Motorcoach Run-Off-the-Road and Collision With Vertical Highway Signpost
State Route 99
Livingston, California
August 2, 2016

Accident Report

NTSB/HAR-17/03
PB2018-100069

National Transportation Safety Board

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Adopted October 13, 2017

Highway Accident Report

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National Transportation Safety Board

490 L'Enfant Plaza SW
Washington, DC 20594

National Transportation Safety Board. 2017. *Motorcoach Run-Off-the-Road and Collision With Vertical Highway Signpost, State Route 99, Livingston, California, August 2, 2016*. Highway Accident Report NTSB/HAR-17/03. Washington, DC.

Abstract: On August 2, 2016, about 3:18 a.m., a 1998 Van Hool 49-passenger motorcoach, operated by Autobuses Coordinados USA Inc., was traveling north on State Route 99, from Los Angeles to Modesto, California, when it departed the travel lanes to the right, crossed the paved shoulder, struck a W-beam guardrail, and collided with a 14-inch-diameter vertical highway signpost. The motorcoach was occupied by the driver and 24 passengers. The signpost entered the passenger compartment at the stepwell entry area. As the vehicle continued forward, the signpost tore the right (passenger side) sidewall, cargo bays, and roof from the bus body for almost its entire length. Four passengers died, 19 received serious-to-minor injuries, and one was not injured. The bus driver was seriously injured. The crash investigation focused on the following safety issues: driver fatigue, poor safety management controls by Autobuses Coordinados, inadequate federal safety ratings for passenger motor carriers with a pattern of driver and vehicle violations, and the need for highway barrier systems capable of safely redirecting heavy commercial passenger vehicles from point hazards. The NTSB made new safety recommendations to the Federal Highway Administration (FHWA) and the American Association of State Highway and Transportation Officials (AASHTO). The NTSB also reiterated a recommendation to the Federal Motor Carrier Safety Administration (FMCSA), reiterated and reclassified recommendations to the FMCSA and to AASHTO, and reclassified recommendations to the FHWA and to AASHTO.

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Acronyms and Abbreviations

AAA	American Automobile Association
AASHTO	American Association of State Highway and Transportation Officials
ABS	antilock braking system
BASIC	behavior analysis and safety improvement category [FMCSA]
BMI	body mass index
Caltrans	California Department of Transportation
CDL	commercial driver's license
CDLIS	Commercial Driver's License Information System
CFR	*Code of Federal Regulations*
CHP	California Highway Patrol
CLP	commercial learner's permit
CMV	commercial motor vehicle
CR	compliance review
CSA	Compliance, Safety, Accountability program [FMCSA]
CSMS	Carrier Safety Measurement System [FMCSA]
CVC	*California Vehicle Code*
CVSA	Commercial Vehicle Safety Alliance
DMV	Department of Motor Vehicles [California]
DOT	US Department of Transportation
ECM	electronic control module
EPN	employer pull notice [California]
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration

FMCSRs	*Federal Motor Carrier Safety Regulations*
FR	*Federal Register*
FY	fiscal year
GVWR	gross vehicle weight rating
HOS	hours-of-service
I-95	Interstate 95
MASH	*Manual for Assessing Safety Hardware* [AASHTO]
MP	milepost
NCHRP	National Cooperative Highway Research Program
NDR	National Driver Register
NHTSA	National Highway Traffic Safety Administration
NPRM	Notice of Proposed Rulemaking
NTSB	National Transportation Safety Board
OOS	out-of-service
PCP	phencyclidine
RDG	*Roadside Design Guide* [AASHTO]
SFD	safety fitness determination process [FMCSA]
SR-99	State Route 99
SRT	slotted rail terminal
TL	test level (1–6)
TRB	Transportation Research Board

Executive Summary

Investigation Synopsis

On Tuesday, August 2, 2016, about 3:18 a.m. Pacific daylight time, a 1998 Van Hool 49-passenger motorcoach, operated by Autobuses Coordinados USA Inc., was traveling north on State Route 99, from Los Angeles to Modesto, California, when it departed the travel lanes to the right, crossed the paved shoulder, struck a W-beam guardrail, and collided with a 14-inch-diameter vertical highway signpost. The motorcoach was occupied by the driver and 24 passengers. The signpost entered the passenger compartment at the stepwell entry area. As the vehicle continued forward, the signpost tore the right (passenger side) sidewall, cargo bays, and roof from the bus body for almost its entire length. Four passengers died, 19 received serious-to-minor injuries, and one was not injured. The bus driver was seriously injured.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the Livingston, California, crash was driver fatigue resulting from acute sleep loss and circadian factors. Contributing to the cause of the crash were the inadequate safety practices of Autobuses Coordinados; and the Federal Motor Carrier Safety Administration's lack of oversight of Autobuses Coordinados, which allowed the company to continue operations despite known safety issues. Contributing to the severity of the crash were the guardrail, which was not designed to redirect the motorcoach and did not prevent it from colliding with the vertical highway signpost; and the extensive intrusion of the signpost into the passenger compartment.

Safety Issues

The crash investigation focused on the following safety issues:

- Driver fatigue.
- Poor safety management controls by Autobuses Coordinados.
- Inadequate federal safety ratings for passenger motor carriers with a pattern of driver and vehicle violations.
- Highway barrier systems capable of safely redirecting heavy commercial passenger vehicles from point hazards.

Recommendations

As a result of this investigation, the NTSB makes new safety recommendations to the Federal Highway Administration (FHWA) and to the American Association of State Highway and Transportation Officials (AASHTO). The NTSB also reiterates a recommendation to the Federal Motor Carrier Safety Administration (FMCSA), reiterates and reclassifies recommendations to the FMCSA and to AASHTO, and reclassifies recommendations to the FHWA and to AASHTO.

1 Factual Information

1.1 Crash Narrative

1.1.1 Precollision

About 3:18 a.m. on August 2, 2016, a 1998 Van Hool 49-passenger motorcoach, operated by Autobuses Coordinados USA Inc., was traveling north on State Route 99 (SR-99) in Merced County, California, near Livingston, when it departed the travel lanes, crossed the paved shoulder, struck a W-beam guardrail, and collided with a vertical highway signpost.[1] The motorcoach, carrying the driver and 24 passengers, was en route from Los Angeles to Modesto, California.

The motorcoach had departed Los Angeles about 7:30 p.m. on August 1. The driver was assigned to drive the 314-mile route segment on SR-99 north to Modesto, with multiple stops to pick up ticketed passengers.[2] The crash occurred at milepost (MP) 27.8, about 25 miles south of Modesto (see figures 1 and 2).

