. Washington, DC.**

Abstract: On April 10, 2014, about 5:40 p.m., a 2007 Volvo truck-tractor in combination with double trailers, operated by FedEx Freight, Inc., was traveling southbound on Interstate 5 (I-5) in Orland, California. At the same time, a 2014 Setra motorcoach, operated by Silverado Stages, Inc., was traveling northbound on I-5. In the vicinity of milepost 26, the combination vehicle moved into the left lane, entered the 58-foot-wide center median, and traveled into the northbound traffic lanes. The truck-tractor collided with a 2013 Nissan Altima passenger car, which then rotated counterclockwise and departed the highway. The truck-tractor continued moving south in the northbound lanes and collided with the front of the motorcoach, and both vehicles partially departed the highway. A postcrash fire ensued. Both the truck and the motorcoach drivers died, along with eight motorcoach passengers. Thirty-seven motorcoach passengers were injured. The two occupants of the passenger car received minor injuries. This investigation identified the following safety issues: inadequate fire performance standards for commercial passenger vehicle interiors, pretrip safety briefings for commercial passenger vehicles, improvements in commercial passenger vehicle design to facilitate evacuation, and event data recorder survivability for crash reconstruction and safety improvements. As a result of this investigation, the National Transportation Safety Board makes recommendations to the National Highway Traffic Safety Administration and the Federal Motor Carrier Safety Administration.

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Acronyms and Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
ADT	average daily traffic
AEX	Aerials Express
BASIC	behavior analysis safety improvement category [FMCSA]
Caltrans	California Department of Transportation
CAMI	Civil Aerospace Medical Institute
CDL	commercial driver’s license
CFR	*Code of Federal Regulations*
CHP	California Highway Patrol
CMV	commercial motor vehicle
CNES	Centre National d’Etudes Spatiales
CPC	common powertrain controller
CVSA	Commercial Vehicle Safety Alliance
DOT	US Department of Transportation
DMV	Department of Motor Vehicles
DVIR	driver vehicle inspection report
ECE	Economic Commission for Europe
ECM	electronic control module
EDR	event data recorder
EMS	emergency medical service
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FMCSRs	*Federal Motor Carrier Safety Regulations*
FMVSS	*Federal Motor Vehicle Safety Standard*
FR	*Federal Register*
GPS	global positioning system
GVWR	gross vehicle weight rating
HOS	hours of service

HSU	Humboldt State University
IC	incident commander
ICR	information collection request
IGN	Instituto Geografico Nacional
IGP	Instituto Geografico Portugues
I-5	Interstate 5
MAIT	Multidisciplinary Accident Investigation Team
MC	motor carrier [number]
MCMIS	Motor Carrier Management Information System [FMCSA]
MPM	milepost marker
NCHRP	National Cooperative Highway Research Program
NDR	National Driver Register
NFPA	National Fire Protection Association
NHTSA	National Highway Traffic Safety Administration
NIST	National Institute of Standards and Technology
NTSB	National Transportation Safety Board
OMB	Office of Management and Budget
OOS	out-of-service
PDPS	problem driver pointer system [NDR]
RDG	*Roadside Design Guide*
SAFER	Safety and Fitness Electronic Records [system]
TL	test level [1–6]
TRB	Transportation Research Board
USC	*United States Code*
USDOT	US Department of Transportation [number]
VPD	vehicles per day

Executive Summary

Investigation Synopsis

On April 10, 2014, about 5:40 p.m., a 2007 Volvo truck-tractor in combination with double trailers, operated by FedEx Freight, Inc., was traveling southbound in the right lane of Interstate 5 (I-5) in Orland, California. At the same time, a 2014 Setra motorcoach, operated by Silverado Stages, Inc., was traveling northbound on I-5 in the right lane. In the vicinity of milepost 26, the combination vehicle moved into the left lane, entered the 58-foot-wide center median, and traveled into the northbound traffic lanes of I-5.

The truck-tractor collided with a 2013 Nissan Altima four-door passenger car, which then rotated counterclockwise and departed the highway to the east. The truck-tractor continued moving south in the northbound lanes and collided with the front of the motorcoach, and both vehicles partially departed the highway to the east. A postcrash fire ensued. Both the truck and the motorcoach drivers died, along with eight motorcoach passengers. The remaining 37 motorcoach passengers received injuries of varying degree. The two occupants of the passenger car received minor injuries.

Probable Cause

The National Transportation Safety Board (NTSB) determines that the probable cause of the Orland, California, crash was the inability of the FedEx Freight truck driver to maintain control of the vehicle due to his unresponsiveness for reasons that could not be established from available information. Contributing to the severity of some motorcoach occupant injuries were high impact forces; the release of combustible fluids, leading to a fast-spreading postcrash fire; difficulties in motorcoach egress; and lack of restraint use.

The crash investigation focused on the following safety issues:

- ***Lack of adequate fire performance standards for commercial passenger vehicle interiors***: The NTSB considered several factors that might have contributed to the severity of the postcrash fire and affected the egress of motorcoach passengers. These factors included an inadequate Federal Motor Vehicle Safety Standard (FMVSS) 302, which specifies the burn resistance requirements for materials used in the occupant compartments of passenger vehicles, trucks, and buses. The standard is intended to reduce deaths and injuries caused by vehicle fires. However, FMVSS 302 flammability testing involves a small-scale fire source as a test method to represent fire originating in the passenger compartment from sources such as matches or cigarettes—which differs drastically from the common causes of bus fires, such as in-service ignition (engine fires, wheel well fires) or postcrash fuel-fed fires. Moreover, this standard is outdated and less discriminating than the flammability standards applied in other modes of transportation under US Department of Transportation safety oversight, such as aviation and rail.

- ***Pretrip safety briefings for commercial passenger vehicles***: In evaluating the circumstances of this crash, the NTSB examined the activities of the motorcoach driver who began the trip in Los Angeles and the driver who relieved him in Sacramento with regard to providing safety information. Our investigation revealed that neither driver played the prerecorded safety briefing that the company had provided. The passengers were not informed of the availability of seat belts on the newly manufactured motorcoach and were not wearing them at the time of the collision. Numerous passengers were injured. When the postcrash fire occurred, passengers reported being panicked and not knowing how to evacuate the bus because of the damaged and inoperable front loading door, the quickly spreading fire, the thick smoke, and the intense heat. The NTSB maintains that it is essential for motorcoach passengers to be informed of safety features and emergency evacuation procedures.

- ***Improvements in commercial passenger vehicle design to facilitate evacuation***: Motorcoaches and buses must be designed to accommodate the rapid egress of all persons in an emergency situation. The windows on the accident motorcoach were more than 7 feet off the ground and did not have a mechanism to keep them open to facilitate safe evacuation. In addition, the lack of federal standards requiring motorcoaches to be equipped with reliable emergency lighting fixtures with a self-contained independent power source puts passengers in jeopardy. Federal safety standards lack adequate requirements for emergency lighting and interior luminescent and exterior retroreflective emergency signage in the event of a crash, fire, or other emergency. Although federal standards permit a second door that can be used as an emergency exit, they do not require such.

- ***Event data recorder (EDR) survivability for crash reconstruction and safety improvements***: The truck-tractor was equipped with an electronic control module (ECM) capable of recording certain vehicle-related data in the event of sudden deceleration or hard braking. The motorcoach was equipped with a common powertrain controller (CPC) capable of recording vehicle-related data, including—but not limited to—vehicle speed, engine speed, throttle usage, cruise control usage, brake pedal application, and clutch pedal application. However, as a result of the collision and postcrash fire, both the truck-tractor ECM and the motorcoach CPC were destroyed. Neither unit was a dedicated crash EDR—which would likely have survived the forces and thermal conditions of the crash, and would have provided critical data on driver inputs and vehicle dynamics throughout the collision sequence. The NTSB maintains that incorporating longer pre-event recording times, learning as much as possible about a heavy vehicle driver’s precrash activities and vehicle control input, and gaining knowledge of the real-world crash dynamics of a collision would yield crucial information for the development of safer highway vehicles. However, the National Highway Traffic Safety Administration (NHTSA) has failed to develop standards or require the use of EDRs for heavy vehicles, which include motorcoaches, school buses, or truck-tractor units such as the one involved in the Orland collision.

Recommendations

As a result of this crash investigation, the NTSB makes safety recommendations to the Federal Motor Carrier Safety Administration (FMCSA) and to NHTSA. We also supersede one recommendation to the FMCSA and reiterate seven recommendations to NHTSA.

1 Factual Information

1.1 Crash Narrative

On April 10, 2014, about 5:40 p.m., a 2007 Volvo truck-tractor in combination with two 28-foot trailers, operated by FedEx Freight, Inc., and driven by a 32-year-old male, was traveling southbound in the right lane of Interstate 5 (I-5) in Orland, California (figure 1).[1] In the vicinity of milepost 26, the truck-tractor moved into the left lane, then departed the southbound traffic lanes and entered the 58-foot-wide center median. A motorist traveling southbound on I-5 behind the truck-tractor told National Transportation Safety Board (NTSB) investigators that he observed the truck move across the lanes from the right, with no signs of braking or obvious steering input. Another motorist traveling behind the truck-tractor stated that he saw the vehicle's left turn signal come on, then the truck moved to the left in a motion described as a "continued drift." The witness did not see any brake lights illuminate.

The truck-tractor traveled through the median; entered the northbound lanes of traffic, heading south; and struck a 2013 Nissan Altima four-door passenger car, occupied by the driver and a front seat passenger. The passenger car rotated counterclockwise and departed the highway on the east side.

At the same time, a 2014 Setra motorcoach, operated by Silverado Stages, Inc., and driven by a 56-year-old female, was traveling northbound on I-5 in the right lane, transporting 42 high school students and three adult chaperones. One motorcoach passenger seated a few rows behind the driver recalled seeing the FedEx Freight truck driver "slumped towards the door" with his head down. Following the impact with the passenger car, the truck-tractor collided with the front of the motorcoach. Both the truck-tractor and the motorcoach departed the highway to the east, as depicted in figure 2.[2] A postcrash fire ensued (figure 3). The fire consumed the truck-tractor, significant portions of its trailers, and the motorcoach interior (figure 4). As a result of the collision, the truck and motorcoach drivers and eight motorcoach passengers died. The remaining 37 motorcoach passengers received injuries of varying degree. The two occupants of the passenger car received minor injuries.

[1] The accident truck-tractor, in combination with two trailers, is interchangeably referred to as the "truck-tractor" or the "combination vehicle."

[2] The truck-tractor traveled about 415 feet from the southbound left pavement edge before impact with the motorcoach. The front of the motorcoach, the truck-tractor, and the first trailer came to rest on the east grassy embankment. The second trailer and half of the motorcoach remained on the shoulder and paved roadway.

Figure 1. Aerial view of crash location, photographed February 4, 2012. (Sources: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, US Department of Agriculture, US Geological Survey, AEX, Getmapping, Aerogrid, IGN, IGP, Swisstopo, and GISuser)

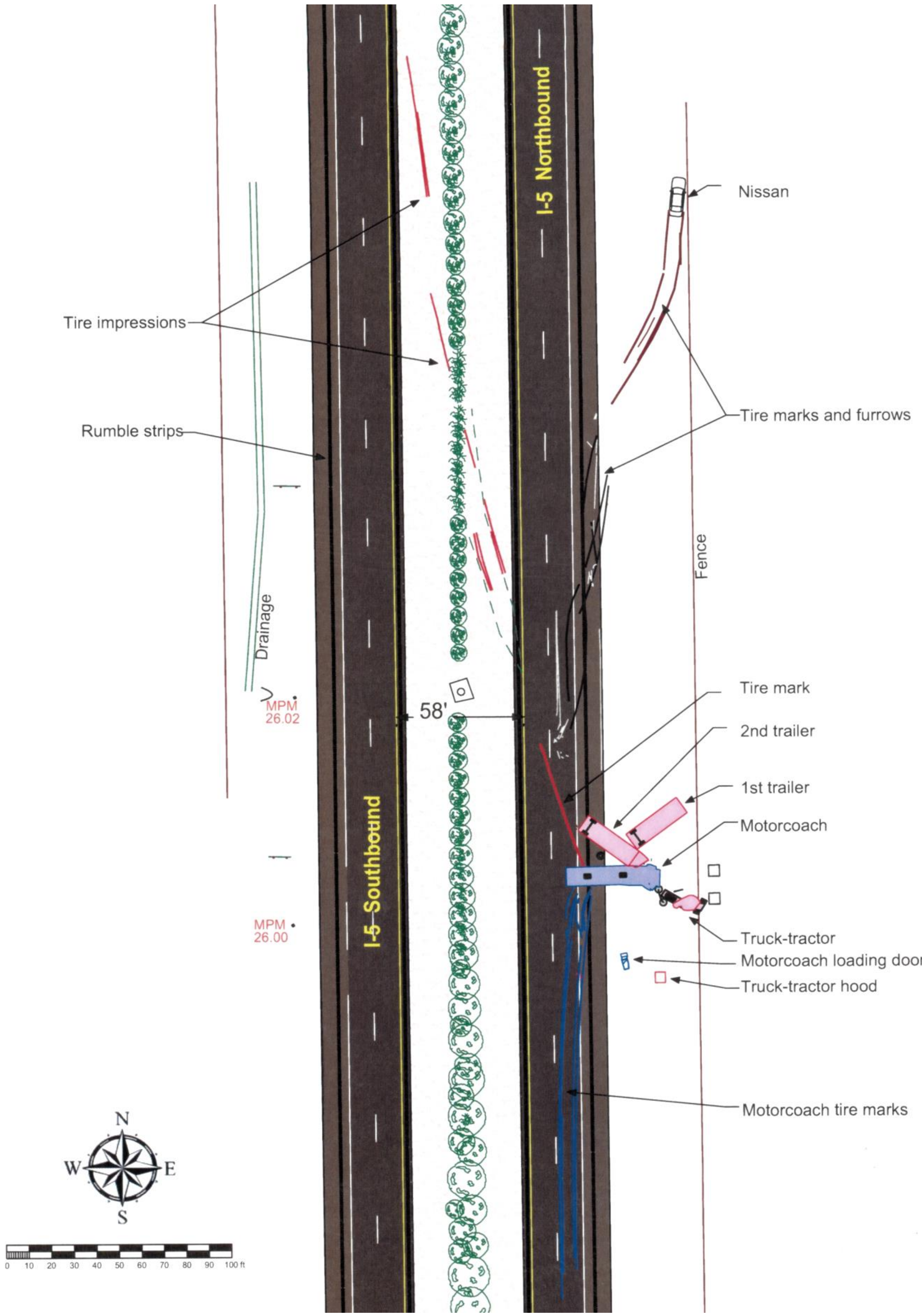

Figure 2. Crash scene diagram.

Figure 3. FedEx Freight truck-tractor double trailers and Silverado motorcoach postcrash. (Source: J. Lockett)

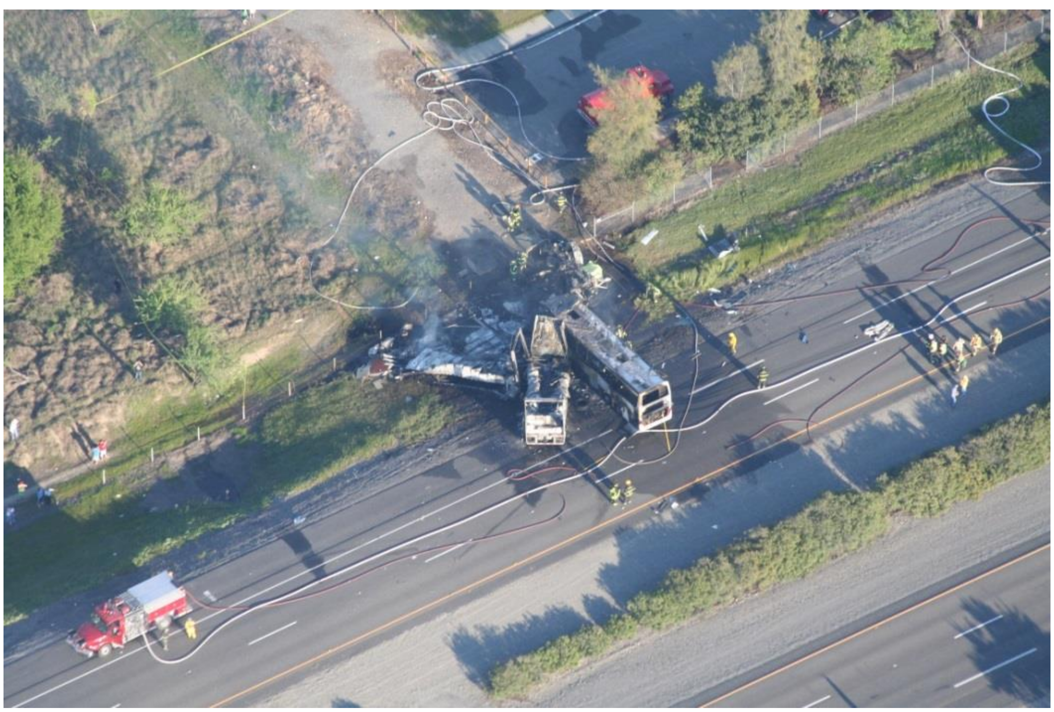

Figure 4. Aerial view of crash scene and center median after fire was extinguished. (Source: California Highway Patrol)

Figure 5 shows a route map for both vehicles. The truck-tractor had originally departed the West Sacramento FedEx Freight facility at 10:25 a.m. on April 10, 2014, and traveled to Weed. About 2:45 p.m., the driver dropped off the double trailers and picked up two other 28-foot trailers to bring back to Sacramento. He departed Weed at 3:29 p.m.

The Silverado motorcoach was part of a chartered trip originating at Union Station in Los Angeles, where it departed about 8:00 a.m. on April 10, en route to Humboldt State University (HSU) in Arcata. HSU had contracted with Silverado for the transportation of 150 high school students and adult chaperones. Two motorcoaches picked up students in Los Angeles, and the third picked up students in Fresno.[3] The accident motorcoach had made a scheduled stop in Sacramento about 3:37 p.m., where a replacement driver took over operation of the vehicle and continued northbound on I-5 at 4:13 p.m. (See appendix A for additional information.)

Figure 5. Route map of accident vehicles, April 10, 2014.

[3] The campus visit was to begin on Thursday, April 10, 2014, with a return home on Saturday, April 12, 2014. Participation in this program was determined by the students, their parents, and the university.

1.2 Injuries

As a result of the crash and subsequent fire, the truck driver, the motorcoach driver, and eight of the 45 motorcoach passengers died. The truck driver sustained a fractured left tibia, was severely burned, and died from asphyxiation due to the inhalation of products of combustion. He was found just outside of his vehicle.[4] The motorcoach driver, who was found near her seat, died from multiple blunt force trauma and was severely burned.

According to the Glenn County Sheriff's Office medical examiner, six motorcoach passengers died from asphyxiation due to the inhalation of products of combustion:

- Three passengers were found inside the motorcoach—two of whom did not exhibit antemortem (before death) traumatic injuries.

- Three passengers were found outside the motorcoach and had sustained multiple antemortem blunt force trauma.

The seventh fatally injured passenger, also found outside the motorcoach, died from multiple blunt force trauma. The eighth passenger was found walking away from the motorcoach postcrash and died later that day at the hospital. The Sacramento County Department of the Coroner reported that this passenger had sustained a fractured left arm and burns over 90 percent of his body. Among the fatally injured motorcoach passengers were all three adult chaperones and five high school students. Six of the fatally injured passengers had been seated in rows 1 and 2, one in row 4, and one in row 5.

The 10 seriously injured motorcoach passengers sustained both fire-related injuries (inhalation injuries, acute respiratory failure, and second- and third-degree burns) and collision/egress injuries (pulmonary contusions, facial fractures, clavicle and arm fractures, and a spleen laceration). Twenty-seven motorcoach passengers sustained minor injuries, such as lacerations, abrasions, and contusions. (See table 1 for injury information and figure 6 for seating locations and injury data.)

[4] Toxicology specimens for the fatally injured occupants were sent to Central Valley Toxicology, with some specimens sent to the Federal Aviation Administration (FAA) Civil Aerospace Medical Institute (CAMI) for further testing, as requested by the NTSB.

Table 1. Injury levels for truck driver, motorcoach occupants, and passenger car occupants.

Injury Severity[a]	Truck Driver	Motorcoach Driver	Motorcoach Passengers	Nissan Occupants	Total
Fatal	1	1	8	0	10
Serious	0	0	10	0	10
Minor	0	0	27	2	29
Total	1	1	45	2	49

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

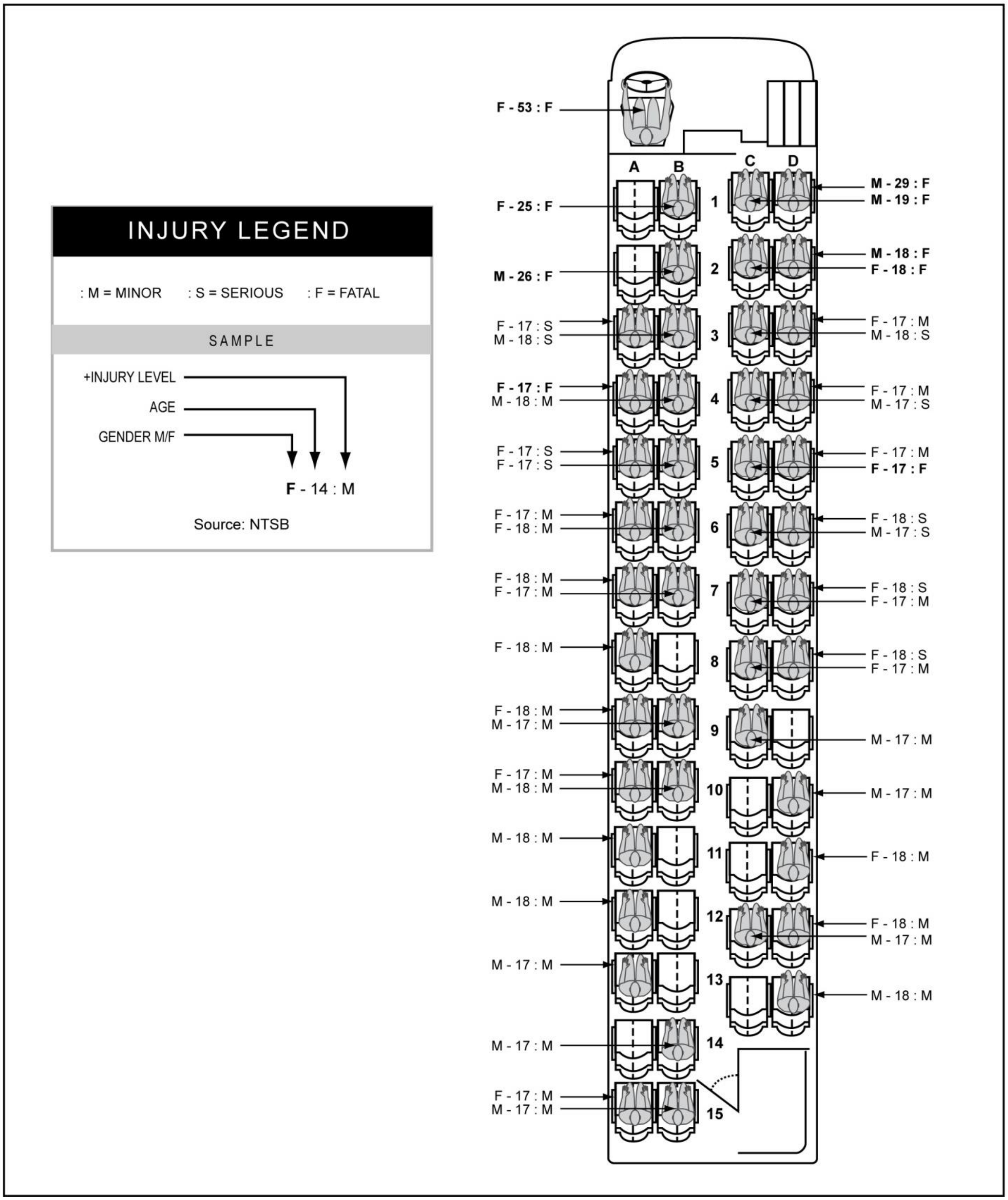

Figure 6. Motorcoach occupant seating chart, injury, and demographic information.

1.3 Emergency Response

The California Highway Patrol (CHP) and Glenn County 911 dispatchers were notified of the crash and fire at 5:41 p.m. and 5:42 p.m., respectively. A captain with the US Forest Service Police, who was driving northbound on I-5 when he saw a plume of smoke, arrived on scene at 5:42 p.m. He immediately notified his dispatcher. An Orland Police Department captain, a sergeant, and two officers who had observed the plume of smoke responded prior to being dispatched. The Orland Volunteer Fire Department chief was the first fire responder on scene. He initiated the fire response as the fire incident commander (IC) at 5:47 p.m. and reported that half of the motorcoach was already engulfed in fire. By 5:48 p.m., a Westside ambulance arrived on scene; and by 5:50 p.m., the first CHP officer arrived.[5] About 5:55 p.m., a CHP lieutenant took over as the crash scene IC. The first medical helicopter was on scene at 6:05 p.m., and the vehicle fires were contained by 6:17 p.m.

All lanes of I-5 were closed to traffic, and the west side of the southbound lanes was designated for patient triage and transport. Thirty-three of the injured, including one passenger who later died and the occupants of the passenger car, were transported to seven area hospitals. Seven motorcoach passengers were treated for minor injuries at a temporary Red Cross shelter. In total, 26 local emergency service agencies responded to the scene of the crash, and seven medical helicopters and 16 ambulances transported injured passengers. (See appendix B for a list of agencies involved in the emergency response.)

1.4 Vehicles

1.4.1 Truck-Tractor and Double Trailers

1.4.1.1 General. The accident truck was a 2007 Volvo truck-tractor with two Wabash National Corporation (2013 and 2006 model years) 28-foot trailers connected by a 2010 Hyundai converter dolly. The vehicle was powered by a Cummins ISX CM870, 400-hp diesel engine, which was equipped with a Cummins electronic control module (ECM). The ECM was severely damaged by the fire, and no data could be recovered.[6] An Eaton Fuller FR-15210B, 10-speed manual transmission transferred engine power; and, according to FedEx Freight, the truck-tractor

[5] The fire IC put in a mutual aid request with the Corning City dispatch for as many medical units as possible to triage and transport the survivors; a Westside ambulance paramedic contacted the Enloe Hospital dispatch to also request medical mutual aid. The California Office of Emergency Services Region III Mass Casualty Incident Plan and the California Mutual Aid Region III Mass Casualty Patient Distribution Plan were activated.

[6] An ECM captures some vehicle information, but it is not intended to capture the full set of data available from an event data recorder (EDR).

was governed to 65 mph.[7] NTSB investigators were unable to determine the gear position at the time of the crash.[8]

1.4.1.2 Truck Vehicle Systems. The collision impact and postcrash fire destroyed much of the truck. The only major remaining components were the frame, drive train, and trailer axles. The internal surface of the truck-tractor's hood was recovered in an area away from the postcrash fire. It revealed no evidence or indication of a precrash fire, such as soot or smoke damage.[9]

Both the left and right fuel tank mounting systems were damaged in the collision, and some components were missing postcrash. The left fuel tank was melted. The right fuel tank was displaced from the vehicle, and the right side frame rail was displaced inward at the location of the fuel tank. The right steel braided fuel line was intact but ruptured, and the left steel braided fuel line remained connected to the fuel filter. Based on fuel records and average consumption estimated by FedEx Freight, the fuel on board the truck-tractor at the time of the crash was approximately 160 gallons.

The first trailer was hauling a stump grinding machine, which was ejected at impact. The second trailer was empty. The fire destroyed both trailers. Collision damage and the postcrash fire prevented investigators from obtaining individual axle weights for the combination vehicle. CHP used certified portable scales to weigh an exemplar vehicle with approximately the same loading as the truck-tractor and estimated the total vehicle weight to be 41,000 pounds.

Due to fire damage, all tires were deflated except for the four on the fifth axle (second trailer's rear axle). NTSB investigators visually examined the tires and rims; of those tires that survived the fire, most appeared to have adequate tread depth, and no noncollision-related defects were found on any of the rims.[10]

NTSB investigators examined the truck-tractor's steering system components and found no precrash defects. At NTSB request, on July 30, 2014, an engineer from TRW Automotive, the manufacturer of the truck's steering gear and a party to the investigation, also examined the steering components.[11] According to the TRW report, a postcrash internal inspection revealed that the recirculating ball bearings left two sets of indentations very close to each other on the

[7] The governed speed reflects the highest speed possible on level grades. The effect of gravity allows faster speeds on downhill grades.

[8] The gear shift control valve was displaced from the vehicle. Although the shift lever remained connected to the shift tower following the collision, it had been disconnected during the process of removing the engine and transmission from the vehicle. None of the sliding clutches aligned with any of the forward main shaft gears, and no witness marks were present on the gears or casing.

[9] NTSB investigators examined the area of the median through which the truck-tractor traversed, as well as a length of median and shoulder approximately 100 yards north of the crash scene on the southbound side of I-5, for evidence of combustible fluids or thermally damaged materials. None were identified.

[10] The tread depths were measured in the major tread grooves of each tire, whenever possible because of fire damage (*Federal Motor Carrier Safety Regulations* [FMCSRs], 49 *United States Code* [USC] 393.75 [Tires]). All of the rims were inspected for cracks, welds, and elongated lug nut holes; several areas of collision damage were noted on many of the rims and tires.

[11] See the NTSB public docket for this investigation (HWY14MH009).

helical worm gear.[12] Impacts concentrated near the center of the worm gear indicate that the output shaft was near center, and the vehicle's steering would have been nearly straight (the wheels were pointing straight ahead on the tractor when the steering gear sustained impact damage). No precrash defects were noted.

Postcrash visual inspection indicated that the brake lining thickness of all 10 brakes on the five axles of the truck exceeded the minimum ¼-inch standard.[13] No evidence of uneven or excessive wear to any of the brake components was present, which would have indicated the brakes being stuck in the applied position. Collision and fire damage prevented operational inspection of the other brakes, except for the second trailer's two axle brakes, which were equipped with type 30/30 long-stroke brake chambers. The inspection showed that both brakes on the fifth axle had pushrod strokes of 1¼ and 1⅜ inches, which are within the adjustment limit of 2½ inches.[14]

1.4.1.3 Inspection, Maintenance, and Safety Recalls. The truck-tractor underwent two full roadside Level 1 inspections, on May 10, 2011, and October 10, 2013; no defects were documented.[15] Driver vehicle inspection reports (DVIR) noted several findings between January 2 and April 10, 2014, including: (1) low tire tread, (2) marker light out, (3) air conditioning not working well, (4) air hose hanger spring needing replacement, (5) small windshield chip, and (6) clutch not engaging.[16] The maintenance records for the truck-tractor, both trailers, and the converter dolly revealed that regularly scheduled maintenance and DVIR-related repairs had been made between April 24, 2009, and April 9, 2014—the day before the crash.[17]

A search of the safety recall database maintained by the National Highway Traffic Safety Administration (NHTSA) indicated three voluntary safety recall campaigns that would have affected the truck-tractor. These safety recalls were satisfied on March 26, 2009; February 2, 2010; and March 28, 2011.[18]

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[12] The helical worm gear is a shaft having helical cuts (threads) on the surface, perpendicular to the axis of rotation or with an angle between a tangent to the helix and gear axis. It is designed to transmit motion and power.

[13] See 49 CFR 393.47(d)(1)(2).

[14] See 49 CFR 396.17(c), appendix G; and Commercial Vehicle Safety Alliance (CVSA) 2014 out-of-service (OOS) criteria.

[15] The CVSA designates seven levels of roadside inspections. A Level 1 inspection is the most comprehensive; it examines the driver, the driver's paperwork, and the vehicle (including under vehicle inspection).

[16] Additionally, some DVIRs reported no defects or reported appearance bodywork defects (such as scratches, dents, or scuffs).

[17] The FedEx Freight Sacramento terminal employs 20 qualified mechanics who conduct all maintenance except warranty work.

[18] See www.odi.nhtsa.dot.gov/recalls/reacallsearch.cfm, accessed March 17, 2015. Volvo Group North America warranty records indicated that five claims were filed for maintenance covered under the original and extended warranties. Repairs were completed between August 2000 and January 2012, none of which required replacement of any major engine, driveline, braking, steering, or suspension system components.

1.4.2 Motorcoach

1.4.2.1 General. The 2014 Setra S417 TC, 56-passenger, 45-foot-long motorcoach was equipped with a Mercedes Benz OM471, 450-hp diesel engine, and an Allison WTB500R automatic transmission.[19] The vehicle was equipped with two data storage modules. The primary module, the common powertrain controller (CPC), was destroyed by the fire. The vehicle's engine was equipped with a Detroit Diesel DDEC VI ECM, which stored limited data compared to the CPC. The ECM was in good condition following the crash, and NTSB investigators imaged the data from that module.[20] The motorcoach was also equipped with Knorr-Bremse (Bendix) air-operated antilock disc brakes; and, according to Silverado, the engine was governed to 70 mph.

The truck-tractor initially struck the front of the motorcoach, at a relative angle of approximately 156 degrees; maximum deformation was 2 feet 10 inches to the right front corner.[21] (See figure 12, which appears in section 2.2 of this report.) The front end of the motorcoach sustained the most deformation from the impact and thermal exposure due to the postcrash fire. Interior impact damage was concentrated in the driver compartment area, front loading door, and stairwell, as well as the frame structure, the windshield, and the first two rows (driver and passenger side) of passenger seats. The forward portion of the luggage shelf was crushed; portions of the shelf were intact from row 11 to the rear on the driver side and from row 12 to the rear on the passenger side.

The collision and postcrash fire destroyed windows at rows 1–10 on the driver side and rows 1–4 on the passenger side, and partially destroyed window glazing and window frames behind these rows. Several exit window latch mechanisms and frames near the bus rear—in addition to the wheelchair lift door frame—were intact, though distorted by the heat. The motorcoach was equipped with several onboard video monitors that were damaged as a result of the collision and fire.

The driver and passenger side modesty panel frames were damaged. The driver side first seat row was partially displaced from the seat tracks and deformed backward. The first row of seats on the passenger side was completely displaced and found just aft of the loading stair. Deformations of the remaining passenger seat frames and anchorages were noted on some seats; however, the fire consumed all of the combustible materials in this forward portion of the

[19] The odometer reading at the time of the crash was estimated at 8,774 miles, based on the last known mileage recorded at the driver exchange in Sacramento, which is located approximately 97 miles south of the crash site.

[20] The DDEC VI stores vehicle parameters and has the capability to record trip activity, including daily, monthly, and lifetime engine data. The CPC stores event data, including hard brake and last stop events, while the ECM stores engine parameters and diagnostic trouble codes. Because the fire destroyed the CPC, no event data were recovered. The ECM reported a total engine run time of 342 hours. It also recorded two active fault codes: "Engine Oil Pressure Very Low (100/1)" and "No Data Received from Engine CAN Link (625/9)." Both fault codes were recorded at 342 engine hours, as the first and last occurrence. The NTSB public docket for this investigation (HWY14MH009) includes the full ECM report.

[21] The driver seat was displaced outward toward the left side of the motorcoach, and the roof was deformed inward. The steel pillars that formed the structure of the passenger entrance were displaced outward and backward toward the right side of the motorcoach.

motorcoach, which precluded inspection and documentation of most seat belt and seating system components.

1.4.2.2 Motorcoach Vehicle Systems. The severe collision and fire affected all major mechanical systems, including steering, suspension, electric, and driver controls. The collision impact and the postcrash fire destroyed much of the bus and prevented investigators from obtaining individual axle weights. CHP weighed an exemplar vehicle (unloaded), and the three axle weights totaled 37,450 pounds.

Because of the extent of fire damage, all tires were deflated. However, NTSB investigators visually examined the rims and tires—and, of those tires that survived the fire, all appeared to have adequate tread depth.[22] Investigators examined the brake system components and found that all of the brake pads exceeded the 1/8-inch-minimum-thickness requirement for disc type brakes.[23] Brake rotors were free of any major cracks, and antilock brake system wheel speed sensors were in place at all of the wheel ends.

1.4.2.3 Inspection, Maintenance, and Safety Recalls. Silverado had performed vehicle inspections on January 30, 2014, and March 12, 2014—neither of which revealed any defects on the motorcoach.[24] CHP had conducted a new vehicle inspection and a school pupil activity bus program inspection on February 3, 2014.[25] No violations or mechanical defects were noted on either inspection report. The DVIRs reviewed by NTSB investigators postcrash noted no major mechanical system defects.[26]

1.4.3 Passenger Sedan Wreckage

The 2013 Nissan Altima sustained collision damage along nearly all of the driver side, beginning about 12 inches forward of the left front axle and continuing to the rear of the vehicle.[27] The passenger car was equipped with an air bag control module, which CHP imaged. The driver and the front right passenger seat positions were equipped with supplemental

[22] The tread depths were measured in the major tread grooves of each tire (FMCSRs, 49 USC 393.75 [Tires]). All of the rims were inspected for cracks, welds, and elongated lug nut holes; several areas of collision damage were noted on many of the rims and tires.