[1] (a) Throughout this report, times are reported in Pacific daylight time unless otherwise indicated. (b) A W-beam guardrail is a steel beam rail element shaped like a "W."

[2] (a) The Autobuses Coordinados northbound route originated in Tijuana, Mexico, with a destination of Pasco, Washington. The 1,200-mile route included multiple segments with different drivers, and pickup and drop off locations in major cities. Route stops varied depending on whether a ticketed passenger was waiting for pickup. (b) SR-99 (Golden State Highway) begins at Interstate 5 near the base of the Tehachapi Mountains in Kern County, California; passes through eight counties; and ends at State Route 36 near Red Bluff, California. SR-99 is part of the National Highway System.

Figure 1. Route map of Autobuses Coordinados motorcoach, August 1–2, 2016.

Figure 2. Aerial view of highway approach to crash site on SR-99 north, Livingston, California. (Source: National Agriculture Imagery Program, June 2014)

1.1.2 The Crash

As the motorcoach approached MP 27.8 about 3:18 a.m., it departed the travel lanes to the right, crossed the 9-foot 9-inch-wide right shoulder, and struck the W-beam guardrail. As the motorcoach overrode and displaced the guardrail, it collided with the 14-inch-diameter vertical highway signpost.

The signpost entered the passenger compartment of the motorcoach at the A-pillar and stepwell (loading door), continued toward the center until it contacted the side frame rail (under the center of the passenger-side seats), moved aft about 29 feet along this rail, and stopped forward of axle 2. Before the motorcoach came to rest, the signpost had separated the right sidewall and cargo bays from the bus body. No tire marks were made on the travel lanes to indicate braking or evasive steering by the driver. (See figure 3 for an aerial view of the crash scene and figure 4 for a diagram depicting the motorcoach striking the guardrail.)

Figure 3. Aerial view of SR-99 north lanes, showing motorcoach at final rest and impact damage caused by 14-inch-diameter signpost penetrating two-thirds of vehicle, from front to back. (Source: California Highway Patrol)

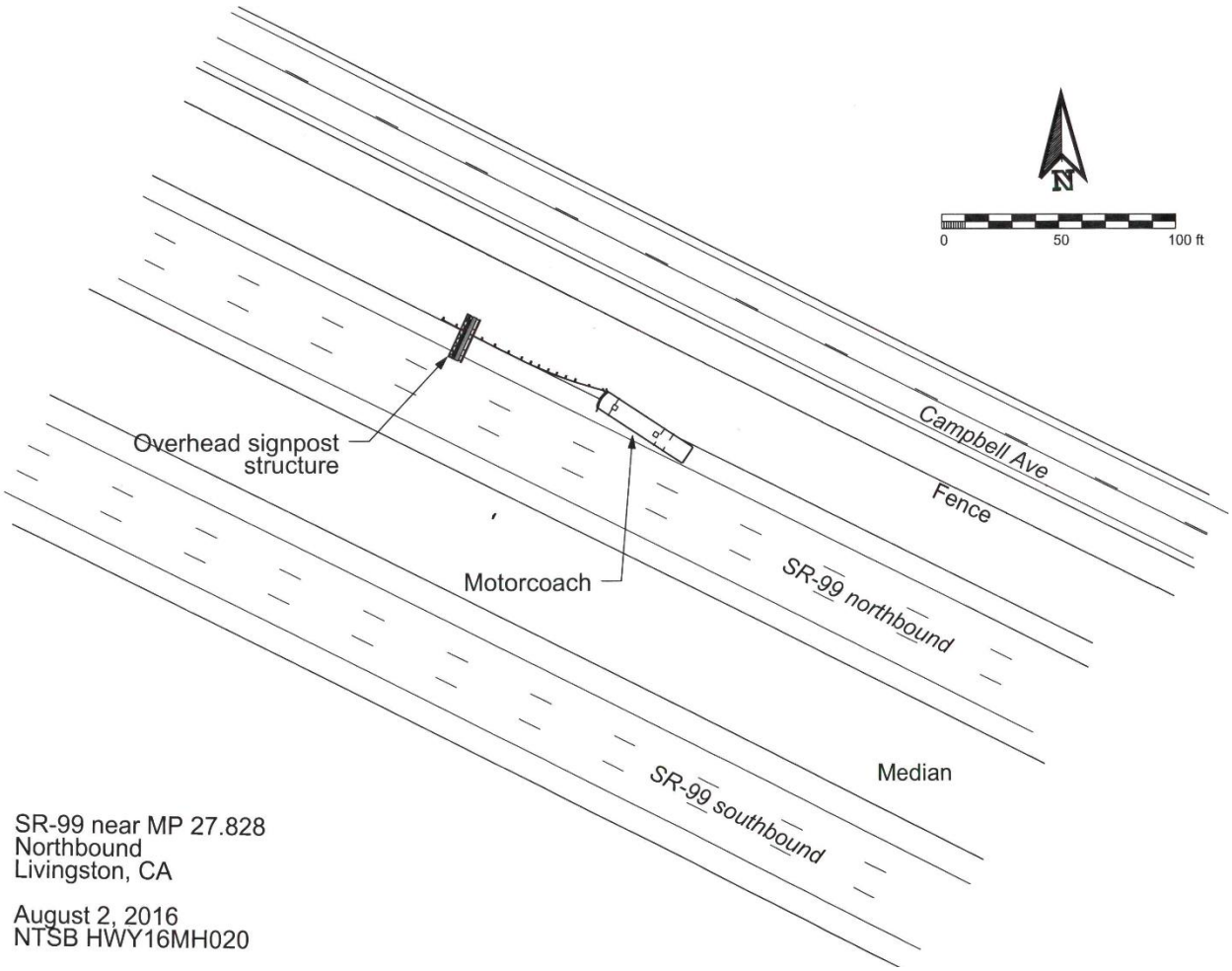

Figure 4. Crash scene diagram as motorcoach departed shoulder and first struck guardrail, 66.5 feet in advance of signpost.

A highway exit sign was mounted on top of the steel tubular signpost, which was set back just over 15 feet laterally from the edge of the travel lane. As shown in figure 5, the guardrail itself was flush with the edge of the paved shoulder adjacent to the rightmost travel lane.

Figure 5. Precrash view of SR-99 north, exit 201, Hammatt Avenue sign, showing signpost and guardrail. (Source: Google Maps, July 2016)

According to three witnesses interviewed postcrash (two of whom were bus passengers), the driver was traveling 75–80 mph. A motorist traveling about 65 mph reported that the bus passed him at an estimated speed of 75–80 mph. The speed limit on this portion of SR-99 is 65 mph for passenger cars (including commercial passenger vehicles, such as motorcoaches and buses) and 55 mph for vehicles with three or more axles (or any vehicle towing a trailer, boat, etc.).