[23] Title 49 CFR 393.47(d)(1) specifies the minimum required thickness for disc-type brakes (37 millimeters [1.457 inches]), which each of the rotors exceeded.

[24] Silverado subjects its buses to preventative maintenance inspection every 3,000 miles or 45 days, whichever occurs first.

[25] *California Education Code*, section 39830.1, defines a "school pupil activity bus" as any motor vehicle, other than a school bus, operated by a common carrier, or by and under the exclusive jurisdiction of a publicly owned or operated transit system, or by a passenger charter-party carrier, used under a contractual agreement between a school and a carrier to transport school pupils at or below the 12th grade level to or from a public or private school activity, or used to transport pupils to or from residential schools, when the pupils are received and discharged at off-highway locations where a parent or adult designated by the parent is present to accept the pupil or place the pupil on the bus. See www.leginfo.ca.gov/cgi-bin/displaycode?section=edc&group=39001-40000&file=39830-39842, accessed March 17, 2015.

[26] Per 49 CFR 396.11 and 396.13, drivers are required to inspect their vehicles both before and after each trip, and to complete a DVIR.

[27] See the NTSB public docket for details on the damage to this vehicle (HWY14MH009).

restraints (air bags), three-point active (pretensioner) seat belts, side torso air bags, and roof rail curtain/tube air bags. The interior inspection revealed that the driver's frontal, side torso, and side roof rail curtain/tube air bags deployed. The system status at the crash event showed the safety belt status for the driver and right front passenger as "On (Fastened)."

1.5 Survival Factors

1.5.1 Pretrip Briefing

Silverado reported that its drivers are directed to either show a video provided by its insurance carrier prior to departing a client's pickup location or provide a verbal briefing on the safety features of the specific coach. The 6-minute video covers boarding procedures; overhead parcel rack storage; embarking and disembarking stairwell safety; emergency exit locations, including the loading door, roof hatches, and emergency exit windows; location of the fire extinguisher and first aid kit; the importance of remaining seated while the vehicle is in motion; and how to hold on for safe movement. The video provided no information on the availability or use of seat belts.

NTSB investigators interviewed the driver who picked up the students in Los Angeles, and he stated that he did not show the video and could not recall if he had provided a verbal safety briefing.[28] None of the student passengers interviewed recalled a pretrip briefing or video being shown, either by the driver who picked them up in Los Angeles or the relief (accident) driver who took over in Sacramento. A passenger seated in the third row stated that a chaperone mentioned how to use the exit windows. Most passengers interviewed reported knowing that the motorcoach was equipped with three-point seat belts; however, only one passenger stated that he was wearing a seat belt at the time of the crash.

According to Silverado, since the crash in April 2014, it has made several changes to the procedures its drivers must follow prior to departing on a trip. These changes include requiring drivers to initial the driver's order form and trip report, acknowledging that they have provided the pretrip safety briefing. The form also includes a space for the client to acknowledge that this task has been performed. The public address system and the audiovisual system are considered safety equipment and part of the driver vehicle inspection items (the DVIR). All drivers are now required to demonstrate their pretrip safety announcement as part of their annual ride-along.[29]

1.5.2 Seat Belts, Emergency Exits, and Signage

The driver seat was air cushioned and equipped with a three-point restraint. The motorcoach had 15 rows of two-person seats on the left (driver) side and 13 rows of two-person seats on the passenger side, forward of the lavatory. All 56 seats were equipped with

[28] This driver stated that in the past he has given a verbal safety briefing, which covered topics such as the exit windows, fire extinguisher, first aid kit locations, and importance of remaining seated when the vehicle is in motion.

[29] If a supervisor determines that the briefing is deficient, the driver is retrained. Silverado management looks for trends in the annual check to identify potential classroom training needs.

three-point restraints. The windows adjacent to each row had a 2-inch circular sticker with a diagram (no text) denoting the available lap and shoulder restraints.

The motorcoach had eight windows on each side, four of which were emergency exit windows. The emergency exit windows on the driver side were the second, third, fifth, and seventh—and on the passenger side, the second, fifth, sixth, and seventh (figure 7). Each window was marked and had an instruction sticker.

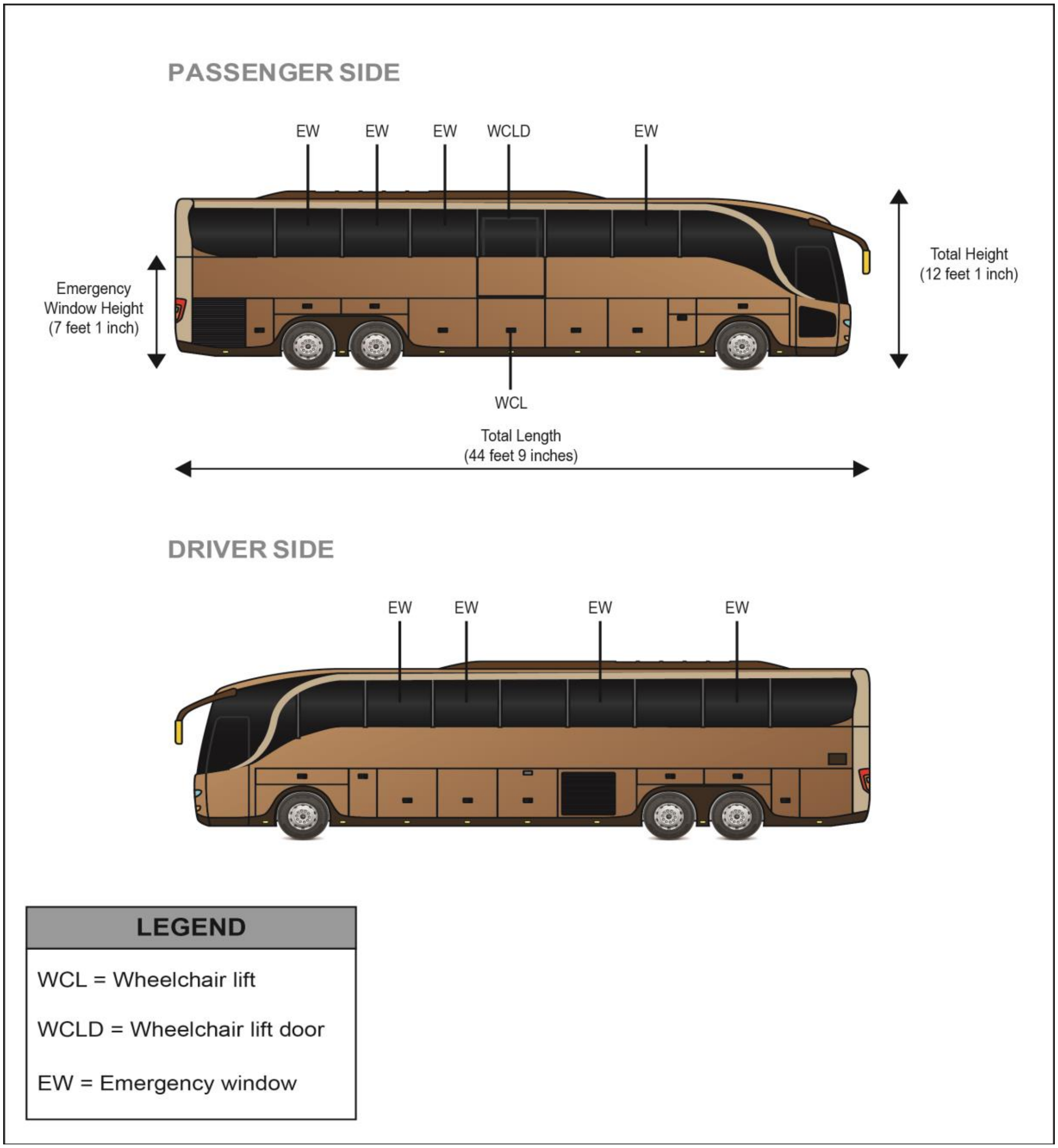

Figure 7. Motorcoach diagram and measurements. (Source: www.setra-coaches.com)

The distance from the base of the emergency exit windows to the ground was 7 feet 1 inch. Roof hatches were located between rows 3–4 and rows 10–11. The distance from the interior passenger compartment floor to the roof hatch was 6 feet 5 inches, and the distance from the motorcoach roof to the ground was 12 feet 1 inch. A door on the passenger side, between rows 6–7, was marked as a wheelchair lift access door.[30] NHTSA defines an emergency exit as any designated area of egress that meets the criteria of FMVSS 217, such as a push-out window, a door, or a roof exit (Pollard and Markos 2009; NHTSA 2002). However, as currently designed, wheelchair-access doors are intended solely for loading and unloading wheelchairs and cannot be opened from the inside of the motorcoach.

1.5.3 Motorcoach Egress

NTSB investigators interviewed 29 of the 37 surviving motorcoach passengers regarding their egress from the motorcoach.[31] All stated that they exited the motorcoach using the emergency exit windows; about half responded that they did not know the exit windows existed prior to the crash. Five of the 29 passengers said that they either opened or kicked out the windows. The remaining passengers reported that the thick smoke made it difficult to see anything, including the emergency exit windows, so they followed other passengers to escape. Passengers expressed concerns about exiting the windows due to their height above ground and the difficulty holding the windows open while trying to evacuate. The evacuation process itself caused some passenger injuries.

Two motorists traveling on I-5 northbound provided NTSB investigators with video recordings of the motorcoach during the postcrash fire. Video images show the motorcoach engulfed in flames and heavy black smoke, as passengers are seen evacuating and moving away from the fire (figure 8).

[30] Title 49 CFR 38.153(c) and (d) specify the size of the wheelchair access door. The minimum door opening is 27 inches wide and 65 inches high. According to the Setra operator's manual, a brake interlock is activated whenever the wheelchair lift is enabled. The interlock cannot be deactivated until specific requirements are satisfied, which include stowing the wheelchair lift in the luggage compartment, closing the top and bottom lift doors, turning off the "wheelchair lift" switch on the driver's panel, and depressing the accelerator. The motorcoach had not yet been equipped with the wheelchair lift mechanism.

[31] A male chaperone reported to emergency responders immediately postcrash that he had jumped out of the front of the motorcoach to escape. He died later that day at the hospital.

Figure 8. Motorcoach postcrash, with occupants (marked with red circle) evacuating toward center median. (Source: witness cellphone video)

1.6 Driver Factors

1.6.1 Truck Driver Licensing and Training

The FedEx Freight truck driver possessed a California class A commercial driver's license (CDL), issued August 2011, with an expiration date of January 2016. His license was not subject to any restrictions and had endorsements "T" for double and triple trailers and "H" for hazardous materials. The California Department of Motor Vehicles (DMV) indicated that the driver had no accidents or violations in his driving history. A search of the National Driver Register (NDR) problem driver pointer system (PDPS) found no matches for this driver.[32]

FedEx Freight hired the driver in March 2010.[33] His initial training included both classroom and on-the-road instruction. FedEx Freight records indicate recurrent training topics (some not specifically related to driving) in the driver's file from June 2010 to March 2014.

[32] The PDPS is a repository of information on problem drivers provided by all 51 US jurisdictions. Based on information from an NDR search, the PDPS will "point" the inquiring jurisdiction to the state of record, where driver status and history information is stored. See www.aamva.org/PDPS, accessed February 17, 2015.

[33] (a) The driver was hired by FedEx Freight as a loader; he entered the driver apprentice program in June 2011 and completed his final road test in August 2011. (b) To be hired as a driver, the applicant must be at least 21 years old and have 1 year of experience with a class A CDL, with an "H" or an "X" (hazardous materials), "N" (tank), and "T" (double and triple semitrailer) endorsements within the previous 6 months. Other requirements include no driving under the influence convictions or drug offenses, and no serious traffic collisions (two or more) within the previous 36 months of application.

1.6.2 Truck Driver Medical History and Toxicology

The 32-year-old truck driver reported no injury or illness within the last 5 years and no medication use on his most recent medical examination for CDL fitness determination, dated May 2013. No issues with the driver's health or vision were noted by the examining physician, and he was qualified for 2 years. His medical certification would have expired in May 2015.

The driver's wife described his health as very good.[34] He did not have a personal physician, never went to the doctor, exercised at the gym three to four times a week, and did not mention any health issues on the morning of the crash. When asked if her husband snored, she stated that he "breathes funny." She could not tell investigators if he woke during the night. She said that her husband occasionally drank beer, but the most recent such time was weeks prior to the crash.

Postcrash, the Glenn County Sheriff's Office conducted toxicology testing as part of the forensic autopsy of the driver. No common drugs were detected; and no alcohol was detected in the driver's blood. The forensic autopsy noted no abnormalities in the driver's brain, lungs, or heart. At NTSB request, the Civil Aerospace Medical Institute (CAMI) conducted a forensic toxicology analysis, and no drugs or alcohol were detected.[35]

1.6.3 Truck Driver Work–Rest History

The truck driver was working as an "extra board" driver, which means that he would fill in on routes where other drivers were not assigned.[36] On April 10, 2014, the day of the crash, the driver was assigned to (1) pick up a load at the West Sacramento FedEx terminal; (2) drive to Weed, a one-way trip of about 226 miles (estimated to take 4 hours); (3) switch trailers with another FedEx driver (referred to as a "meet and turn"); and (4) return to the West Sacramento FedEx terminal. A review of 3 months of the driver's logbooks indicated that he had previously driven to Weed twice, on February 28 and March 24—and that he had driven the accident truck-tractor twice in that period, on March 21 and 22.[37]

Considering the driver's logbook entries, cell phone records, and a family interview, NTSB investigators determined that he had a maximum of 14.5 hours (roughly 4:30 p.m.–7:00 a.m.) available in which to sleep on April 8 and up to 10 hours (9:00 p.m.–7:00 a.m.) on the night before the crash, as shown in figure 9.

[34] The driver's wife told NTSB and CHP investigators that her husband did not take any prescription or over-the-counter medications, his vision was good, and he did not wear contacts or glasses. A canvass of pharmacies in the area of the driver's home revealed no record of current prescriptions.

[35] CAMI tests for amphetamines, opiates, marihuana, cocaine, phencyclidine, benzodiazepines, barbiturates, antidepressants, and antihistamines.

[36] A review of the driver's logbook entries from January to April 2014 showed no hours-of-service (HOS) violations.

[37] When interviewed, the driver's wife said that he did not have a set bedtime, because he worked different hours. He would nap when he had downtime. She also stated that he was assigned a different truck-tractor each day.

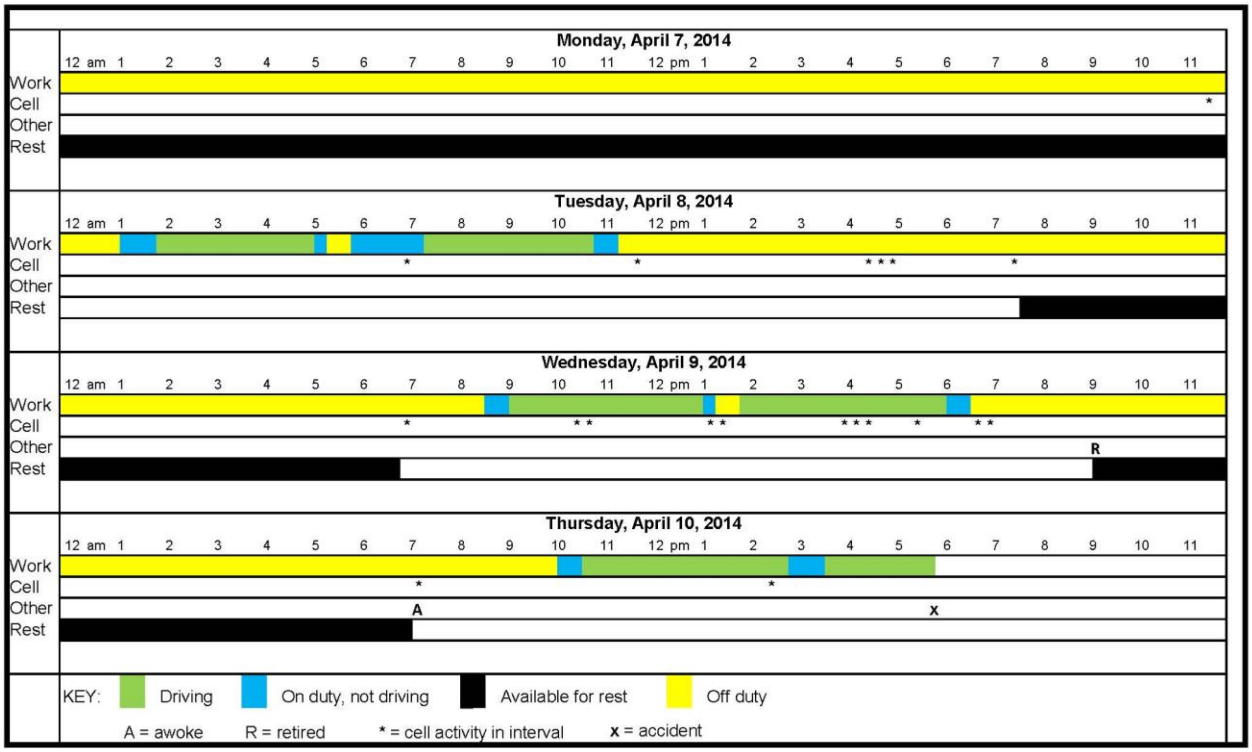

Figure 9. Work–rest schedule for FedEx Freight truck driver, April 7–10, 2014.

According to FedEx Freight, it tracks its truck fleet through an Intermec system, which relies on a hand-held scanner global positioning system (GPS) device for two-way communication.[38] NTSB investigators reviewed the truck-tractor's Intermec system for truck location data.

The Intermec system received the first truck-tractor data for April 10 at 10:25 a.m., at the FedEx Freight service center in West Sacramento (see table 2 for more information on the driver's work/rest history).[39] When the accident driver arrived in Weed and conducted the "meet and turn," exchanging trailers with another FedEx driver about 2:45 p.m., that driver (when interviewed by NTSB investigators) recalled that he appeared to be "clammy and pale." He then observed the accident driver entering a nearby McDonald's restaurant. The restaurant surveillance camera video recording showed him entering about 2:55 p.m. and departing about 3:00 p.m. with a beverage cup. The Intermec system logged the truck-tractor as moving at

[38] The telematics system is manufactured by Intermec, a subsidiary of Honeywell International, Inc. The system is integrated with other vehicle systems, such as GPS and the vehicle engine ECM, to capture data in support of various business functions, such as equipment location and estimated and actual arrival times. Collection and transmission of the data are automatic as the vehicle reaches predetermined (geo-fenced) locations or at approximately 10-minute intervals. Intermec data provided to NTSB investigators included time and general location, along with geographic coordinate positions and average vehicle speed.

[39] Information in this section was obtained from interviews with the driver's wife, coworkers, and witnesses; his logbooks; his driver qualification file; GPS data (Intermec) from the truck-tractor; records from his cell phone service provider; and surveillance video from a restaurant.

3:29 p.m. The accident truck had traveled about 118 miles when the crash occurred at 5:40 p.m. The driver's cell phone provider records indicate that he was not using his phone at or near the time of the crash.[40]

Table 2. FedEx Freight truck driver's precrash activities, April 7–10, 2014.

Time	Event	Source
Monday, April 7		
12:00 a.m.	Logs off duty (off duty all day)	Logbook
11:24 p.m.	Receives incoming cell call[a]	Phone records
Tuesday, April 8		
1:00 a.m.	Logs on duty, not driving	Logbook
1:45	Logs driving	Logbook
1:54	*Dispatch logged*	Intermec
5:00	Logs on duty, not driving	Logbook
5:07	*Arrival logged at Salinas FedEx center*	Intermec
5:15	Logs off duty	Logbook
5:45	Logs on duty, not driving	Logbook
6:50	Makes outgoing call (first of day)	Phone records
7:15	Logs driving	Logbook
7:23	*Dispatch logged*	Intermec
10:45	Logs on duty, not driving	Logbook
10:49	*Arrival logged at Sacramento FedEx center*	Intermec
11:15	Logs off duty	Logbook
11:39	Receives incoming call	Phone records
4:24 p.m.	Sends outgoing text message	Phone records
Wednesday, April 9		
6:51 a.m.	Receives incoming call (first of day)	Phone records
8:30	Logs on duty, not driving	Logbook
9:00	Logs driving	Logbook
9:12	*Dispatch logged*	Intermec
1:00 p.m.	Logs on duty, not driving	Logbook
1:00	*Arrival logged at Kettleman City FedEx center*	Intermec
1:15	Logs off duty	Logbook
1:45	Logs driving	Logbook
2:04	*Dispatch logged*	Intermec
6:00	Logs on duty, not driving	Logbook
6:04	*Arrival logged at Sacramento FedEx center*	Intermec
6:30	Logs off duty	Logbook
6:57	Receives incoming call	Phone records
7:30	Arrives home	Family interview
9:00	Retires to bed	Family interview

[40] These records show no voice call, short message service text, or data activity at or near the time of the crash. The last call made or received on the day of the crash was at 2:24 p.m.

Thursday, April 10		
7:09 a.m.	Receives incoming call from FedEx Freight	Phone records
unknown	Goes to gym and returns home	Family interview
10:25	*First data of day logged*	Intermec
10:47	*Dispatch logged*	Intermec
2:24 p.m.	Receives incoming call from his wife[b]	Phone records
2:24	Speaks with his wife	Family interview
2:45	Arrives at Weed for "meet and turn"	Family interview
2:48	*Arrival logged at Weed*	Intermec
2:55	Enters McDonald's restaurant	Video data
3:00	Leaves McDonald's restaurant	Video data
3:29	*Dispatch logged*	Intermec
5:34	*"Breadcrumb" (last Intermec data point)*	Intermec
5:41 p.m.	**Crash occurs**	

[a] Cell phone calls listed include only the first or last calls or text messages of each day.
[b] According to the driver's wife, he used a wired hands-free unit.

1.6.4 Motorcoach Driver Licensing, Medical History, and Toxicology

The motorcoach driver possessed a California class "B" CDL, with a "P" passenger endorsement and a "64" restriction, limiting her to drive only a commercial motor vehicle (CMV) with automatic transmission.[41] Her CDL was issued in December 2010 and was to expire in December 2015. The California DMV indicated that the driver had no accidents or violations in the previous 10 years. A search of the NDR PDPS for this driver found one pointer record from California. The Federal Motor Carrier Safety Administration (FMCSA) pre-employment screening program report indicated that the driver had been subject to one roadside inspection in June 2012, with no violations noted.[42]

The motorcoach driver was a 53-year-old female. Her most recent medical examination for CDL fitness determination was completed in June 2013, in which she indicated that she had hypertension and listed her medication for it; her blood pressure was recorded as 120/73. No other issues with the driver's health were noted by the examining physician, and she was qualified for 2 years. Her medical certification would have expired in June 2015.[43] Postcrash, the Glenn County Sheriff's Office conducted toxicology testing as part of the forensic autopsy of the driver. No common drugs were detected; and no ethyl alcohol was detected in the driver's

[41] The 2014 Setra motorcoach was equipped with an automatic transmission.

[42] The driver's previous employment included working for the San Mateo, California, county transit agency as a bus driver from June 1988–April 2008, and then as a charter coach driver for two other bus companies from June 2009–March 2014.

[43] The driver's family described her health as good. She did not take any over-the-counter drugs or illicit drugs, consume alcohol, or smoke cigarettes. Her family described her as an early riser who did not use an alarm clock. She also did not snore, take naps, or get up during the night. The driver wore prescription glasses and sunglasses while driving.

blood.[44] At NTSB request, CAMI conducted a forensic toxicology analysis, and no drugs or alcohol were detected.

1.6.5 Motorcoach Driver Work–Rest History

The motor carrier, Silverado, hired the driver in March 2014.[45] Once applicants have passed Silverado's pre-employment phase, they are subject to a road test supervised by a qualified senior driver or management personnel, evaluated for their driving proficiency, and provided company orientation training. The March 26–April 9, 2014, logbook entries—reviewed by NTSB investigators—indicated that the driver had worked April 2–6, was off duty April 7, worked April 8, and was off duty April 9.

On April 10, 2014, the day of the crash, the motorcoach driver reported to the Sacramento terminal at 2:15 p.m. and was then transported by a terminal employee in a crew car to the driver exchange location, where she met the Los Angeles driver about 3:37 p.m. She began driving north on I-5 about 4:13 p.m.

The trip was estimated to take 5 hours 49 minutes (a distance of 322 miles from Sacramento to HSU in Arcata). At the time of the crash, the motorcoach had traveled about 122 miles from Sacramento. Records from the driver's cell phone provider indicated that she was not using her phone at or near the time of the crash.[46]

1.7 Motor Carrier Factors

1.7.1 FedEx Freight, Inc.

1.7.1.1 General. FedEx Freight, established in 2001, operated the accident truck. With corporate offices in Harrison, Arkansas, the company operates a fleet of 14,703 power units and employs 18,820 drivers. FedEx Freight is registered with the FMCSA as a "for hire" cargo carrier of general freight and hazardous materials.[47]

The West Sacramento terminal operates 24 hours a day, 5.5 days per week (generally closed on Sunday), and has 100 truck-tractors and 350 trailers. Of its 112 drivers, 29 operate over-the-road ("meet and turn"), and 83 operate as city drivers within a 70-mile radius of the terminal.

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[44] The forensic autopsy noted no abnormalities in the driver's brain, lungs, or heart.

[45] According to Silverado, applicants must have operated a CMV for at least 1 year, have a valid and current CDL with a passenger "P" endorsement, and have a relatively clean driving history. A third party conducts background checks. Applications are reviewed by the corporate risk and safety office and then by the insurance company. Applicants are subjected to pre-employment drug and alcohol screening, which is conducted by a Silverado-selected third party.

[46] Silverado's distracted driving policy prohibits drivers from using their cell phones while driving.

[47] According to FMCSA Safety Fitness and Electronic Records (SAFER) data, FedEx Freight is assigned US Department of Transportation (USDOT) number 239039 and motor carrier (MC) number 121805. See about.van.fedex.com/fedex_freight, accessed March 19, 2015.

1.7.1.2 FMCSA Oversight. FedEx Freight was subject to a "nonrated" review in 2007. Motor Carrier Management Information System (MCMIS) data indicated that, during the 2 years prior to the crash, the carrier had been subject to the following:

- 7,308 roadside inspections.
- 5,524 vehicle inspections, with 669 out-of-service (OOS) violations, for an OOS rate of 12.8 percent (national average in 2013: 19.9 percent).
- 7,161 driver inspections, with 49 OOS violations, for an OOS rate of 0.7 percent (national average in 2013: 4.9 percent).
- 2,447 hazardous materials inspections, with 92 OOS violations, for an OOS rate of 3.8 percent (national average in 2013: 3.9 percent).[48]

In the same time frame, FedEx Freight experienced 731 reportable traffic crashes: 24 involving fatalities, 225 involving injuries only, and 482 requiring a vehicle to be towed from the scene.[49] FedEx Freight's roadside inspection and safety review information was recorded in the MCMIS database. These data are evaluated with the FMCSA Safety Measurement System, and scores are recorded in the appropriate behavior analysis and safety improvement category (BASIC). A carrier's measurement for each BASIC depends on the number of adverse safety events (violations related to a BASIC or a crash), severity of violations or crashes, and time of occurrence (more recent events are weighed more heavily). After a measurement is determined, the carrier is placed in a group with other carriers with similar numbers of inspections.

Percentiles from 0 to 100 are determined by comparing the BASIC measurements of the carrier to the measurements of other carriers in the peer group. A percentile of 100 indicates the worst performance. The FMCSA has created "intervention" percentile thresholds for each BASIC, which allow it to prioritize which carriers require a safety intervention and the type of intervention necessary. At the time of the crash, the FedEx Freight BASIC scores were below the threshold for intervention in all seven on-road safety performance categories.[50]

[48] The 24-month period covered April 19, 2012–April 19, 2014; the crash occurred on April 10, 2014. The CVSA North American OOS criteria are a set of driver and vehicle requirements that have been determined—in conjunction with federal, state, and industry representatives—to constitute an imminent hazard (CVSA 2015). They are applicable at both the federal (interstate) and state (intrastate) levels. Although the set of criteria has its origin in the FMCSRs, it also differs from them in some areas—in which case, it recognizes state regulations for citation purposes. A finding of an OOS condition by a qualified inspector precludes further operation by the driver or of the vehicle, as appropriate, until the condition is corrected.

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

[50] At the time of the crash, FedEx Freight's BASIC scores were as follows: unsafe driving (25 percent), HOS compliance (51 percent), driver fitness (70 percent), controlled substances and alcohol (10 percent), and vehicle maintenance (62 percent). The thresholds for FMCSA intervention are 65 percent for unsafe driving and HOS compliance; and 80 percent for driver fitness, controlled substances and alcohol, and vehicle maintenance.

1.7.2 Silverado Stages, Inc.

1.7.2.1 General. Silverado, established in 1994, operated the accident motorcoach. The company is headquartered in San Luis Obispo, California, and operates satellite terminals throughout the state. It has a fleet of 119 vehicles with 142 drivers. Registered with the FMCSA as a "for hire" passenger carrier, Silverado was the subject of one compliance review in 2004, and it received a "satisfactory" rating. Additionally, Silverado's summary data in the Safety and Fitness Electronic Records (SAFER) system indicated that its safety rating was "satisfactory."[51]

1.7.2.2 Postcrash. In the 24 months prior to the crash, Silverado had been subject to the following:

- 147 roadside inspections.
- 142 vehicle inspections, with four OOS violations, for an OOS rate of 2.8 percent (national average in 2013: 7.3 percent).
- 40 driver inspections, with two OOS violations, for an OOS rate of 5 percent (national average in 2013: 5.2 percent).

Company records indicated two reportable traffic collisions—one injury and one towaway. Silverado's roadside inspection and safety review information was recorded in the MCMIS database. As discussed above for FedEx Freight, the Safety Measurement System determines percentiles from 0 to 100 by comparing the BASIC measurements of the carrier to the measurements of other carriers in the peer group. At the time of the crash, Silverado's BASIC scores were below the threshold for intervention in all seven on-road safety performance categories.[52]

The FMCSA inspected eight Silverado vehicles on April 14–15, 2014, at the Pomona and San Luis Obispo terminals. In total, 10 defects were noted, and three OOS violations were found (broken left turn signal, exhaust system defect, and steering system defect). The compliance review resulted in an overall "satisfactory" safety rating.

[51] See safer.fmcsa.dot.gov/query.asp?searchtype=ANY&query_type=queryCarrierSnapshot&query_param=-USDOT&query_string=388417#Inspections, accessed April 14, 2015.

[52] At the time of the crash, Silverado's BASIC scores were as follows: unsafe driving (0 percent), HOS compliance (<3 inspections with violations), driver fitness (0.5 inspection with violations), controlled substances and alcohol (0 percent), and vehicle maintenance (7 percent). The thresholds for FMCSA intervention are 65 percent for unsafe driving and HOS compliance; and 80 percent for driver fitness, controlled substances and alcohol, and vehicle maintenance.

1.8 Highway Factors

1.8.1 Description and Characteristics

I-5 is classified as a principal urban arterial (interstate freeway) highway, serving as a major US north–south transportation route from the southern border at San Ysidro, California, through Oregon, and up to Blaine, Washington. The crash occurred in the northbound lanes at milepost marker 26.02. The site is identified locally as west of Orland.

In the area of the crash, I-5 is a four-lane highway (two lanes in each direction). Solid white pavement stripes delineate the travel lanes from the 12-foot-wide right shoulders. The left side shoulders, measuring 4–4.5 feet wide, are delineated from the travel lanes by yellow pavement stripes. Six inches to the right of the yellow stripes, raised yellow retroreflective pavement markers, spaced at 48-foot intervals, delineate the lanes in nighttime conditions. Rumble strips are located on the shoulders on both sides of the travel lanes. The alignment of the southbound travel lanes is straight for approximately 1,214 feet approaching the crash site. The alignment of the northbound travel lanes is straight for approximately 16,671 feet approaching the crash site.[53]

The posted speed limit for I-5 is 70 mph for cars and buses, and 55 mph for trucks with three or more axles. The average daily traffic (ADT) count in 2012 was 23,400 vehicles.[54] The California Department of Transportation (Caltrans) indicated that large trucks accounted for about 25 percent of total traffic along I-5 in the vicinity of the crash.[55] A speed survey conducted by CHP on April 16, 2014, indicated that the 85th percentile speed was 75 mph for cars traveling northbound and 76 mph for cars traveling southbound. For truck-tractor combination units, the 85th percentile speed was 60 mph northbound and 61 mph southbound.

1.8.2 Median Barriers

A 58-foot-wide gravel earthen median separates the northbound and southbound lanes of I-5 in the area of the crash.[56] Oleander bushes of varying height are located near the centerline of the median; in the vicinity of the crash, the bushes were 3–5 feet high. There are no median

[53] The as-built plans for the 1964 construction project indicated that the roadway at the crash site was in a 17,871.34-foot-long tangent section, which ended about 1,200 feet north of the crash site. A 634-foot-long curve, with an approximate 30,000-foot radius, preceded the 1,214-foot-long straight section on the southbound side.

[54] Volumes were recorded at the junction of State Route 32 and I-5, about 0.5 mile south of the crash site, for both northbound and southbound traffic.

[55] Caltrans defines "large truck" as a truck with a gross vehicle weight rating (GVWR) greater than 10,000 pounds.

[56] The median width is measured from yellow shoulder line to yellow shoulder line. It can vary from the original as-built construction plan width of 60 feet due to variations in lane and shoulder paving.

barriers in this portion of the roadway.[57] No cross-median collisions had previously occurred in the area of the crash.[58]

No national standard defines when and where to install a median barrier on high-speed, fully controlled-access roadways.[59] For locations such as the Orland crash site, with median widths greater than 50 feet, the *Roadside Design Guide* (RDG) indicates that a median barrier is not typically necessary except in special circumstances, such as in an area with a significant history of cross-median crashes (American Association of State Highway and Transportation Officials [AASHTO] 2011).[60] Engineering judgment, RDG guidance, and state department of transportation policies are followed in determining when and where to install median barriers. The RDG guidance for median barrier placement is based on factors such as traffic volume and median width, as shown in figure 10.

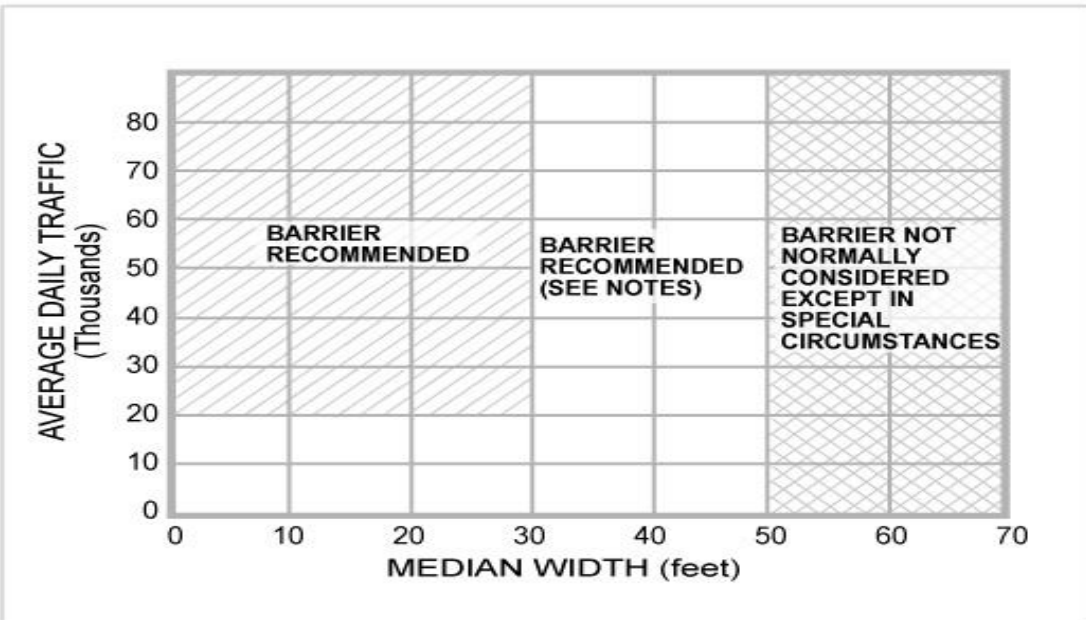

Figure 10. Guidelines for determining whether to install median barriers on high-speed, fully controlled-access roadways (adapted from AASHTO 2011, figure 6.1). (States are encouraged to assess whether a barrier is appropriate for locations with median widths of 30–50 feet, as well as for locations with median widths of less than 30 feet with ADT less than 20,000.)

[57] Median barriers are longitudinal roadside obstructions designed to redirect vehicles that may strike either side of the barrier.