The other two witnesses were bus passengers who reported that the bus was late for the pickups at Huntington Park and Goshen. They each commented that the driver was driving fast. One passenger observed that the driver used all lanes of the highway to pass slower moving vehicles and was speaking on his cell phone about his location. These witnesses stated that at each stop the driver rushed passengers onto the bus, seemed to be in a hurry, and departed abruptly.[3] (See appendix A for additional information on the National Transportation Safety Board [NTSB] launch to the crash scene and parties to the investigation.)

1.2 Injuries

Four motorcoach passengers died in this crash. Autopsy reports from the Merced County medical examiner state that the deaths were caused by blunt force trauma to the head, torso, and extremities. Nineteen passengers were injured; serious injuries included internal blunt force trauma, rib fractures, extremity fractures, amputations, abrasions, lacerations, and contusions. One passenger was not injured. The driver was seriously injured, either from the initial collision or from being struck by a passenger car after the crash.[4] The driver and injured passengers were

[3] Another interviewed passenger reported that he was picked up at the Goshen location about 12:40 a.m., 2 hours later than the scheduled pickup time of 10:30 p.m.

[4] The driver's medical records indicated that emergency medical services personnel reported that he was ejected and struck on scene by a passing vehicle. He sustained a closed head injury without edema, a right occipital contusion, fuel contamination, a scalp laceration, an open left superior orbital fracture, and a laceration of his left hand.

transported to local hospitals for treatment (see table 1). NTSB investigators developed the seating chart shown in figure 6 based on passenger interviews.

Table 1. Injuries.

Injury Severity[a]	Fatal	Serious	Minor	None	TOTAL
Motorcoach driver	0	1	0	0	1
Motorcoach passengers	4	9	10	1	24
TOTAL	4	10	10	1	25

[a] Although 49 *Code of Federal Regulations* (*CFR*) Part 830 pertains only to the reporting of aircraft accidents and incidents to the NTSB, section 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, muscle, 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.

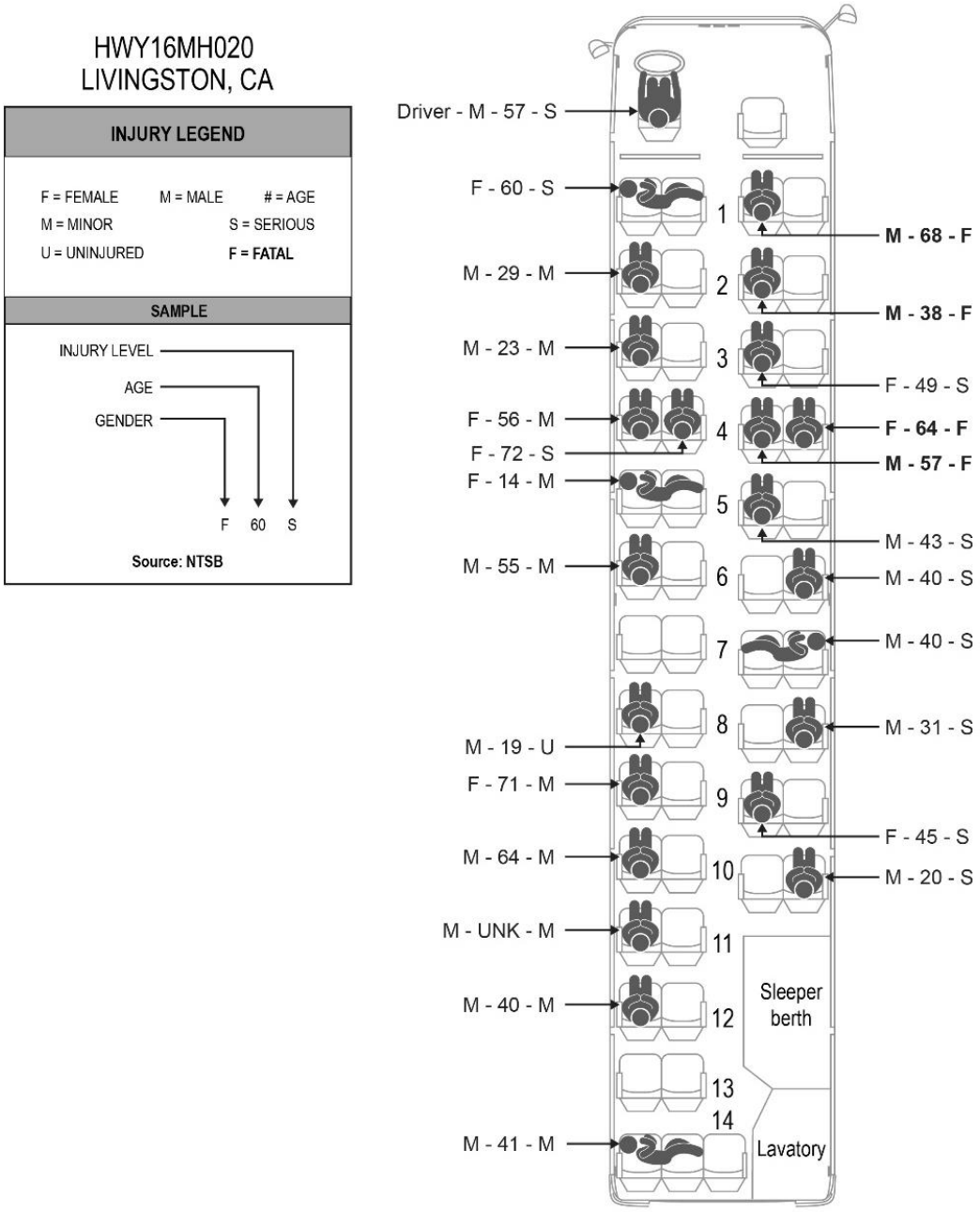

Figure 6. Motorcoach occupant seating chart with injury and demographic information.

1.3 Emergency Response

At 3:19 a.m., the California Highway Patrol (CHP) Merced communications center began receiving 911 calls reporting the crash. CHP had primary jurisdiction for the crash; its officers were dispatched and on scene by 3:29 a.m. Seventy-nine CHP units responded. CHP closed the northbound SR-99 lanes for emergency fire rescue and medical response.

The Merced County Fire Department coordinated emergency fire and medical response. By 3:24 a.m., it had dispatched seven fire units for extrication and rescue; the first engine arrived on scene at 3:28 a.m. The first ambulances arrived on scene by 3:34 a.m., and medical helicopters had landed by 3:45 a.m. In total, eight advanced life support ambulances and four air medical helicopters responded for patient triage, treatment, and transport.

1.4 Driver Information

1.4.1 License, Medical Certification, Driving History, and Employment

The 57-year-old motorcoach driver held a California class B commercial driver's license (CDL), issued on March 8, 2016, with a "P" passenger endorsement and no restrictions.[5] The CDL expired in May 2020. His current medical examiner's certificate was issued in November 2015 and expired in November 2017. The medical certificate listed no restrictions.

The California Department of Motor Vehicles (DMV) and the Commercial Driver's License Information System (CDLIS) databases showed 13 violations for the driver in the previous 19 years, as listed in table 2.[6] A search of the National Driver Register (NDR) problem driver pointer system found no indication that the driver was listed.[7] As shown in table 3, the driver was placed out of service in three roadside driver inspections in 2014 and 2015.[8]

[5] A California commercial class B driver's license permits the holder to operate, in commerce, a vehicle with a gross vehicle weight rating (GVWR) of 26,001 pounds or more. A passenger endorsement permits the holder to operate a vehicle designed to seat 10 or more people, including the driver. See the California DMV website on classes of driver licenses, accessed October 18, 2017.

[6] CDLIS is a nationwide computer system that enables state driver licensing agencies to ensure that each commercial driver has only one driver's license and one complete driver record. State driver licensing agencies use CDLIS to transmit out-of-state convictions and withdrawals, transfer the driver record when a CDL holder moves to another state, and respond to requests for driver status and history.

[7] The NDR is maintained by the National Highway Traffic Safety Administration (NHTSA), which compiles information from state licensing authorities to ensure that individual driver licensing information is complete and accessible. All 51 US jurisdictions submit information to the NDR for drivers whose licenses have been revoked, suspended, canceled, or denied, or who have been convicted of serious traffic-related offenses. Although the accident driver had numerous entries in his California driving history record and CDLIS, none of the entries met the criteria for inclusion in the NDR.

[8] Serious driver violations found during roadside inspections result in a driver out-of-service (OOS) order. This condition is so unsafe that a driver should not be allowed to proceed until it is completely remedied, as specified by the Commercial Vehicle Safety Alliance (CVSA 2015).

Table 2. State of California DMV and CDLIS accident driver violation history, 1997–2015.

Date	State	Violation[a]	Vehicle
05/15/15	Washington	Speeding	CMV
03/05/15	Oregon	Unlicensed driver (disqualified driver)	CMV
12/18/14	Oregon	Speeding >15 mph over limit	CMV
04/22/14	Washington	Improper lane change	CMV
05/07/12	California	Disobeying traffic sign	Unknown
01/18/12	California	Motor vehicle crash	Unknown
09/22/10	California	Illegal U-turn	Unknown
05/21/10	California	Red light violation	Unknown
08/21/08	California	Speeding	Unknown
11/06/06	California	Blocking highway	Unknown
10/10/00	California	Speeding	Personal
04/20/98	California	Stop sign violation	Personal
09/09/97	California	Failure to produce insurance, headlight violation	Personal

[a] The violations listed in tables 2 and 3 may not match because the driver was not issued a summons to court. If he had been issued a warning and the officer had listed the violation on the roadside inspection report, it would appear only in table 3.

Table 3. FMCSA accident driver violation and out-of-service history.

Date	State	FMCSA Violation Description[a]	Violation
02/05/15	Oregon	Driving CMV with CDL suspended for safety-related or unknown reason and in state of driver's license issuance (49 *CFR* 383.51(A)-SIN)	OOS
01/20/14	Washington	Improper lane change (49 *CFR* 392.2LC)	Non-OOS
		Speeding 6–10 mph over speed limit (49 *CFR* 392.2-SLLS2)	Non-OOS
		Driving after 10-hour driving limit (49 *CFR* 395.5(A)(1)-PASS)	OOS
01/04/14	Oregon	Driver failing to retain previous 7-day records-of-duty status (49 *CFR* 395.8K2)	OOS

[a] The violations listed in tables 2 and 3 may not match because the driver was not issued a summons to court. If he had been issued a warning and the officer had listed the violation on the roadside inspection report, it would appear only in table 3.

The *California Vehicle Code* (*CVC*) 1808.1 requires that all drivers who possess a class B CDL be enrolled in the California DMV employer pull notice (EPN) program. The EPN provides notice to employers, including self-employed drivers, when a driver is convicted of a *CVC* violation, has a crash posted to his or her driving record, is classified as a negligent operator, or has his or her license suspended or revoked.[9] According to the California DMV, the latest pull notice for the driver occurred on July 22, 2016, and was viewed by the Autobuses Coordinados owner on July 29, 2016.

The driver was hired by Autobuses Coordinados on October 10, 2010. During a postcrash CHP interview, the driver stated that his prior experience included driving interstate motorcoaches for about 11 years for various carriers, including one motorcoach that he owned. He had not attended a formal CDL course, though he had purchased a motorcoach and taught himself how to drive.[10]

1.4.2 Medical History

The accident driver's most recent medical examination for commercial driver fitness determination was conducted by a chiropractor at an occupational health clinic in Commerce, California, on November 10, 2015.[11] In the self-reporting health history section, the driver indicated "no" to having had an illness or injury in the last 5 years. The medical examiner indicated that the driver "reported negative health history; denied use of current or recent medications and does not use supplements." The driver was also noted to be a nonsmoker and nondrinker. His height was recorded as 5 feet 4 inches and weight as 144.7 pounds, corresponding to a body mass index (BMI) of 28.4.[12] The report noted no abnormalities in any of the driver's body systems. In a postcrash interview with NTSB investigators, the driver described his health as "good." He stated that he had recently been prescribed medication for depression but could not identify the medication name or the prescribing physician.[13]

1.4.3 Toxicology

Postcrash, the motorcoach driver was transported to Doctors Medical Center in Modesto, where blood and urine were collected for diagnostic and medical treatment purposes. Treatment records indicated that the driver tested negative for alcohol. The clinical drug screen results were positive for benzodiazepine. A review of hospital records showed that the positive indicator of

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[9] The EPN program requires that employers periodically obtain reports on all their class B drivers. They are obligated to keep a record stating that the reports were reviewed and signed, dated, and kept on file for inspection by CHP.

[10] Drivers seeking to obtain a CDL must pass a written test as well as a behind-the-wheel skills test. See the California DMV website, accessed April 25, 2017.