[58] From 2007 to 2011, two cross-median crashes occurred from milepost 21 in Glenn County south to milepost 2.179 in Tehama County: one fatal crash (a passenger car crossed the median and struck a truck-tractor semitrailer) and one nonfatal crash (a vehicle attempted a U-turn across the median and then slid into traffic [Caltrans 2013]).

[59] However, the Federal Highway Administration (FHWA) requires that when median barriers are used on the national highway system, they must, at a minimum, comply with test level (TL)-3 standards for crash testing.

[60] The RDG is a synthesis of current information and operating practices related to roadside safety. It does not define “significant crash history,” nor does it formally define a cross-median crash.

The criteria for installing median barriers in California exceed the RDG guidance. However, the Transportation Research Board (TRB) recently requested proposals for National Cooperative Highway Research Program (NCHRP) project 22-31, on guidelines for the selection and placement of test level (TL) 2–5 median barriers. Once published, the guidelines will augment the criteria used by the RDG and the states.

The RDG encourages states to determine whether a median barrier is appropriate along certain parts of the interstate highway system. In addition to ADT and median width, Caltrans has established that the crash history of a site should be included as a criterion for determining the need for a median barrier.[61] The Caltrans warrant states that locations meeting either of the following criteria are justified for further evaluation: (1) at least three cross-median crashes and a total crash rate of at least 0.5 crash per mile per year within 5 years; or (2) three fatal cross-median crashes and a total crash rate of at least 0.12 crash per mile per year within 5 years. Figure 11 depicts Caltrans guidelines for median width and ADT combinations that merit a median barrier study.

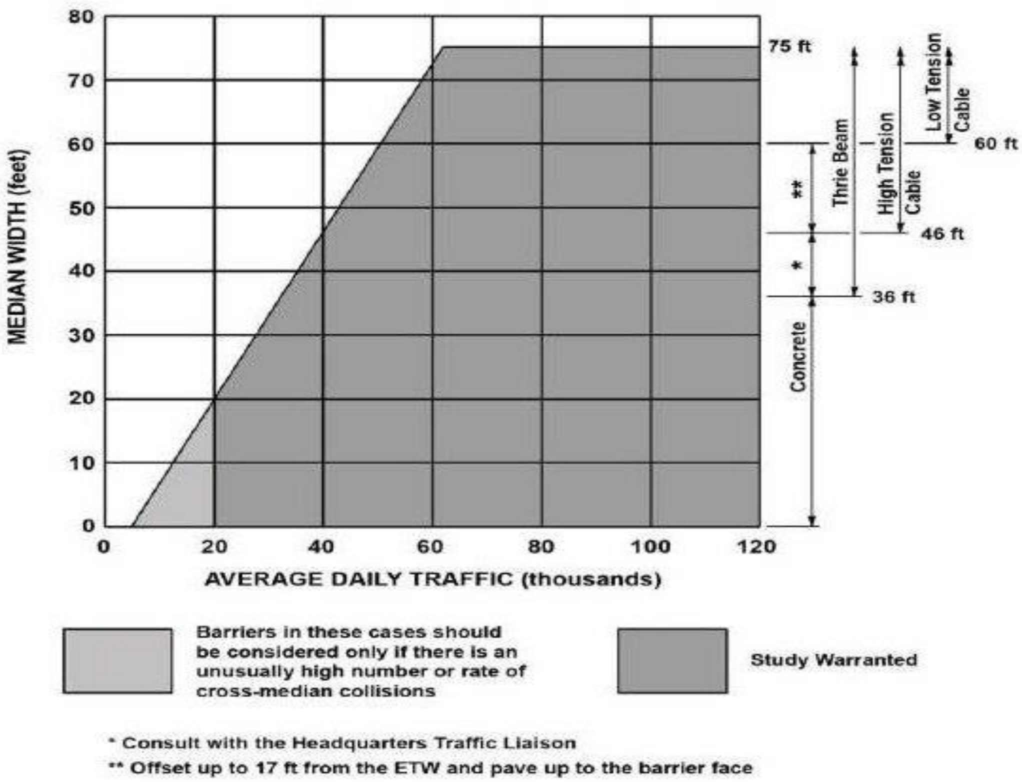

Figure 11. Guidelines for determining when to install median barriers (adapted from Caltrans 2013, figure 7-12).

61 The warrants are titled "Freeway Volume/Width Study Warrant" and "Collision Study Warrant." From 2007 to 2011, 1,043 cross-median crashes occurred on multilane highways in California—which included 128 fatal crashes and 731 crashes that resulted in injuries (Caltrans 2013). Caltrans districts are directed to complete investigations and reports for those highway segments that meet any of the traffic volume median width warrants or two collision warrants.

Additionally, in 1997, Caltrans established that a roadway with traffic volumes in excess of 60,000 vehicles per day (VPD) would warrant a barrier study. The Orland crash site, with an ADT of 23,400 vehicles, had less than 60,000 VPD and did not exceed the 45,000 VPD for a median width of 58 feet. Caltrans indicated that this cross-median crash would not trigger a median barrier study because neither the ADT for the median width warrant nor the cross-median fatal crash rate warrant was met.[62]

1.8.3 Physical Evidence

Physical evidence at the crash scene indicated that the truck-tractor departed the left lane of I-5 into the median at an approximate 8 degree angle. The tire impressions appeared intermittently across the median surface, exhibited a consistent path of travel through the oleander bushes, and entered the northbound traffic lanes at an approximate 17 degree angle, leading to the area of impact with the motorcoach. Photographs of the tire impressions through the median did not depict the characteristics of tire slip indicative of emergency braking or steering.[63] The truck-tractor traveled a total of approximately 415 feet from the southbound pavement edge to impact with the motorcoach.

Evidence of precollision braking by the motorcoach was observed in the northbound right travel lane preceding the area of impact. Tire friction marks, which were characteristic of hard braking, were initially oriented parallel to the right travel lane, but—about 95 feet after onset—they began arcing toward the right, indicative of a driver steering input. About 162 feet after onset, the tire marks exhibited an abrupt offset to the right, indicative of a collision. The tire marks terminated about 30 feet farther north beneath the motorcoach at its postcrash position of rest.

At the time the truck-tractor and motorcoach collided, the front of both vehicles had substantially crossed onto the right shoulder. The heading of the pre-impact tire marks indicates that the relative angle between the two vehicles at impact was approximately 156 degrees.

Intermec data indicated that the truck-tractor—after entering I-5 southbound until the final recorded data point—had been in motion approximately 2 hours 7 minutes, at an average speed of 57.3 mph. The last location data point recorded was at 5:34:58 p.m., in Kirkland, California, 5.56 miles north of the crash site, and the recorded vehicle speed was 59.5 mph.

[62] The RDG glossary defines a warrant as, "the criteria by which the need for a safety treatment or improvement can be determined." For the purposes of this discussion and with respect to median barrier information, it should be emphasized that "guidance" and "guidelines" are not synonymous with "warrants." Warrants identify specific metrics—such as accident rate, ADT, and percentage of heavy vehicle traffic—that, if exceeded, indicate the need for a barrier.

[63] The southbound and northbound roadways were inspected (1) for physical evidence of tire failure or mechanical disablement prior to the truck-tractor's point of departure; and (2) for evasive maneuvers to avoid the passenger car or motorcoach collisions. No such evidence was found. The median was compacted and firm, though the surface aggregate could be easily displaced.

1.9 Weather and Visibility

Historical data from the weather station at Chico Municipal Airport in Chico, California, about 19 miles from the crash site, indicated that on April 10, 2014, at 5:50 p.m., the temperature was 82.4°F, with a visibility of 40 miles and wind direction to the northeast at 5.8 mph, with scattered clouds. According to the US Naval Observatory, at 5:40 p.m. local time on April 10, 2014, in Orland, the sun was at an altitude of 22.5 degrees above the horizon at 261.8 degrees east of true north. Based on National Oceanic and Atmospheric Administration data, NTSB investigators determined that the sun’s position at the time of the crash was behind, and to the left of, the motorcoach driver—and ahead, and to the right of, the truck driver.

2 Analysis

2.1 Introduction

This crash involved three vehicles: a truck-tractor in combination with double trailers, a passenger car, and a motorcoach. The truck-tractor was traveling southbound on I-5 in Orland, California, when it crossed the median and entered the northbound traffic lanes. It first struck the passenger car and then the motorcoach. The second collision resulted in a postcrash fire. Eight motorcoach passengers and the drivers of both the truck and the motorcoach died. The remaining 37 motorcoach passengers and the two occupants of the passenger car were injured.

This analysis discusses possible reasons why the truck driver departed the southbound lanes of I-5, traveled through the median, and entered the northbound lanes, ultimately striking two vehicles (see sections 2.2 through 2.4). In addition, we discuss the following safety issues:

- Lack of adequate fire performance standards for commercial passenger vehicle interiors (section 2.5).
- Pretrip safety briefings for commercial passenger vehicles (section 2.6).
- Improvements in commercial passenger vehicle design to facilitate evacuations (section 2.7).
- Event data recorder (EDR) survivability for crash reconstruction and safety improvements (section 2.8).

As a result of its investigation, the NTSB determined that the following factors did *not* contribute to the cause of the crash:

- ***Driver experience:*** The truck and motorcoach drivers held current CDLs, were familiar with their vehicles, and had several years of driving experience.
- ***Driver substance impairment and alcohol or drug use:*** Postcrash toxicology test results revealed that neither driver had used alcohol or drugs (prescription or otherwise) prior to the crash.
- ***Driver distraction*:** Neither the truck driver nor the motorcoach driver was using a cell phone just prior to, or at the time of, the truck-tractor’s departure from the southbound travel lanes of I-5. Furthermore, there is no suggestion that any other driver distraction caused or contributed to the crash.
- ***Driver operation:*** Precollision braking tire marks found at the scene and witness statements indicated that the motorcoach driver initiated evasive steering and braking just prior to the collision. Furthermore, there is no suggestion that either driver made any operational decisions or errors that caused or contributed to the crash.

- ***Motor carrier operations:*** All available FMCSA and state of California motor carrier oversight data indicated that both FedEx Freight and Silverado were rated as "satisfactory" carriers, their OOS numbers for both driver and vehicle inspections were well below the national average, and both companies had procedures to train and monitor drivers and to maintain vehicles.

- ***Vehicles:*** NTSB investigators examined the accident truck-tractor, double trailers, motorcoach, and passenger car, and found no preexisting mechanical conditions related to the circumstances of the crash.

- ***Weather:*** The weather was clear, there was no precipitation at or near the time of the crash, and the road surface was dry. The crash occurred under daylight conditions, and the sun was not in a position to cause glare for either driver.

The NTSB, therefore, concludes that none of the following were factors in the crash: (1) truck or motorcoach driver experience, licensing, or alcohol or drug use; (2) driver distraction or operational error; (3) motor carrier operations; (4) mechanical condition of either vehicle; or (5) weather.

Following the crash, emergency responders were quickly dispatched to the scene, and the regional multicasualty incident response plan was rapidly activated. The NTSB investigation found that multiagency fire, emergency medical service (EMS), and law enforcement personnel responded with adequate resources, which led to coordinated and successful incident management. The triage, treatment, and transportation of injured occupants to area hospitals was efficiently facilitated. The NTSB concludes that the emergency response to the crash was timely and effective.

2.2 Crash Reconstruction

The initiating event occurred when the truck-tractor, which was traveling south on I-5, departed the roadway and crossed the highway median toward the northbound lanes. Analysis of this event sequence indicates that the truck driver should have begun corrective steering about the time the truck-tractor's left tires departed the left lane, while his vehicle was still on the left shoulder. Instead, the truck-tractor traversed rumble strips and headed toward the median, continuing straight until striking the passenger car. The truck driver did not brake or steer even after his vehicle struck the car. With little or no deviation, the truck-tractor traveled in this direction for about 415 feet from departing the southbound travel lanes until colliding with the motorcoach.

The entire sequence of events in this crash involved two collision impacts between three motor vehicles. Because of the complex collision dynamics and the resulting fire, which destroyed the truck-tractor and motorcoach ECMs, NTSB investigators could not determine the precise speed of either vehicle at impact. Based on the path of travel prior to impact, the resulting damage, the postimpact limited trajectory, and the final vehicle point-of-rest positions, it appears that a reasonable impact speed range is 50–55 mph for the truck-tractor and 35–37 mph for the motorcoach.[64]

Prior to departing the southbound lanes, the truck-tractor was traveling on a flat and straight roadway. No vehicle debris or evidence of a road hazard was found on the southbound lanes. The truck-tractor departed the roadway at a relatively shallow angle of 8 degrees, a road departure type typically consistent with a driver drifting off the road due to distraction, fatigue, or incapacitation. The tire impressions through the median exhibited a consistent path of travel, leading to the area of impact with the motorcoach, and did not depict the characteristics of tire slip indicative of emergency braking or steering. Therefore, it is unlikely that the truck driver performed an abrupt, evasive steering maneuver. The NTSB, therefore, concludes that the truck driver did not depart the roadway to avoid another vehicle or a roadway obstruction.

At the time the truck-tractor and motorcoach collided, the front of each vehicle had substantially crossed onto the right shoulder. The heading of the pre-impact tire marks indicates that the relative angle between the two vehicles at impact was approximately 156 degrees (figure 12). With the exception of the driver seating position, the forward structure of the motorcoach was displaced toward the right. The leftward displacement of the driver seating position indicates that the impact from the truck-tractor was laterally inboard of the driver seat. As the vehicles continued to engage, the truck-tractor began to penetrate the front of the motorcoach, which was torn open, exposing the interior. The front of the motorcoach collided with the right side diesel fuel tank of the truck-tractor. Diesel fuel was expelled onto the exterior and into the interior of the motorcoach, and a fire ignited.[65]

[64] With an initial speed of 59–57 mph and departing the right southbound travel lane at an angle similar to that of its off-pavement path of travel, the truck-tractor likely struck the motorcoach in about 6.3–6.6 seconds.

[65] Postcrash scene photographs and damage to the two trailers (primarily the first trailer) indicate that they also made contact with the motorcoach during the collision, which influenced the vehicles' post-impact travel to point of rest.

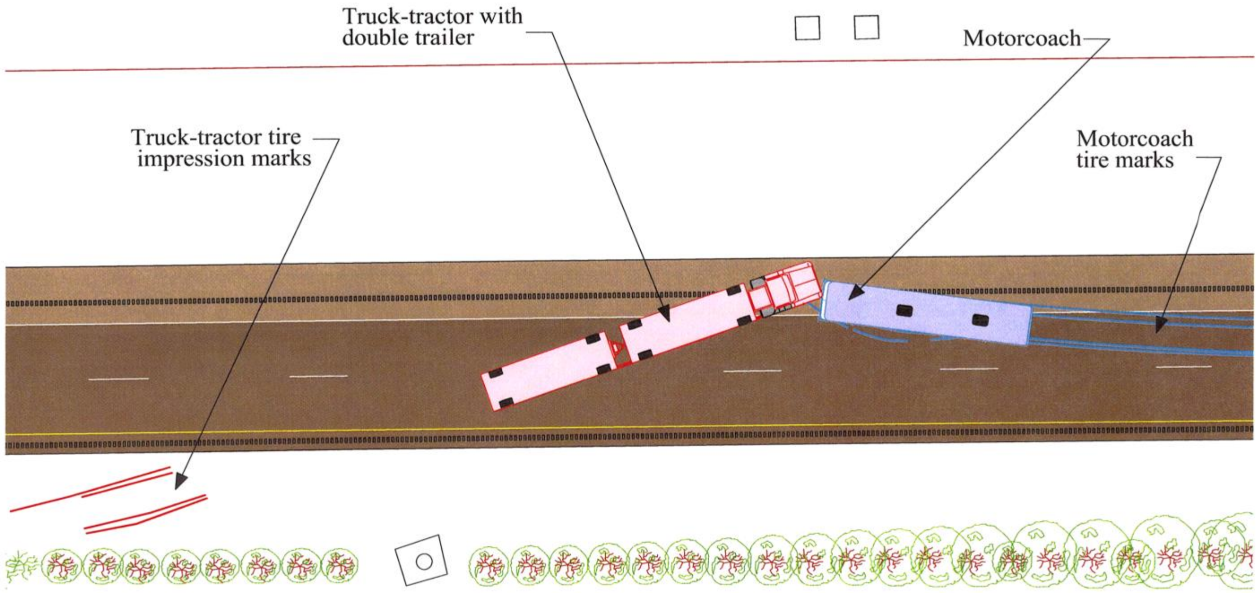

Figure 12. Crash scene diagram depicting truck-tractor tire impressions in median, motorcoach pre-impact tire marks, and vehicle angles at impact.

2.3 Truck Driver

The NTSB cannot conclusively establish that the truck driver was awake/conscious immediately prior to, or at the time of, the crash. NTSB investigators found no evidence that the driver was experiencing mental health or family issues, making it less likely that he would intentionally cross into opposing traffic. As a result, investigators focused on fatigue and medical (physiological) incapacitation as the more likely causal factors.

NTSB assessment of four fatigue factors—acute sleep loss, time of day, circadian dysrhythmia, and time awake—indicated that the truck driver would not likely have been fatigued at the time of the crash. NTSB investigators were unable to assess other relevant fatigue risk factors—such as chronic partial sleep restriction and sleep quality—because of limited information.

If the truck driver had experienced a microsleep, it is likely that he would have been alerted as his vehicle departed the road.[66] Numerous auditory and vibratory feedback events occurred during the crash sequence. For example, the truck-tractor moved across the left lane, over rumble strips, into the gravel-laden median, through oleander bushes, across a second set of rumble strips—and then struck a passenger car before colliding with the motorcoach. This sequence of events may have taken as long as 6.6 seconds. Each of these individual events represents multiple instances of feedback that would have alerted the driver, even if he were fatigued or asleep. However, there is no evidence that the driver reacted to these multiple

[66] A microsleep is a sudden shift from waking characteristics to sleep, lasting up to 30 seconds. Microsleeps are typically associated with excessive sleepiness.

episodes of stimuli, such as by braking or evasive steering. Therefore, the NTSB concludes that the circumstances of the crash, such as the driver's work and rest history and his complete lack of reaction to the roadway departure and crash event stimuli, are inconsistent with fatigue as a causal factor.