[11] The clinic's primary function is to conduct CDL medical certification exams.

[12] The US Centers for Disease Control and Prevention classify a BMI of 30 or greater as "obese." For BMI information, see the National Institutes of Health, National Heart, Lung, and Blood Institute website, accessed April 25, 2017.

[13] (a) Interviewed family members reported that the driver's wife of 25 years died in June 2016. (b) NTSB investigators were unable to identify any healthcare provider who may have treated the driver.

benzodiazepine was the result of medical treatment following the crash. Toxicological screening of the blood was negative for tested drug substances.[14]

1.4.4 Precrash Activities

NTSB investigators developed a table of activities for the motorcoach driver for the 5 days preceding the crash using records from his personal cell phone, timecards, and hours-of-service (HOS) logs. The driver's phone records (and passenger interviews) indicated that he did use his cell phone during the crash trip, including while operating the motorcoach. Because of injuries sustained in the crash, the driver was unable to recall recent events; he could not provide any information regarding when he slept in the days leading up to the crash.

Autobuses Coordinados payroll records indicated that in the 30 days preceding the crash, the driver typically worked from 8:30 a.m. to 6:30 p.m. During these shifts, he drove a roundtrip route from Los Angeles to Tijuana, Mexico. However, 2 days prior to the crash, the driver began a new shift and route. On July 31, 2016, he drove a roundtrip northbound route that departed the Los Angeles area at 7:30 p.m. and arrived in Modesto at 4:15 a.m., with multiple stops to pick up passengers. The return trip to Los Angeles departed Modesto at 4:45 a.m. and arrived at 9:30 a.m.[15]

At the end of his shift on August 1, the driver had a 9-hour off-duty period. Evidence from the driver's cell phone records indicated that he used his phone frequently during this time. Based on when his cell phone was not in use, he had a 5-hour opportunity for sleep (see table 4).[16] The driver was on duty later that day, by at least 6:51 p.m., when company receipts show that he fueled the motorcoach. The crash occurred about 8.5 hours later, at 3:18 a.m. on August 2.

[14] The blood was screened for amphetamines, barbiturates, cannabinoids, methadone, opiates, and phencyclidine (PCP).

[15] The shorter trip southbound (4.75 hours compared with 8.75 hours northbound) is due to no stops for passengers and limited traffic delays because of the time of day. Northbound stops on the day of the crash included Huntington Park, at a travel agency; Los Angeles, at the Autobuses Coordinados travel agency; and seven curbside locations: Pacoima, likely a gas station in Arleta, near the junction of Interstates 5 and 405; Bakersfield, at a restaurant; Earlimart, at a gas and liquor store; Tulare, at a vacant parking lot; Goshen, at a restaurant near Visalia; Manning, at a gas station near Fowler; and Fresno, at a gas station.

[16] Sleep opportunity generally refers to times when a driver is not on duty or not engaged in other documented activities. In this case, NTSB investigators were unable to verify whether the driver used the 5 available hours to obtain sleep.

Table 4. Motorcoach driver's precrash activities, July 28–August 2, 2016.

Time	Event	Source
Thursday, July 28, 2016		
8:30 a.m.	Departs Los Angeles, California	Payroll records
1:30 p.m.	Arrives in Tijuana, Mexico	Payroll records
2:00	Departs Tijuana	Payroll records
6:00	Arrives in Los Angeles	Payroll records
9:35	Incoming call[a]	Cell records
Friday, July 29, 2016		
2:55 a.m.	Incoming call	Cell records
3:07	Outgoing call	Cell records
6:11–8:22	Outgoing and incoming calls[b]	Cell records
9:00	Departs Los Angeles	Payroll records
1:00 p.m.	Arrives in Tijuana	Payroll records
2:00	Departs Tijuana	Payroll records
6:30	Arrives in Los Angeles	Payroll records
Saturday, July 30, 2016		
8:13 a.m.	Incoming call	Cell records
9:00	Departs Los Angeles	Payroll records
1:00 p.m.	Arrives in Tijuana	Payroll records
2:00	Departs Tijuana	Payroll records
6:00	Arrives in Los Angeles	Payroll records
8:34	Incoming call	Cell records
Sunday, July 31, 2016		
11:21 a.m.–6:35 p.m.	Incoming and outgoing calls[c]	Cell records
7:30 p.m.	Departs Los Angeles	Payroll records
Monday, August 1, 2016		
1:45 a.m.	Outgoing call – Livingston	Cell records
2:24	Incoming call – Modesto	Cell records
4:15	Arrives in Modesto	Payroll records
4:45	Departs Modesto	Payroll records
8:49	Incoming call – Los Angeles	Cell records
9:30	Arrives in Los Angeles	Payroll records
9:54	Outgoing call	Cell records

Time	Event	Source
10:00 a.m.	Goes to bed (estimated)	Family interview
10:38	Outgoing call	Cell records
12:06 p.m.	Outgoing call	Cell records
5:00	Awakes	Family interview
5:30–6:00	Departs home for work	Family interview
6:51	Purchases fuel for motorcoach in Los Angeles	Driver company receipts
7:30	Departs Los Angeles	Employee records
8:58	Incoming call – Valencia	Cell records
Tuesday, August 2, 2016		
3:08 a.m.	Incoming call (duration 30 seconds) – Merced	Cell records
3:18 a.m.	**Crash occurs**	

[a] Not all cell phone calls and text messages are listed. For additional details, see the NTSB public docket and search for NTSB accident ID HWY16MH020.

[b] Calls in this time range were logged at 6:11 a.m., 7:31 a.m., and 8:22 a.m.

[c] Calls in this time range were logged at 11:21 a.m., 12:08 p.m., 1:06 p.m., 3:06 p.m., 4:40 p.m., and 6:35 p.m.

1.4.5 Hours of Service and Record-of-Duty Status

In reconstructing the motorcoach driver's hours of service, NTSB investigators found that his logbook contained false entries and did not accurately reflect his duty status on August 1, 2016. Per 49 *Code of Federal Regulations* (*CFR*) 395.5, drivers operating passenger-carrying vehicles interstate cannot exceed 10 hours driving time or drive after having been on duty for more than 15 hours.[17] On July 31, the driver left Los Angeles at 7:30 p.m. and continued to operate until 9:30 a.m. on August 1 (about 14 hours on-duty driving). He had 30 minutes off between 4:15 and 4:45 a.m. on August 1; any operation of the motorcoach after 6:00 a.m. was in violation of the 10-hour rule found in 49 *CFR* 395.5(a)(1).[18]

The roundtrip driving time between Los Angeles and Modesto is 10 hours without slowing or stopping, such as for traffic, road construction detours, or passenger pickup and drop-off. HOS rules for passenger-carrying operations allow *up to* 10 hours of driving time following

[17] (a) HOS rules for passenger-carrying operations allow up to 10 hours of driving time following 8 consecutive hours off duty. Driving is prohibited after the operator has accumulated 15 hours of on-duty time following 8 consecutive hours off duty (15-hour rule). (b) Per *CVC* 34501.2(a), the regulations adopted under section 34501 for vehicles engaged in interstate or intrastate commerce shall establish HOS regulations adopted by the US Department of Transportation (DOT) in 49 *CFR* Part 395 as those regulations now existing or hereafter as amended.

[18] The driver reported on duty by at least 6:30 p.m. on August 1. He was fueling the motorcoach by 6:51 p.m. When the crash occurred at 3:18 a.m. on August 2, he was driving within the 10-hour window. However, his destination was Modesto, over 25 miles away. In addition, he was scheduled to drive the return trip to Los Angeles in the same shift—which would have placed him in an OOS status for HOS violation.

8 consecutive hours off duty. The 10-hour rule includes any on-duty driving, such as traveling to a fueling station before embarking on a trip.

The owner of Autobuses Coordinados stated that the company did not have a process to monitor hours of service or to examine records-of-duty status for adherence to federal regulations or for falsification. Title 49 *CFR* 395.8 requires motor carriers to ensure that each driver maintain a daily record-of-duty status detailing the hours driven and the hours spent off duty.

1.5 Motor Carrier Operations

1.5.1 General

Autobuses Coordinados was headquartered in Fresno, California, with a fleet of six vehicles (three motorcoaches and three 15-passenger vans) and four drivers. Registered in 2007 with the Federal Motor Carrier Safety Administration (FMCSA) as a "for hire" passenger carrier, Autobuses Coordinados began transporting passengers from Tijuana, Mexico, to Los Angeles, California.[19] The carrier completed the FMCSA new entrant program in 2008.[20] In 2013, it began operating the Los Angeles–to–Pasco, Washington, route.

The owner of Autobuses Coordinados reported that its only written policy was for FMCSA drug and alcohol requirements. The company had no written procedures for hiring, training, safety, dispatch, vehicle maintenance, hours of service, or fatigue management.[21] The carrier verbally notified drivers of company procedures and requirements, handled driver discipline on a case-by-case basis, and had no progressive disciplinary policy to address driver violations.

The company had no policy regarding cell phone use while driving. The accident driver was responsible for contacting the passengers he was to pick up to let them know of his arrival time. Due to the traffic-related delay in departing Los Angeles on August 1, he made numerous calls en route to passengers awaiting pickup. Passengers on the bus reported that the driver was using his cell phone but did not know whether he was using a hands-free device.[22] Other passengers

[19] Autobuses Coordinados was issued US Department of Transportation number 1649722 and motor carrier number 607271.

[20] This program is an 18-month safety-monitoring period for all new entrant carriers, during which the FMCSA conducts a safety audit of the carrier and evaluates its accident and roadside inspection data. According to the FMCSA, the safety audit should cover the following areas: driver qualifications, driver duty status, vehicle maintenance, accident register, and controlled substance and alcohol use testing requirements. If the FMCSA identifies deficiencies, the carrier must provide evidence that it is correcting the faults.

[21] Autobuses Coordinados did not provide a formal driver training program. The carrier reported that it required prospective drivers to have a driver history less than 30 days old, and that it checked licenses for points and violations.

[22] (a) The FMCSA restricts a commercial motor vehicle (CMV) driver from holding a mobile device to make a call or from dialing by pressing more than a single button. CMV drivers who use a mobile phone while driving can only use a hands-free phone. See the FMCSA mobile phone restrictions fact sheet, accessed October 20, 2017. (b) *CVC* 23123 prohibits all drivers from using a handheld wireless phone while operating a motor vehicle. Motorists 18 years and over may use a hands-free device. See the California DMV website on the 2009 text messaging law and the 2008 cellular phone laws, accessed October 18, 2017.

reported to CHP postcrash that they had spoken with the driver while he was en route about where and when to meet.

1.5.2 State of California

CHP is the designated law enforcement agency responsible for ensuring the safe operation of commercial motor vehicles (CMV) in the state.[23] The annual bus terminal inspection program requires CHP to inspect every designated maintenance facility or terminal, or any person who operates any regulated bus (and inspect a portion or all of the carrier's fleet), at least once every 13 months (*CVC* 34501.12(a) and 34501.4(c)).

The most recent precrash annual inspection for Autobuses Coordinados occurred on December 15, 2014, and resulted in a satisfactory rating. CHP had conducted six precrash inspections of Autobuses Coordinados since 2010. Terminal inspections are similar to the FMCSA safety audit and compliance review (CR) program. However, in compliance with state requirements, the CHP terminal inspection focuses on vehicles (California Department of Transportation [Caltrans] 2012). Three categories are inspected for a passenger carrier safety rating: the preventive maintenance program, the condition of regulated vehicles, and HOS or time records. Inspections result in a satisfactory or unsatisfactory rating in each category as well as an overall rating.[24]

From 2010 through 2016, Autobuses Coordinados underwent six precrash inspections. The 2010 and 2011 inspections resulted in unsatisfactory ratings, and the four most recent inspections (2012–2014) resulted in satisfactory ratings. On August 25, 2016, CHP concluded a postcrash inspection, which resulted in an unsatisfactory rating.[25]

When asked why it did not conduct the annual bus inspection of the Autobuses Coordinados terminal within the 13 months set forth in regulation, CHP responded that the carrier did not inform CHP of its new location when it moved from Los Angeles to Fresno. Motor carriers in California are required to inform CHP of any change in location or any cessation of regulated vehicle activity within 15 days of the occurrence. As a result, the CHP district reviewed its database and found two other carriers that had not been inspected during the required 13-month interval.

CHP has since implemented a process to ensure that each California bus terminal is inspected at least once every 13 months. The new inspection process includes evaluating every motor carrier listed in the CHP tracking database. Once every 90 days, CHP prepares a report outlining each bus terminal due for inspection. Terminals overdue for inspection are individually

[23] Passenger-carrying operating authority in California is a shared responsibility among the Public Utilities Commission, the California DMV, and CHP.