The truck driver was reported to be in excellent health—supported by his limited visits to a physician, his age, lack of prescription medication use, negative toxicology testing, and lack of significant findings of natural disease in the autopsy. However, one witness described the driver as "pale and clammy" before the southbound return trip to Sacramento. Several motorcoach passengers reported seeing the truck-tractor through the front windshield of the motorcoach just before impact. One passenger, seated in the aisle seat in the third row, behind the driver, reported seeing the truck driver slumped toward the driver's door just prior to the collision. Although NTSB investigators did not find evidence of a specific medical condition that would explain his driving behavior, numerous medical events could incapacitate a driver and not leave any additional evidence. Such conditions include a complex partial seizure, fainting as a result of dehydration or nausea, or decreased blood pressure from a sudden sustained abnormal heart rhythm—any one of which might explain a sudden loss of awareness or inability to act. Witness statements raise the possibility that the truck driver may have been experiencing a medical event of unknown cause at or near the time of the crash; however, no clinical evidence was found that any such conditions had occurred or that he had experienced any similar event in the weeks or months preceding the crash. Furthermore, once he departed the I-5 southbound left lane and shoulder, he provided no steering input, nor did he apply the brakes.

Ultimately, NTSB investigators were unable to determine whether the truck driver may have been affected by a medically incapacitating but undiagnosed condition or a medical event that prevented him from controlling the truck-tractor. Therefore, the NTSB concludes that based on the truck driver's lack of braking or other appropriate reaction prior to or during the crash sequence—and witness accounts concerning the driver's behavior and condition—he was unresponsive due to an unknown cause, which prevented him from controlling his vehicle and led to the crash.

2.4 Cross-Median Crashes and Highway Median Barriers

Research has demonstrated that cross-median crashes do not occur during a specific time of day or day of the week—and they occur on both horizontally and vertically curved, as well as straight and flat, roadways. In addition, the events that can lead to a cross-median crash range from fatigue and improper lane changes to inattention, medical emergencies, and weather.[67] Although median barriers are not required on any highway in the National Highway System, state transportation departments and the RDG provide guidelines for the installation of median barriers. The RDG, which includes warrants to assist highway designers in determining the need for median barrier protection, indicates that barrier applications are not normally considered for medians wider than 50 feet (AASHTO 2011, 3-1).

[67] See www.fhwa.dot.gov/publications/publicroads/05jan/06.cfm, accessed February 10, 2015.

However, because of the severity of cross-median crashes, some states, including California, have stronger median barrier application policies than the RDG and have installed barriers in crash-prone locations with median widths up to 75 feet (TRB 2009; Donnell and Mason 2006).[68] Even with the more robust barrier application policies in the state of California, the Orland crash site did not exceed the Caltrans minimum ADT of 45,000 vehicles for the 58-foot-wide median, and the fatal cross-median crash rate had not been exceeded in the preceding 5 years. For these reasons, the site had not been selected for further study on whether to install a protective median barrier. The NTSB concludes that, based on the state of California's median barrier application policies, which are more robust than national guidelines, the Orland crash location on I-5 did not warrant a median barrier due to the ADT and crash history.

The NTSB is encouraged by the recent TRB announcement of an NCHRP research project (no. 22-31) to develop guidelines on median barrier placement location criteria and selection of median barriers types. It is anticipated that these guidelines will be integrated into an updated edition of the RDG and, therefore, will augment the criteria used by California and other states.[69]

2.5 Vehicle Fires

2.5.1 Fuel Sources and Fire Propagation

Postcrash examination of the truck-tractor, motorcoach, and roadway revealed that the collision resulted in the sudden and catastrophic rupture of the truck's right side fuel tank, which led to a spraying dispersal of diesel fuel. This fuel entered the forward portion of the motorcoach, which had been breached at impact, and ignited either immediately or shortly thereafter as a result of friction and sparks generated by the collision and scraping of metallic materials on the pavement, by electrical arcing of damaged wiring, or by contact with hot engine or exhaust components.[70]

Examination of the motorcoach indicated that it was slightly nose down (approximately 7 degrees) during the fire.[71] This nose-down orientation, with the fire at the front of the vehicle and emergency exit windows opening at the rear, began to create a flow through the vehicle akin to a chimney. This condition was exacerbated as the fire spread along the roof interior and burned through the roof hatches, increasing the flow through the vehicle by entrainment (air flow). These circumstances accelerated the spread of the fire to the combustible interior of the

[68] See 58 *Federal Register* (FR) 38298, July 16, 1993.

[69] This project is scheduled for completion in June 2018.

[70] In this instance, electrical arcing refers to a luminous discharge that is formed when a strong current jumps a gap in a circuit or between two electrodes.

[71] In its postcollision position, the motorcoach was oriented eastward and angled about 88 degrees relative to the highway. About one-half of the vehicle's length, including the rear wheels, remained on the pavement. Examination of the fuel tank exterior revealed a thermal damage pattern resembling a "water line" between the liquid level in the tank and the ullage space above, creating a 7 degree angle.

motorcoach, causing the fire to rapidly escalate in intensity, heat, and production of toxic gases and smoke.

Visibility within the motorcoach deteriorated rapidly prior to actual flame spread to the rear of the vehicle and made egress very difficult. Bystander video evidence, surviving passenger statements, and inhalation injuries confirm that the motorcoach interior quickly filled with smoke, intense heat, and fire. Dark smoke was observed venting from the motorcoach while passengers were still evacuating (see figure 8, presented earlier in the report).[72] Fifteen passengers seated near the front of the motorcoach sustained some degree of burns, at least five passengers experienced smoke inhalation injuries while trying to evacuate, and three fatally injured passengers found inside the motorcoach died from asphyxiation due to the products of combustion. The NTSB concludes that the catastrophic rupture of the truck-tractor fuel tank released fuel that sprayed into the interior of the motorcoach, resulting in the fire and causing fatal and serious injuries to numerous motorcoach occupants.

2.5.2 Vehicle Flammability Requirements

Several initiating events can cause commercial passenger vehicle fires, such as collisions or electrical system malfunctions, engine compartment leaks, component overheating, and tire fires. Regardless of the method of fire initiation, the longer vehicle construction materials can impede or slow flame spread in the passenger compartment, the better the chance of occupant survival.

Federal Motor Vehicle Safety Standard (FMVSS) 302 specifies the fire resistance requirements for materials used in the occupant compartments of passenger cars, multipurpose vehicles, trucks, and buses. The standard is intended to reduce deaths and injuries caused by vehicle fires, particularly fires originating in the vehicle interior from sources such as matches or cigarettes. However, FMVSS 302 flammability testing involves a small-scale fire source as a test method to represent fire originating in the passenger compartment (from sources such as matches or cigarettes)—which differs from the common causes of bus fires, such as in-service ignition sources (for example, engine fires) or a postcrash fuel-fed fire ignition source, as was the case in Orland.

In addition to real-world ignition sources, an adequate safety standard for the flammability of interior materials should take into account those materials that represent the main fire load in current vehicle design. Today’s motorcoach and bus interiors feature dramatically more combustible materials (fuel load such as plush seating, fabric paneling, carpet, drapery, or shades) than those produced in 1972, when FMVSS 302 was implemented. Combustible polymers, plastics, and fabrics are the first materials to ignite in a vehicle fire, have high heat release rates, and have high levels of toxic gas output—all of which greatly increase the fire hazard (Patronik 2008; Tewarson and others 2005).

A flammability standard for materials used in high-occupancy passenger vehicles should include a wide spectrum of fire performance properties, including heat release rate, smoke

[72] This information was provided from witness video documentation of the postcollision fire and from the dashcam of a US Forest Service vehicle.

production, ignition resistance, and flaming droplets of vehicle components. Additionally, currently installed interior combustible fabrics and foam surfaces in buses and motorcoaches may pass FMVSS 302 when tested in a horizontal position; however, the flame spread rate is drastically increased when materials are installed vertically, such as with drapes or window shades (Briggs and Hunter 2004; National Fire Protection Association [NFPA] 2007; Spearpoint and others 2005; Tewarson and others 2007).

An upgraded FMVSS flammability standard must consider these aspects of real-world ignition scenarios and vehicle design and construction. The improvement of interior material flammability can mitigate the outcome of motorcoach fires. For example, the American Public Transportation Association—which represents the bus, rapid transit, and commuter rail systems industry—provides a bus buying guide that specifies fire safety features on all new transit buses (Meltzer and others 2009). These features include fire-retardant/low-smoke materials for passenger-compartment and insulation materials; fireproof passenger-compartment lighting modules; fire detection systems; firewalls; and facilitation of passenger evacuation, including two door exits, an escape hatch, and other evacuation features. The federal safety standards for commercial passenger vehicles pertaining to the flammability of interior components should meet those standards established for other commercial passenger transport modes, such as aircraft, rail cars, and transit buses (Meltzer and others 2009).[73]

2.5.3 Bus and Motorcoach Flammability Standards Historical Review

The NTSB has been concerned about motorcoach and bus interior material flammability and smoke emission standards for nearly 40 years. Since 1975, we have issued recommendations to NHTSA to improve FMVSS 302: (1) to provide sufficient time for occupant evacuation before the creation of a lethal environment; (2) to expand testing to include a vertical burn test of vehicle interior materials; and (3) to establish flammability standards in a manner similar to the Federal Aviation Administration (FAA) to reduce the rate of fire spread in all buses. However, NHTSA has responded that FMVSS 302 was designed to require a burn rate low enough to permit occupants sufficient time to evacuate the vehicle (auto–bus–van) but not to fireproof an interior or to be a countermeasure against a fuel-initiated fire. The agency stated that its position was that emergency exits work in many different crash scenarios, while reducing flammability only slows the rate of fire propagation. As a result, NHTSA has not changed FMVSS 302 since the standard was established in 1972.

In 2006, the NTSB held a public hearing on motorcoach fires in support of its investigation of the motorcoach fire that occurred near Wilmer, Texas, in September 2005, resulting in 23 fatalities (NTSB 2007). In 2012, in response to NTSB recommendations from the Wilmer investigation, the National Institute of Standards and Technology issued a report on motorcoach passenger compartment tenability during a fire (NIST 2012). The NIST testing showed that (1) interior motorcoach thermal conditions were generally more severe at earlier times than toxic, irritant, or asphyxiant gas conditions; (2) the combination of incapacitating thermal and toxic gas effects shortened tenability time and time to escape; and (3) each of these

[73] See (a) 49 CFR 25.853, *Airworthiness Standard for Flammability of Seat Cushions*; (b) 49 CFR 238.103, *Fire Safety, Flammability, and Smoke Emission Tests*; (c) 58 FR 54250, October 20, 1993.

hazards would normally act synergistically to cause incapacitation, leading to death earlier than any single component alone.[74] Flammability testing using FMVSS 302, a corresponding European standard (Economic Commission for Europe [ECE] regulation 118), FAA standards, and Federal Railroad Administration standards showed that motorcoach seat components and parcel rack doors burned significantly more easily than comparable components approved for use in aircraft and rail cars.[75]

During the Wilmer public hearing, the FMCSA testified that—in recognizing the difficulty in obtaining meaningful motorcoach and bus fire data—it had contracted with the John A. Volpe National Transportation Systems Center to gather data and studies on motorcoach fires; set up a database or spreadsheet system to structure the data; and analyze the motorcoach and bus fire problem, including causes, frequency, and severity.

The Volpe Center has published two reports analyzing motorcoach fire incidents that occurred between 1995 and 2008. The Volpe Center defined a motorcoach fire as (1) a fire that occurs spontaneously due to typical onboard sources of ignition (heat or sparks) and flammable or combustible material; or (2) a fire that is caused by mechanical failures and malfunctions. The Volpe studies excluded fires originating from passenger activities, such as smoking (which are the types of fire sources that FMVSS 302 tests for [Meltzer and others 2009; 2012]).

According to the Volpe Center, of the total 14 direct injuries from the 899 reported noncollision fires in 1995–2008 (excluding the Wilmer, Texas, fire), seven injuries were due to six fires originating in engine compartments (0.67 percent), and another seven injuries were due to three fires originating in wheel wells (0.33 percent [Meltzer and others 2009]). In the majority of noncollision reported bus fire cases studied, passengers were able to evacuate rapidly and without significant injury. However, the study does not encompass all motorcoach fires (such as fires caused by collisions with other vehicles and fixed objects) in which occupants may have sustained injury from smoke or fire or during evacuations.

Study analyses found that, though fatality and injury reductions may be small on average, active and passive fire suppression systems (such as improved flammability standards for interior materials) could help avert the most severe consequences in an extreme or catastrophic fire scenario (Meltzer and others 2009). In January 2015, the FMCSA announced that the Volpe Center will publish an updated report in August 2016, to include data on motorcoach fires that occurred from 2009 to 2013; evaluation of school bus fires; and additional evaluation of the effectiveness of automatic fire detection and suppression systems.[76]

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[74] NIST tested the onset of untenable conditions within the passenger compartment by measuring interior and exterior temperatures, interior heat flux, heat release rate, toxic gases, and visibility. Tests included radiative (heat flux), convective temperatures (fully clothed and lightly clothed), combined radiative and convective (fully clothed and partially clothed), carbon monoxide, hydrogen cyanide, combined carbon monoxide and hydrogen cyanide, hydrogen chloride, and oxygen vitiation.

[75] Flammability testing was conducted on four interior combustible motorcoach components: interior wall panels, parcel rack doors, seat fronts, and seatbacks.

[76] See cms.fmcsa.dot.gov/research-and-analysis/research/motorcoach-and-school-bus-fire-safety-analysis, accessed March 18, 2015.

2.5.4 Safety Recommendations

Witness video and passenger interview descriptions illustrate the speed with which the fire accelerated and the rapid increase of smoke density within the motorcoach. Recent fire testing and fire investigations have shown that once the motorcoach passenger compartment is breached (whether from a fuel-fed immediate ignition event or an exterior fire that enters the coach), a fire spreads quickly; and the smoke, toxicity of gases, and heat make the interior untenable. Current flammability and smoke emissions testing criteria for all motor vehicle interior materials are inadequate.

Significant upgrades of FMVSS 302 are needed to improve the safety of today's high-occupancy commercial passenger vehicles. The standard should establish a more stringent set of flammability requirements to address the fast propagation of passenger compartment fires and permit longer evacuation times. Such standards could help increase interior tenability during passenger egress. Further, FMVSS 302 performance tests cannot predict a material's fire performance (combustion behavior) when exposed to a larger size ignition source, such as the initiating fire from the truck-tractor fuel tanks in this collision. To increase the likelihood of passenger survivability and delay the onset of flashover events, interior material flammability and smoke emission requirements for high-occupancy commercial passenger vehicles are needed.

Currently, FMVSS 302 is applicable to all vehicles, regardless of the number of passengers and the time needed for egress. Increased passenger capacity with commercial high-occupancy buses and motorcoaches also increases the risk of loss of life, because evacuation in the event of a vehicle fire requires more time. As a result of its motorcoach investigations, the NTSB has issued many recommendations aimed at identifying a means of increasing postcrash occupant survivability, such as the use of fire-retardant materials that can extend the time available for escaping a vehicle. In aviation, for example, NTSB recommendations have provided the impetus for many improvements in postcrash occupant protection (NTSB 2001).

FMVSS 302 is outdated and less discriminating than the flammability standards applied in other modes of transportation under US Department of Transportation (DOT) safety oversight, such as aviation and rail (NIST 2012). Just as in airplane and passenger train fires, the danger to motorcoach passengers is not limited to exposure to flames. The side effects of a fire, such as inhaling products of combustion, can be equally deadly. The NTSB concludes that FMVSS 302 does not adequately account for modern vehicle interior components or conditions experienced in real-world vehicle fires, nor does it include specific fire-resistant material standards more appropriate for large commercial vehicles with increased passenger capacity. Therefore, the NTSB recommends that NHTSA revise FMVSS 302 to adopt the more rigorous performance standards for interior flammability and smoke emissions characteristics already in use throughout the DOT for commercial aviation and rail passenger transportation.

2.6 Passenger Pretrip Briefings

The motorcoach passengers—the majority of whom were high school students—did not receive a pretrip safety briefing on the location and use of emergency exits (even though the company had provided the driver with a safety video), or on the advantages of using the available three-point restraints. NTSB investigators interviewed passengers who described feeling panic when they were thrown from their seats, and then attempted to identify and use unfamiliar exits in the midst of instantaneous fire and heavy smoke.[77] The passengers reported that the thick smoke made it difficult for them to breathe, which, in turn, made them more anxious to get out. Several passengers said that because of the thick smoke, they could not see anything, including the emergency exit windows, so they just followed others.[78]

2.6.1 Safety Briefings Historical Review

In a special investigation report on motorcoach issues, the NTSB (1999b) determined that emergency instructions given in advance can be crucial to facilitating a safe and expedient evacuation in the event of a crash or an emergency. The NTSB issued the following recommendations to the FMCSA:

> Provide guidance on the minimum information to be included in safety briefing materials for motorcoach operations. (H-99-7)
>
> Require motorcoach operators to provide passengers with pre-trip safety information. (H-99-8)

The FMCSA produced guidance on what information should be included in safety briefing materials, and convened a government and industry working group to develop a list of best practices for informing passengers about bus safety features. The FMCSA also developed safety brochures, posters, and a video for bus and motorcoach associations, carriers, and nontraditional carriers—and made the materials available on its website. As a result, Safety Recommendation H-99-7 was classified "Closed—Acceptable Action." However, the FMCSA stated that it did not support mandating motorcoach companies to conduct pretrip safety briefings and proposed a flexible safety-awareness program for voluntary adoption by the industry.

According to the FMCSA, it would continue to monitor motorcoach operators, as well as customer comments, to confirm that the companies were presenting pretrip safety information to their passengers. In 2011, the FMCSA published a public notice that it was concerned about the

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[77] Precollision, the motorcoach driver had begun emergency braking and steering to the right to avoid the oncoming truck-tractor. When the truck-tractor collided with the mid-front of the motorcoach, the passengers' motion was forward and to the left side of the vehicle. For those passengers not wearing the available three-point restraints, the deceleration caused them to collide with interior components, such as windows or the seats in front of them. Many of the passenger injuries were consistent with the forces that acted upon their bodies as the collision occurred.

[78] One passenger, seated in an aisle seat in row 7, mentioned being thrown to the floor and being stepped on. She recalled another passenger helping her up and out of the bus.

accuracy of self-reported pretrip safety briefings data provided by motorcoach operators.[79] The FMCSA reported that voluntary compliance was measured during its "national passenger carrier strike forces"—though data were based solely on input from the motorcoach companies and not actual passengers. The FMCSA needed third-party validation (by surveying passengers) of industry efforts to provide pretrip safety information, the effectiveness of the means of conveying the information, and any recommended improvements.[80]

In the public notice, the FMCSA invited comment on its plan to submit a passenger survey information collection request (ICR) to the Office of Management and Budget (OMB). The agency requested emergency processing of the ICR because it believed that any delay in collecting the information could be detrimental to motorcoach passenger safety. Then, in May 2013, the FMCSA announced its plan to submit another ICR to OMB for approval to survey passengers; and, once again, in April 2014, it submitted an ICR—8 days after the Orland crash.[81] According to the FMCSA, it will use the information to determine whether further evaluation is needed to support future program, policy, and regulatory initiatives. In the interim, Safety Recommendation H-99-8 remains classified "Open—Acceptable Alternate Response."

2.6.2 Safety Recommendations

Other modes of passenger transportation mandate pretrip safety briefings. For example, before takeoff, each pilot in command of an aircraft carrying passengers must ensure that all passengers have been orally briefed on the use of safety belts, including instructions on how to fasten and unfasten the belts; and the location and means of opening emergency exits. Further, the oral briefing must be supplemented by printed cards placed in locations convenient for the use of each passenger. The cards must be appropriate for the aircraft on which they are used, and must contain a diagram and method of operating the emergency exits. Pretrip briefings help ensure that passengers understand all safety features and are able to safely exit the vehicle in case of emergency.

In many of the bus crashes investigated by the NTSB, passengers have described a general sense of panic and disorientation following a crash, and they often indicate that they did not know what to do or how to exit the bus. Enabling motorcoach passengers to assume responsibility for their own safety in the event of an imminent hazard or emergency situation can only happen if passengers are informed of the vehicle safety features, such as seat belts, and how to operate the emergency exits. If the Silverado drivers had either conducted a pretrip safety briefing or shown the video to point out the emergency exit windows and demonstrate how to open them, the evacuation may have been improved, possibly saving lives and mitigating injuries. The NTSB concludes that the lack of a pretrip safety briefing led to confusion and panic during the motorcoach evacuation, as many passengers struggled to locate and open the emergency exit windows.

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[79] See 76 FR 64423–64424, October 18, 2011.

[80] According to the public notice, the FMCSA intended to use these data to provide the NTSB and Congress with additional information on voluntary compliance levels.

[81] A new ICR, "Motorcoach Passenger Survey: Motorcoach Safety and Pre-Trip Safety Awareness and Emergency Preparedness Information," was submitted to the OMB Office of Information and Regulatory Affairs on May 7, 2014. See www.reginfo.gov/-public/do/PRAViewICR?ref_nbr=201404-2126-004, accessed April 15, 2015.

Although the FMCSA, bus and motorcoach associations, and insurance companies have developed oral safety briefing guidelines and videos for motor carriers, the briefings are of value only if they are provided to passengers—and there is currently no requirement for operators or drivers to do so. Moreover, Safety Recommendation H-99-8 was issued prior to the mandate for three-point restraints on motorcoaches; and the FMCSA website, safety brochures, posters, and video materials do not discuss the use of seat belts, which are required beginning in 2016 for (1) all new over-the-road buses; and (2) other than over-the-road buses, with a gross vehicle weight rating (GVWR) greater than 11,793 kilograms (26,000 pounds).[82]

The FMCSA has several opportunities in which to work with passenger-carrying operators in the interim, such as during new entrant safety audits, driver and vehicle inspections, and reassessment of safety fitness ratings (required no less frequently than once every 3 years). Therefore, the FMCSA can ensure that carriers are aware of updated material on its website, have instituted procedures to ensure that drivers provide emergency evacuation briefings, and have established additional procedures to incentivize or require drivers to emphasize the importance of passengers wearing their seat belts at all times when seated. Procedures could include additional announcements, video presentations, and pamphlets or printed safety cards in seat pockets.

The NTSB maintains that motorcoach passengers should be provided with a pretrip safety briefing on how to evacuate a bus or motorcoach, as well as the safety features of already available and soon-to-be-required three-point restraints at each passenger seating location. Therefore, the NTSB classifies Safety Recommendation H-99-8 "Closed—Superseded"; and recommends that the FMCSA require all passenger motor carrier operators to (1) provide passengers with pretrip safety information that includes, at a minimum, a demonstration of the location of all exits, explains how to operate the exits in an emergency, and emphasizes the importance of wearing seat belts, if available; and (2) also place printed instructions in readily accessible locations for each passenger to help reinforce exit operation and seat belt usage. The NTSB also recommends that the FMCSA update its website guidance to include information on the mandated three-point restraints effective November 2016 for all new over-the-road buses and for other than over-the-road buses with a GVWR greater than 11,793 kilograms (26,000 pounds).

2.7 Motorcoach Emergency Egress

NTSB investigators identified several problems with motorcoach egress that may have contributed to an increase in the number of injuries and possibly fatalities. The collision and postcrash fire had rendered the motorcoach loading door inoperable and inaccessible. Remaining available emergency egress options were either to (1) open the rear available emergency exit windows and jump more than 7 feet to the ground; or (2) access and open the emergency escape

[82] FMVSS 208, on occupant crash protection, now requires by November 2016, lap/shoulder seat belts for each passenger seating position in (a) all new over-the-road buses; and (b) new buses other than over-the-road buses, with a GVWR greater than 11,793 kilograms (26,000 pounds). Optional early compliance is permitted. According to the final rule, NHTSA stated that it was not aware of any bus meeting the over-the-road bus definition with a GVWR of less than 4,536 kilograms (10,000 pounds). Neither the Motorcoach Enhanced Safety Act (subtitle G of title II of the Moving Ahead for Progress in the 21st Century Act) nor the NHTSA final rule for such buses has any lower GVWR bound on the definition of over-the-road bus.

roof hatches, which are more than 6 feet above floor level, and then jump from the roof to the ground, a distance of 12 feet. Moreover, the passengers had to be standing to release the latches and climb through the emergency exit windows—which was complicated by the rapid propagation of the fire, and the heavy, thick black smoke that quickly obscured the motorcoach interior and subjected the passengers to toxic fumes. Standing upright during a fire is counter to the common convention of staying low and crawling to safety to avoid inhaling and succumbing to potentially toxic smoke. Furthermore, the intense heat from the fire, coupled with the oppressive smoke, cut off all practical egress in a matter of minutes.

Forensic autopsy results confirmed that each of the three fatally injured occupants found inside the motorcoach died from asphyxia due to the inhalation of products of combustion. Two of the three passengers had no signs of blunt force trauma or any observable incapacitating injuries, and the third had sustained a left upper arm fracture. Two of these passengers, who had originally been seated farther from the impact area, were found postcrash in the aisle and near the wheelchair lift door, and had carboxyhemoglobin levels of 18 percent and 45 percent, respectively.[83] The NTSB concludes that the quick-spreading fire and thick smoke prevented at least two passengers from extricating themselves from the motorcoach, resulting in their fatal injuries.

2.7.1 Interior Emergency Lighting and Emergency Exit Signage

FMVSS requirements for buses specify that emergency exit markings must be legible to occupants seated in the adjacent seat, seated in the seat directly adjoining the adjacent seat, and standing in the aisle location that is closest to that adjacent seat. The markings must be legible from each of these locations when the other two corresponding locations are occupied, where the source of light is the normal nighttime illumination of the bus interior.[84] The current FMVSS has no requirement that emergency exit signage be visible to motorcoach passengers in the event of an emergency, where the interior is darkened either by smoke or as a result of a crash where the electrical system that provides nighttime interior illumination is damaged.[85] Moreover, other modes of transportation, such as aviation and rail passenger transport, have requirements for emergency lighting. For example, in the aviation industry, carriers are required to install interior emergency floor lighting to illuminate a pathway to emergency exits—and to ensure that passengers are aware of the lighting. Regardless of the mode of transportation, emergency lighting decreases the likelihood of death or injury from either panic or the inability to find an available exit.

[83] Passengers seated toward the front of the motorcoach mentioned stepping on a fallen passenger as they rushed toward the back, away from the fire. A 17-year-old female was found in the aisle of the motorcoach toward the front (near the driver side second window); prior to the crash, she had been seated on the passenger side in the aisle seat in row 5. Another 17-year-old female was found in row 8 on the passenger side, facing rearward with her knees on the seatpan next to the window; she had originally been seated on the driver side in the window seat in row 4. A 25-year-old female was found at the front of the motorcoach on the driver side; she had originally been seated on the driver side lying across the seat in row 1.

[84] See 49 CFR 571.217.S5.5.2.

[85] In Europe, fire testing research documented that igniting a liter of fuel on a motorcoach seat caused the vehicle interior to fill with smoke down to the level of the headrest (which is about the height of most emergency exit signage) within 44 seconds.

2.7.2 Emergency Exit Windows

The NTSB has investigated several motorcoach crashes involving impeded and difficult evacuations, with corresponding injuries due to heavy windows and a greater than 7-foot fall to the ground from the window exits. In emergency situations, window height and design can injure passengers, or hinder or prevent their timely egress, especially in a situation involving a rapidly propagating fire. Although the Orland motorcoach was equipped with emergency egress windows, only two or three windows were used by 33 passengers because:

- Student passengers had not been instructed on the availability of the window exits or how to use them, and some were unaware of their potential as a means of exit during an evacuation.

- Most of the passengers reported that they were hesitant to jump from the windows and the windows would not stay open, which caused them to spend valuable time negotiating the movements necessary to escape.

Depending on the type of crash—such as fire, submersion in water, collision, rollover, or operational failure—the front door of the motorcoach and some exit windows may be unavailable for escape. As previously described, the windows of a motorcoach are typically 7 feet above ground, which is a distance higher than the wings of some airplanes, such as the 727, 737, and Canadair regional jet. Although FAA regulations require an approved means to assist passengers in descending from an exit higher than 6 feet above ground, no such federal regulations are in place for the motorcoach industry. In Europe, the minimum number of doors in a bus or motorcoach is two, either two service doors or one service door and one emergency door. In addition, every emergency window that is hinged at the top is provided with an appropriate mechanism to hold it open.[86]

Research has shown that, under the stress of an evacuation, passengers do not necessarily use the most appropriate exit. Passengers in such situations are less able to cope with new equipment and information if it is not intuitive or does not match their immediate expectations, and their natural inclination is to leave by the exits they recognize, such as the front loading door (ICE Ergonomics Ltd. 1996, 5). To achieve a safe and effective evacuation with minimal panic, passengers must have a basic understanding of the function of exits (as discussed in section 2.6) and be able to identify emergency exits and to read their instructions in poor lighting or smoke-filled environments.[87]

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[86] ECE 36, "Uniform Provisions Concerning the Approval of Large Passenger Vehicles With Regard to Their General Construction," governs emergency exits, signage, and lighting for large buses built for operation in European countries.

[87] The FAA had determined that floor lighting could improve the evacuation rate by 20 percent under certain conditions. As a result, by 1986, the US commercial fleet was retrofitted with floor proximity lighting.

2.7.3 Emergency Interior Lighting and Signage Historical Review

The NTSB has investigated a number of motorcoach crashes involving either fire or darkness in which passengers reported issues in seeing emergency exit signage or in egressing from the vehicle. The NTSB has long maintained that the capability to quickly evacuate buses and motorcoaches in emergencies is essential. Thirty years ago, as a result of the investigation of a truck–bus head-on collision near Laredo, Texas, in October 1984, the NTSB recommended that the Federal Highway Administration (FHWA), in conjunction with NHTSA, adopt standards to require emergency interior lighting for intercity-type buses that is of sufficient intensity and duration to aid occupants in identifying exit routes and to aid rescuers in assisting injured occupants (NTSB 1985).[88] When the FHWA responded that it did not find sufficient justification to issue standards for emergency interior lighting for intercity buses, Safety Recommendation H-86-63 was classified "Closed—Unacceptable Action."

In addition, the NTSB has investigated several crashes in which a bus left the roadway and either rolled or vaulted into water, making evacuation difficult. In May 1986, a charter motorcoach rolled over 360 degrees into the Walker River near Walker, California (NTSB 1987). Twenty-one of the 41 occupants, who were mostly senior citizens, died. Of those 21, seven had drowned. Then, in August 1996, a 1980 TMC motorcoach, operated by Greyhound, drove off the right side of I-95 and came to rest upright in Chockoyotte Creek, near Roanoke Rapids, North Carolina.[89] Of the 50 occupants, 19 were injured.

In another crash, in July 1997, a 1985 TMC motorcoach, operated by Rite-Way Transportation, Inc., drifted off I-95 near Stony Creek, Virginia, and down an embankment into the Nottoway River. One passenger was killed, and the driver and 31 passengers were injured. The motorcoach came to rest on its left side, partially submerged in water (NTSB 1999b). The front of the motorcoach was severely damaged, and the vehicle immediately began to fill with water. Some of the passengers, who were as young as 11 years old, could not push the heavy emergency windows open far enough to evacuate. Other passengers said that they had trouble keeping their heads above water and seeing through the murky water to read the emergency window operating instructions. The motorcoach was submerged in water up to the bottom of the push-out emergency windows, and some passengers panicked because the windows would not stay open. The NTSB concluded that some passengers—especially children, senior citizens, and injury victims—lack the strength and height required to open an emergency window, particularly when a motorcoach is not upright. The NTSB recommended that NHTSA:

> Revise the Federal Motor Vehicle Safety Standard 217, "Bus Window Retention and Release," to require that other than floor-level emergency exits can be easily opened and remain open during an emergency evacuation when a motorcoach is upright or at unusual attitudes. (H-99-9)

[88] At the time Safety Recommendation H-86-63 was issued, the FHWA had oversight of commercial vehicle operation. The FMCSA was established on January 1, 2000.

[89] For more detailed information, see the NTSB public docket for this crash (SRH96FH015).

The lack of motorcoach emergency interior lighting and retroreflective signage proved to be a problem in a June 1998 run-off-the-road rear-end collision between a motorcoach and a truck-tractor semitrailer near Burnt Cabins, Pennsylvania (NTSB 2000). According to passengers, the bus was "pitch black" after the crash. Lighting conditions on the bus were such that the surviving passengers had difficulty locating and operating the emergency exit windows, which slowed the evacuation. The NTSB made the following recommendations to NHTSA:

> Revise the Federal Motor Vehicle Safety Standards to require that all motorcoaches be equipped with emergency lighting fixtures that are outfitted with a self-contained independent power source. (H-00-1)
>
> Revise the Federal Motor Vehicle Safety Standards to require the use of interior luminescent or exterior retroreflective material or both to mark all emergency exits in all motorcoaches. (H-00-2)

Safety Recommendations H-99-9 and H-00-1 and -2 are currently classified "Open—Unacceptable Response."

In response to the NTSB emergency egress recommendations, in October 2000, NHTSA reported that it had met with motorcoach manufacturers to examine sharing the costs of research to produce appropriate emergency lighting standards. NHTSA also reported that it intended to pursue the feasibility of requiring emergency lighting systems and the marking of emergency exits; and that, if the cooperative research program did not materialize, it intended to explore other means of addressing these issues. However, in 2003, NHTSA informed the NTSB that it was aware of only two motorcoach crashes (both investigated by the NTSB) where interior or exterior emergency exit lighting would have been beneficial to the crash victims. Therefore, NHTSA maintained that safety would be better served by upgrading FMVSS 217, the standard covering requirements for bus emergency exits and window retention and release—though it stated that additional research was needed to do so.[90]

In June 2005, NHTSA informed the NTSB that no manufacturers offered photoluminescent emergency exit labels or materials for highway transportation vehicles. The agency stated that it was gathering information on the performance specifications of such materials used in other applications to determine if they could be cost effectively modified for highway vehicles.[91]

In 2010, NHTSA stated that it had completed a 2-year research study at the Volpe Center to examine motorcoach emergency egress, including the number, size, and type of emergency exits; the force required to open them; and their signage and illumination. This study was conducted in response to Safety Recommendation H-07-8, from the Wilmer, Texas,

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[90] This NHTSA response also pertained to Safety Recommendation H-99-9. NHTSA entered into a joint research program with Transport Canada to examine worldwide motorcoach regulations, including those in Europe and Australia.

[91] NHTSA stated that a key priority for the FMVSS 217 effort was to identify new technologies or options for illuminating and labeling the exits on buses; according to NHTSA, this issue was "especially important" for nighttime crashes. Key issues were the size of the lettering used, duration of luminance (for example, 2, 3, 6, or 8 hours), test procedures, and cost.

investigation, in which the NTSB asked that NHTSA evaluate current emergency evacuation designs of motorcoaches and buses, taking into account acceptable egress times for postcrash environments, including fire and smoke; unavailable exit situations; and the current above-ground height and design of window exits (NTSB 2007). Safety Recommendation H-07-8 is currently classified “Open—Acceptable Response.”

The Volpe Center research included simulation studies examining egress times for various crash environments, egress models, and occupants. Volpe recommendations included the following:

- An additional emergency exit door or a second service door that can be used as the primary means of emergency egress.

- Larger size exit signs and instructions, using high-performance photoluminescent material to assist passengers with locating and operating the emergency exits.

- Crash-survivable emergency exit lighting to assist passengers with locating and operating emergency exits.

- Dual-mode emergency exit signage, integrating electric illumination using an independent power source and photoluminescent material to provide the highest conspicuity, legibility, and probability of functionality in a severe motorcoach crash under darkness conditions.

In February 2014—just 2 months before the Orland crash—the NTSB wrote to NHTSA, stating that though we had been encouraged by its progress in evaluating effective motorcoach passenger egress measures, we were concerned with the lack of expediency. The NTSB urged NHTSA to promptly move forward with rulemaking to improve current egress standards. Safety Recommendations H-00-1 and -2 still had not been implemented, almost 14 years after their issuance. Beyond the Volpe Center study, NHTSA has not moved to implement improved emergency exit signage and interior emergency lighting in motorcoaches and buses. Other DOT modal agencies recognize that postcrash—or in the event of an in-route fire—when passengers are evacuating, buoyant hot smoke and gases can fill the cabin to floor level, obscuring overhead lighting. Clearly, the use of lights, reflectors, or other devices to mark the emergency escape path along the floor improves the speed and efficiency of passenger evacuation.

2.7.4 Safety Recommendations

In the Orland crash, the postcrash fire quickly diminished visibility for passengers within the motorcoach, severely restricting their ability to identify or read emergency exit signage, even in broad daylight conditions. A lack of clearly visible emergency egress signage and proper lighting may have contributed to the number of fatalities. Expedient emergency egress requires readily identifiable emergency window exit signage and adequate emergency lighting—both of which are vital in a smoke-filled enclosed vehicle with a rapidly progressing fire/heat/toxic environment.

Current FMVSS requirements specifying that motorcoach emergency exit markings be legible to occupants standing in the aisle when the source of light is the normal nighttime illumination of the bus interior are inadequate in situations with thick smoke, darkness, or lack of emergency lighting. Motorcoach passengers should be afforded the same level of cabin safety as those traveling by airplane or train. The NTSB concludes that the lack of emergency lighting fixtures with self-contained independent power sources contributes to delays in the evacuation of motorcoach and bus passengers. Additionally, the NTSB concludes that FMVSS 217 lacks adequate safety requirements for emergency lighting and interior luminescent and exterior retroreflective emergency signage in the event of a crash, fire, or other emergency. The NTSB, therefore, reiterates Safety Recommendations H-00-1 and -2 to NHTSA.