[24] A rating of "satisfactory" means that the carrier was found to comply with applicable laws and regulations, and inspection categories were found to be satisfactory. If any inspection category is unsatisfactory, the terminal receives an unsatisfactory rating, which means that the carrier was found to be out of compliance in several areas or serious violations were discovered. Serious violations—regardless of whether they are found to be imminently dangerous—represent consistent failure on the part of the motor carrier to comply with applicable requirements.

[25] See the California Highway Patrol website, accessed April 25, 2017.

identified. The information is provided to each CHP field division motor carrier safety unit to assist with scheduling and completing the required terminal inspections.

1.5.3 Federal Motor Carrier Safety Administration

As part of its mission of reducing crashes, fatalities, and injuries involving large trucks and buses, the FMCSA monitors motor carriers to ensure that they have adequate safety management controls in place to comply with the *Federal Motor Carrier Safety Regulations* (*FMCSRs*).

1.5.3.1 Compliance, Safety, Accountability Program. The FMCSA monitors carrier safety through the Compliance, Safety, Accountability (CSA) program. A key component of the CSA is the Carrier Safety Measurement System (CSMS), which analyzes all safety-based violations from inspections and crash data to determine a motor carrier's on-road performance and potential crash risk. Thresholds for safety measurement system scores are determined through a mathematical formula that includes vehicle miles driven, number of vehicles and drivers in the fleet, and time since a violation. Because violations are time-weighted, recent violations have more weight than older ones.

The CSMS uses seven behavior analysis and safety improvement categories (BASIC): unsafe driving, HOS compliance, driver fitness, controlled substances and alcohol, vehicle maintenance, improper loading/cargo securement, and crash indicator.[26] Each BASIC has a threshold that triggers an alert and interventions by the FMCSA, including warning letters or more extensive scrutiny, such as targeted roadside inspections and focused investigations.[27] Autobuses Coordinados had one alert for vehicle maintenance (77 percent) at the time of the crash. In the 24 months prior to the crash, the carrier had been over the BASIC threshold for hours of service (based on a 24-month record ending July 22, 2016).[28] Postcrash, the ratings were 88th percentile for vehicle maintenance and 87th percentile for hours of service (the other BASICs remained at 0 percentile).

[26] HOS compliance applies to the drivers of CMVs. Example violations for this BASIC include exceeding hours of service, maintaining an incomplete or inaccurate logbook, and operating a CMV while ill or fatigued (49 *CFR* Parts 392 and 395). For more information, see the FMCSA website, accessed April 25, 2017.

[27] To determine alert status, carriers are compared to a peer group of other carriers with similar numbers of inspections using a percentile rating of 0–100, with the 100th percentile indicating the worst performance. For carriers with safety issues across multiple BASICs, the FMCSA will continue to conduct onsite comprehensive CRs. The FMCSA intervention threshold for passenger carriers for unsafe driving, HOS compliance, and crash indicator is 50 percent. For driver fitness, controlled substances and alcohol, and vehicle maintenance, the threshold is 65 percent. See the FMCSA CSA website, accessed June 6, 2017.

[28] Precrash, the carrier's motor carrier management information system profile indicated no DOT-reportable crashes in 2015.

According to its motor carrier management information system profile, Autobuses Coordinados was subject to 29 roadside or terminal inspections from August 9, 2014, to April 28, 2016.[29] The CSMS profile also shows the carrier's vehicle out-of-service (OOS) rate at 38 percent (eight OOS violations) and its driver OOS rate at 25 percent (three OOS violations).[30] Both OOS rates exceeded the national averages for passenger carriers of 8 percent and 2 percent, respectively.[31]

1.5.3.2 Compliance Reviews. A CR is an onsite examination of a motor carrier's operations to determine its compliance with the FMCSRs and to evaluate its safety culture. The FMCSA (or a qualified state or local jurisdiction agent) conducts the CR. The CR may include examination of HOS practices, vehicle maintenance and inspections, driver qualifications, CDL requirements, financial responsibility, crashes, hazardous materials compliance, controlled substances and alcohol testing requirements, and other safety and transportation-related records. The FMCSA conducted five CRs of Autobuses Coordinados from 2008 to 2016:[32]

- May 17, 2016: "satisfactory"
- November 6, 2015: "conditional"
- April 30, 2013: "satisfactory"
- December 12, 2011: "satisfactory"
- January 11, 2008: "satisfactory."

Postcrash, the FMCSA placed the carrier out of service because of its unsatisfactory safety rating (see table 5).[33]

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[29] According to the FMCSA, 31,407 motorcoach roadside inspections were conducted in fiscal year (FY) 2015 and 31,751 in FY 2016 (as of September 30, 2016). The total numbers of overall bus inspections in FY 2015 and in FY 2016 (as of September 30, 2016) were 121,955 and 122,966, respectively. Motorcoach inspection figures are a subset of total bus inspections. For further information, see the FMCSA website, accessed April 25, 2017.

[30] Serious violations found during roadside inspections result in driver or vehicle OOS orders; these violations must be corrected before the affected driver or vehicle can return to service (CVSA 2015).

[31] See the FMCSA website, accessed July 6, 2017.

[32] (a) To develop a safety rating for a CR, an FMCSA investigator or state or local agency agent visits a carrier's terminal to review its compliance with the safety fitness standard based on a selected number of *FMCSRs* (appendix B, 49 *CFR* 385.7 and 385.9). (b) Safety ratings: (1) *Satisfactory*: the motor carrier has in place and functioning adequate safety management controls to meet the safety fitness standard prescribed in 49 *CFR* 385.5. (2) *Conditional*: the motor carrier does not have adequate safety management controls in place to ensure compliance with the safety fitness standard, which could result in occurrences listed in 49 *CFR* 385.5(a) through (k). (3) *Unsatisfactory*: the motor carrier does not have adequate safety management controls in place to ensure compliance with the safety fitness standard, resulting in occurrences listed in 49 *CFR* 385.5(a) through (k). (4) *Unrated:* the FMCSA has not assigned a safety rating.

[33] Postcrash, the vehicle and driver category OOS rates for Autobuses Coordinados were 36 percent and 25 percent, respectively. See the FMCSA website, accessed May 2, 2017.

Table 5. Postcrash CR violations for Autobuses Coordinados, August 2016.