For more than 30 years, the NTSB has addressed the issue of motorcoach emergency evacuations (NTSB 1968; 1974).[92] The circumstances of the Wilmer, Texas, fire and the Orland postcrash fire—along with the increasing number of tire and engine fires noted by the industry—highlight the critical need to evaluate the adequacy of current motorcoach emergency egress design (NTSB 2007). In any such evaluation, passenger negotiation of the more than 7-foot window drop as a means of escape cannot be ignored. Yet, today, decades after the release of the DOT reports on evacuation of intercity buses and evacuation of elderly and disabled passengers from paratransit vans and buses, motorcoach designs still incorporate the same window exit heights (DOT 1984; FHWA 1977).

The NTSB identified the first step to improving emergency egress for motorcoaches as studying actual evacuation scenarios—such as darkness, fire- and smoke-impaired vision, and water submersion—involving all passenger populations. Motorcoaches and buses must be designed to accommodate the rapid egress of all persons in an emergency situation. ECE 36 requires two doors, one of which must be a service door.[93] Currently, some manufacturers (most of which are European and also produce buses regulated by ECE 36) offer a second door, either as a wheelchair lift service door or a passenger loading door. If redesigned with proper safety measures and a release handle permitting passengers to open the door from the inside, a wheelchair access door could provide a secondary or alternate means of emergency egress. This second door provides an additional exit option, one that does not involve a 7-foot drop to the ground.[94]

Twenty-one of the 29 Orland motorcoach passengers interviewed indicated that they sustained some type of injury as a result of having to jump from the windows to the ground. The NTSB concludes that the combination of the visibility issues due to smoke and a darkened interior, and concern over the risk of injury from exiting by way of the windows, negatively affected passengers trying to evacuate the motorcoach. To facilitate emergency evacuations, emergency exits and windows should be designed such that they can be easily

[92] See the NTSB public docket for the Roanoke Rapids, North Carolina, crash (SRH96FH015).

[93] ECE 36, "Uniform Provisions Concerning the Approval of Large Passenger Vehicles With Regard to Their General Construction."

[94] The Orland accident motorcoach was equipped with a wheelchair lift side door. It should be noted, however, that even when the door is mechanically operable, it is locked and can only be opened with a key, which the driver may not have in his or her possession.

opened by all potential passengers and remain open in the event of an emergency or collision. For these reasons, therefore, the NTSB reiterates Safety Recommendation H-99-9 to NHTSA.

FMVSS 217 requires that motorcoaches and buses provide side emergency exit windows and at least one rear emergency exit door. However, motorcoaches and buses with a rear engine are permitted to have (instead of a rear exit door) at least one emergency roof exit hatch. The roof hatch can be found in most motorcoaches manufactured in the last 20 years for the US market (Pollard and Markos 2009). Nevertheless, as is common in Europe, a secondary door either at the midpoint or the rear of the motorcoach should be required to allow passengers to stay low, avoid the fire-related heat and smoke, and rapidly egress. Based on the market availability of secondary service doors or wheelchair lift doors—and the fact that they are currently permitted, though not required, under US federal safety standards—they should be a standard component of any emergency egress regulation applicable to all new high-occupancy commercial passenger vehicles. An additional door exit, located on the side and in the middle or rear half of the bus for passenger egress, could either be added as another curb-height side service door or be modified from the floor-level wheelchair access door to permit it to be opened from inside for use as an emergency exit. The NTSB concludes that the evacuation of motorcoaches can be improved by the availability of a secondary door for emergency egress. The NTSB further concludes that having a secondary door for use as an emergency exit would expedite the evacuation process and reduce the need for passengers to jump from windows, thereby mitigating the potential for fatalities and injuries. The NTSB recommends that NHTSA require new motorcoach and bus designs to include a secondary door for use as an additional emergency exit.

2.8 Event Data Recorders

The truck-tractor was equipped with an ECM capable of recording certain vehicle-related data in the event of sudden deceleration or hard braking. The motorcoach was equipped with a CPC capable of recording vehicle-related data, including—but not limited to—vehicle speed, engine speed, throttle usage, cruise control usage, brake pedal application, and clutch pedal application.

Certain electronic data were recovered from each of the involved vehicles following the collision. These data generally fell into one of two categories:

- Location data acquired from both the truck-tractor and the motorcoach, which were GPS-based and either captured data at predetermined intervals or as a function of changes in travel (for example, predetermined geographic locations).

- Event data acquired from the passenger car, which rely on a triggering event (for example, acceleration preceding a restraint system deployment).

As a result of the collision and postcrash fire, however, both the truck-tractor ECM and the motorcoach CPC were too damaged to yield any event-related information. Data from the passenger car, though, were useful for impact and precollision analysis.

Although the heavy vehicle modules had the potential to record data, neither was a dedicated crash EDR—which would likely have survived the forces and thermal conditions of the Orland crash, and would have provided critical data on driver inputs and vehicle dynamics throughout the collision sequence. Incorporating longer pre-event recording times, learning as much as possible about a heavy vehicle driver's precrash activities and vehicle control input, and gaining knowledge of the real-world crash dynamics of a collision would yield crucial information for the future development of safer highway vehicles.

2.8.1 Event Data Recorders Historical Review

The NTSB has a long history of advocating technology to record crash data in all modes of transportation. Cockpit voice recorders and flight data recorders have been required on commercial airliners for decades. Since 1993, event recorders have been required on trains. In marine transportation, voyage data recorders are now required on all international passenger and cargo ships.

NTSB recommendations for recorders in highway transportation date to 1990, when Safety Recommendation H-90-28 was issued to the FHWA, asking that recording devices be required to identify commercial truck drivers who exceed hours-of-service (HOS) regulations (NTSB 1999). The FHWA replied that "the benefits and practicality of on-board recorders must be firmly established before rulemaking ensues." In 1997, Safety Recommendation H-90-28 was classified "Closed—Unacceptable Action" due to the lack of response from the FHWA.

As the result of a crash investigation involving two truck-tractor semitrailers in Slinger, Wisconsin, in February 1997, the NTSB issued Safety Recommendations H-98-23 and -26 to truck industry associations (NTSB 1998), requesting that they advise their members to equip their commercial vehicle fleets with recording devices to identify both driver and vehicle operating characteristics. No action was taken on either recommendation. In 2001, the NTSB classified Safety Recommendations H-98-23 and -26 "Closed—Unacceptable Action."

The NTSB has also made recommendations concerning the development of standards and requirements for EDRs in heavy vehicles that carry passengers—specifically, school buses and motorcoaches. In a special investigation of bus crashworthiness, the NTSB (1999a) made two EDR recommendations to NHTSA (Safety Recommendations H-99-53 and -54):

> Develop and implement, in cooperation with other Government agencies and industry, standards for on-board recording of bus crash data that address, at a minimum, parameters to be recorded, data sampling rates, duration of recording, interface configurations, data storage format, incorporation of fleet management tools, fluid immersion survivability, impact shock survivability, crush and penetration survivability, fire survivability, independent power supply, and ability to accommodate future requirements and technological advances. (H-99-54)

Safety Recommendation H-99-53 is not listed above because it was superseded by Safety Recommendation H-10-7, as discussed below.

As the result of an investigation of a bus loss-of-control and rollover in Dolan Springs, Arizona, in January 2009, the NTSB (2010a) recommended that NHTSA:

> 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)

Upon issuance of Safety Recommendation H-10-7, Safety Recommendation H-99-53 was classified "Closed—Unacceptable Action/Superseded." Safety Recommendations H-99-54 and H-10-7 are currently classified "Open–Unacceptable Response."

Additionally, in the investigation of a heavy vehicle collision in Miami, Oklahoma, in June 2009, in which there were 10 fatalities, the NTSB (2010b) made the following recommendations to NHTSA:

> Develop and implement minimum performance standards for event data recorders for trucks with gross vehicle weight ratings over 10,000 pounds that address, at a minimum, the following elements: data parameters to be recorded; data sampling rates; duration of recorded event; standardized or universal data imaging interface; data storage format; and device and data survivability for crush, impact, fluid exposure and immersion, and thermal exposure. The standards should also require that the event data recorder be capable of capturing and preserving data in the case of a power interruption or loss, and of accommodating future requirements and technological advances, such as flashable and/or reprogrammable operating system software and/or firmware updates. (H-10-14)

> After establishing performance standards for event data recorders for trucks with gross vehicle weight ratings over 10,000 pounds, require that all such vehicles be equipped with event data recorders meeting the standards. (H-10-15)

To date, NHTSA has failed to develop standards or require the use of EDRs for heavy vehicles, which include motorcoaches, school buses, or truck-tractor units such as the one involved in the Orland collision. Had the accident truck-tractor and the motorcoach been equipped with dedicated crash EDRs built to minimum performance standards—which include device and data survivability—vital precrash and crash information could have been captured, allowing for a more comprehensive investigation and analysis. Both Safety Recommendations H-10-14 and -15 are currently classified "Open—Unacceptable Response."

2.8.2 Safety Recommendations

The lack of EDR data for the Orland collision represents another missed opportunity to better understand why and how the crash occurred. The NTSB concludes that, due to a lack of standards and requirements for heavy vehicle EDRs, crash data essential to better understanding collisions continue to go unrecorded, thus impeding improvements in highway safety. Therefore, the NTSB reiterates Safety Recommendations H-99-54 and H-10-7, -14, and -15 to NHTSA.

3 Conclusions

3.1 Findings

1. None of the following were factors in the crash: (1) truck or motorcoach driver experience, licensing, or alcohol or drug use; (2) driver distraction or operational error; (3) motor carrier operations; (4) mechanical condition of either vehicle; or (5) weather.

2. The emergency response to the crash was timely and effective.

3. The truck driver did not depart the roadway to avoid another vehicle or a roadway obstruction.

4. The circumstances of the crash, such as the driver's work and rest history and his complete lack of reaction to the roadway departure and crash event stimuli, are inconsistent with fatigue as a causal factor.

5. Based on the truck driver's lack of braking or other appropriate reaction prior to or during the crash sequence—and witness accounts concerning the driver's behavior and condition—he was unresponsive due to an unknown cause, which prevented him from controlling his vehicle and led to the crash.

6. Based on the state of California's median barrier application policies, which are more robust than national guidelines, the Orland crash location on Interstate 5 did not warrant a median barrier due to the average daily traffic and crash history.

7. The catastrophic rupture of the truck-tractor fuel tank released fuel that sprayed into the interior of the motorcoach, resulting in the fire and causing fatal and serious injuries to numerous motorcoach occupants.

8. Federal Motor Vehicle Safety Standard 302 does not adequately account for modern vehicle interior components or conditions experienced in real-world vehicle fires, nor does it include specific fire-resistant material standards more appropriate for large commercial vehicles with increased passenger capacity.

9. The lack of a pretrip safety briefing led to confusion and panic during the motorcoach evacuation, as many passengers struggled to locate and open the emergency exit windows.

10. The quick-spreading fire and thick smoke prevented at least two passengers from extricating themselves from the motorcoach, resulting in their fatal injuries.

11. The lack of emergency lighting fixtures with self-contained independent power sources contributes to delays in the evacuation of motorcoach and bus passengers.

12. Federal Motor Vehicle Safety Standard 217 lacks adequate safety requirements for emergency lighting and interior luminescent and exterior retroreflective emergency signage in the event of a crash, fire, or other emergency.

13. The combination of the visibility issues due to smoke and a darkened interior, and concern over the risk of injury from exiting by way of the windows, negatively affected passengers trying to evacuate the motorcoach.

14. The evacuation of motorcoaches can be improved by the availability of a secondary door for emergency egress.

15. Having a secondary door for use as an emergency exit would expedite the evacuation process and reduce the need for passengers to jump from windows, thereby mitigating the potential for fatalities and injuries.

16. Due to a lack of standards and requirements for heavy vehicle event data recorders, crash data essential to better understanding collisions continue to go unrecorded, thus impeding improvements in highway safety.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of the Orland, California, crash was the inability of the FedEx Freight truck driver to maintain control of the vehicle due to his unresponsiveness for reasons that could not be established from available information. Contributing to the severity of some motorcoach occupant injuries were high impact forces; the release of combustible fluids, leading to a fast-spreading postcrash fire; difficulties in motorcoach egress; and lack of restraint use.

4 Recommendations

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

4.1 New Recommendations

To the National Highway Traffic Safety Administration:

> Revise Federal Motor Vehicle Safety Standard 302 to adopt the more rigorous performance standards for interior flammability and smoke emissions characteristics already in use throughout the US Department of Transportation for commercial aviation and rail passenger transportation. (H-15-12)
>
> Require new motorcoach and bus designs to include a secondary door for use as an additional emergency exit. (H-15-13)

To the Federal Motor Carrier Safety Administration:

> Require all passenger motor carrier operators to (1) provide passengers with pretrip safety information that includes, at a minimum, a demonstration of the location of all exits, explains how to operate the exits in an emergency, and emphasizes the importance of wearing seat belts, if available; and (2) also place printed instructions in readily accessible locations for each passenger to help reinforce exit operation and seat belt usage. (H-15-14) (Supersedes Safety Recommendation H-99-8)
>
> Update your website guidance to include information on the mandated three-point restraints effective November 2016 for all new over-the-road buses and for other than over-the-road buses with a gross vehicle weight rating greater than 11,793 kilograms (26,000 pounds). (H-15-15)

4.2 Previously Issued Recommendations Reiterated in This Report

The National Transportation Safety Board also reiterates the following safety recommendations:

To the National Highway Traffic Safety Administration:

> Revise the Federal Motor Vehicle Safety Standard 217, "Bus Window Retention and Release," to require that other than floor-level emergency exits can be easily opened and remain open during an emergency evacuation when a motorcoach is upright or at unusual attitudes. (H-99-9)

Develop and implement, in cooperation with other Government agencies and industry, standards for on-board recording of bus crash data that address, at a minimum, parameters to be recorded, data sampling rates, duration of recording, interface configurations, data storage format, incorporation of fleet management tools, fluid immersion survivability, impact shock survivability, crush and penetration survivability, fire survivability, independent power supply, and ability to accommodate future requirements and technological advances. (H-99-54)

Revise the Federal Motor Vehicle Safety Standards to require that all motorcoaches be equipped with emergency lighting fixtures that are outfitted with a self-contained independent power source. (H-00-1)

Revise the Federal Motor Vehicle Safety Standards to require the use of interior luminescent or exterior retroreflective material or both to mark all emergency exits in all motorcoaches. (H-00-2)

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)

Develop and implement minimum performance standards for event data recorders for trucks with gross vehicle weight ratings over 10,000 pounds that address, at a minimum, the following elements: data parameters to be recorded; data sampling rates; duration of recorded event; standardized or universal data imaging interface; data storage format; and device and data survivability for crush, impact, fluid exposure and immersion, and thermal exposure. The standards should also require that the event data recorder be capable of capturing and preserving data in the case of a power interruption or loss, and of accommodating future requirements and technological advances, such as flashable and/or reprogrammable operating system software and/or firmware updates. (H-10-14)

After establishing performance standards for event data recorders for trucks with gross vehicle weight ratings over 10,000 pounds, require that all such vehicles be equipped with event data recorders meeting the standards. (H-10-15)

4.3 Previously Issued Recommendation Reclassified in This Report

The NTSB reclassifies Safety Recommendation H-99-8 from its current classification of "Open—Acceptable Alternate Response" to "Closed—Superseded" in section 2.6.2, "Safety Recommendations," of this report (superseded by Safety Recommendation H-15-14).

To the Federal Motor Carrier Safety Administration:

> Require motorcoach operators to provide passengers with pre-trip safety information. (H-99-8)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

CHRISTOPHER A. HART Chairman	**ROBERT L. SUMWALT** Member
T. BELLA DINH-ZARR Vice Chairman	**EARL F. WEENER** Member

Adopted: July 14, 2015

Appendix A: Investigation

The National Transportation Safety Board was notified of this crash on April 10, 2014, and an investigative team was dispatched. Groups were established to investigate human performance; motor carrier operations; crash reconstruction; and fire, highway, survival, and vehicle factors. Then-Member Mark R. Rosekind was the spokesperson on scene.

Parties to the investigation were representatives from the California Highway Patrol; California Department of Transportation; FedEx Freight, Inc.; Silverado Stages, Inc.; Eaton Corporation LLC; and TRW Automotive.

No depositions were taken, and no public hearing was held.

Appendix B: Responding Emergency Agencies

Law Enforcement, Fire, Medical Agencies, and Other Services

Federal
US Forest Service
State
California Highway Patrol (CHP)
California Highway Patrol - Multidisciplinary Accident Investigation Team (MAIT)
California Department of Public Health Emergency Preparedness Office Medical and Health Operational Area Coordinator Regional Disaster Medical Health Specialist
California Department of Transportation (Caltrans)
California Emergency Medical Services Authority
California Office of Emergency Services
California State University, Humboldt
Local Emergency Response
Police
Glenn County Sheriff's Office Search and Rescue Office of Emergency Services Coroner
Orland Police Department
Orland Volunteers in Police Service
Willows Police Department
Fire
Artois Volunteer Fire Department
Bayliss Volunteer Fire Department
Capay Volunteer Fire Department
Corning Fire Department
Glenn Codora Volunteer Fire Department
Hamilton Fire Department
Kanawha Volunteer Fire Department
Orland Volunteer Fire Department
Red Bluff Fire Department
Tehama County Fire Department (in cooperation with California Department of Forestry and Fire Protection)
Willows Fire Department
EMS/Ambulance
Butte County EMS (includes Willows Ambulance)
CalStar Medical Helicopter

Colusa Ground Ambulance Service (with Enloe Medical Center)
Dignity Healthcare EMS
Enloe EMS (FlightCare Helicopter / Medical Center Ambulance)
Nor-Cal EMS
REACH Medical Helicopter
Redding Ambulance (from Mercy Medical Center)
Shasta Regional Medical Center Ambulance
Sierra-Sacrament Valley EMS
St. Elizabeth Community Hospital Ambulance
Westside Ambulance Service, Inc.
Hospitals
Enloe Medical Center (medical control facility)
Glenn Medical Center
Mercy Medical Center
Oroville Hospital
Shasta Regional Medical Center
St. Elizabeth Community Hospital
University of California, Davis Medical Center
Other
American Red Cross – Sacramento Chapter
Glenn County Health & Human Services Agency Planning and Public Works Agency
Los Angeles Unified School District
Orland Memorial Hall
Orland Unified School District
Salvation Army

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