Violation	Basic Area	Description
49 *CFR* 383.37(a)	Driver fitness	Knowingly allowing, requiring, permitting, or authorizing an employee to operate a CMV during any period in which the driver does not have a current commercial learner's permit (CLP) or CDL, or does not have a CLP or CDL with the proper class or endorsements. An employer may not use a driver to operate a CMV who violates any restriction on the CLP or CDL.
49 *CFR* 396.11(a)	Vehicle maintenance	Failing to require a driver to prepare a driver vehicle inspection report
49 *CFR* 396.17(a)	Vehicle maintenance	Using a CMV not periodically inspected
49 *CFR* 396.17(a)	Vehicle maintenance	Using a CMV not periodically inspected

NTSB investigators reviewed violations from the five precrash CRs. A violation from the May 17, 2016, CR showed the accident driver listed for a "false record of duty status" on April 6, 2016, and for driving without a valid CDL on April 1, 2016 (49 *CFR* 391.11(a)(4)).[34] The April 30, 2013, CR listed the accident driver with a violation for "form and manner" in his records-of-duty status from January 28, 2013.[35] See appendix B for a complete list of violations found during the five CRs.

1.6 Vehicle

1.6.1 General

The 1998 Van Hool model T2145 49-passenger motorcoach was equipped with a Cummins Diesel engine and an Allison six-speed automatic transmission.[36] The motorcoach was also equipped with Meritor WABCO six-wheel air-operated antilock disc brakes. It had a gross vehicle weight rating (GVWR) of 47,400 pounds.

[34] The accident driver listed in his CDL renewal application that he operated only as an intrastate driver within California. The application was corrected, and the intrastate restriction was lifted after Autobuses Coordinados was made aware of the issue.

[35] Per 49 *CFR* 395.8(h)(5): "*Location–remarks*. The name of the city, town, or village, with State abbreviation where each change of duty status occurs shall be recorded."

[36] The accident motorcoach was equipped with an electronically controlled Cummins engine; however, the electronic control module (ECM) on this model year engine did not have the capability to capture or record events, such as vehicle speed, engine rpm, brake circuit status, throttle percentage, and other associated data in the event of a sudden deceleration or hard braking. The motorcoach was not equipped with event or video event data recorders.

1.6.2 Motorcoach Damage

The motorcoach sustained damage primarily to the front and passenger (right) side; the driver side received relatively minor damage. The vertical signpost split the roof and flooring from the right front corner to just forward of the second axle, collapsed the fuel tank, and destroyed the luggage compartment cargo areas. The right-front frame assembly, passenger loading door, and all side cargo area compartment doors separated from the motorcoach. The upper and lower windshields, front bumper cover, right-front head lamp, right-front turn signal assemblies, and right-side tail lamp assembly were missing. Two windows on each side of the coach were broken, in addition to the driver-side small outboard window.

In the interior, the stairwell and right-front dashboard were destroyed. The intruding signpost separated the right sidewall and moved toward the center of the motorcoach near the front axle until it contacted the passenger-side frame rail located under the center of the seats. As the coach continued forward, the signpost bisected the passenger compartment aft along the frame rail to the second set of axles. The signpost destroyed or displaced rearward nine of the 10 seat rows on the passenger side.[37] The driver seat and some passenger seats on the driver side exhibited evidence of occupant impacts in the forward direction. Several rows of seats on both sides of the motorcoach were cut away during the rescue and extrication process. The tour operator seat, located on the passenger side and mounted to the modesty panel wall below the front row, remained intact.

1.6.3 Restraints

The driver seat was an air-ride bucket seat with a two-point (lap-only) restraint. Examination of the driver's lap belt showed that it was functional, with no obvious indications of use during the crash. The four front row passenger seats, the tour operator seat, and the inboard seat in the back row were equipped with two-point restraints.[38] Seat belts at the driver-side front row and at the back row inboard seat showed no obvious indications of use. Seat belt use at the passenger-side front row seats could not be determined because of crash-related damage. None of the remaining passenger seats were equipped with restraints, nor were such restraints required. The passenger seats were equipped with adjustable headrests and folding armrests.

1.6.4 Vehicle Systems, Inspections, and Maintenance

NTSB investigators examined the steering, suspension, braking, and electrical systems, as well as the wheels and tires. The motorcoach was equipped with pneumatic disc brakes on axles 1 and 3, and pneumatic drum brakes on axle 2, with 3-inch automatic slack adjusters.[39] All brake

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[37] The motorcoach had 14 rows of seats on the driver side and 10 rows on the passenger side forward of a lavatory and sleeper berth.

[38] (a) The inboard seat in the back row is the center seat position open to the aisle (see figure 6). (b) According to Van Hool, when this bus was manufactured in Europe, seat belts were mandatory at these exposed seat locations.

[39] The model year 1998 motorcoach was built in 1997; 49 *CFR* 393.55(c) requires that all air-braked motorcoaches manufactured after March 1998 be equipped with antilock braking systems (ABS).

linings were found to exceed the minimum thickness limit of 1/4 inch.[40] No evidence of preexisting vehicle damage or defects was found.

Autobuses Coordinados performed routine maintenance and repairs in-house at its terminal location. The accident motorcoach had an annual inspection on May 30, 2016, and no defects were found.[41]

1.7 Highway Factors

1.7.1 State Route 99

The motorcoach crash occurred on SR-99 north (Golden State Highway), at MP 27.8, south of Livingston.[42] Caltrans maintains and operates the Golden State Highway.

At the crash location, SR-99 is classified as an urban principal arterial road. It was constructed in 1949 and reconstructed in 1986. The most recent rehabilitation project was completed in 2008. The northbound lanes consist of three travel lanes, each 12 feet wide and separated by evenly spaced, broken white pavement stripes 4 inches wide and 12 feet long. A 4-inch-wide solid yellow pavement stripe delineates the inner edge of the left travel lane from the 9-foot 9-inch-wide left shoulder, and a 4-inch-wide solid white pavement stripe delineates the outer edge of the right travel lane from the 10-foot-wide right shoulder.[43]

Two curves characterize the SR-99 north lanes near the crash site: a 2,594-foot-long curve that turns to the left in the direction of travel, followed by a short 263-foot-long tangent segment that transitions to a 1,297-foot-long curve that turns to the right. Both the left and right curves have a horizontal curve radius of 4,921 feet. The motorcoach came to final rest about 623 feet from where the rightward curve ends. The vertical alignment of SR-99 in this vicinity consists of a -0.44 percent downgrade slope in the direction of travel. The cross slope of the three northbound travel lanes is 2 percent downward from the leftmost travel lane to the rightmost travel lane in the direction of travel. The cross slope of the paved shoulder adjacent to the rightmost travel lane is 5 percent downward from the highway marking to the edge of the shoulder (see figure 7).

[40] Title 49 *CFR* 393.47(d) requires 1/4-inch minimum thickness for air-braked nonsteering axles or 3/16-inch minimum thickness for air-braked front steering axles.

[41] The vehicle had been placed out of service during a terminal level 5 FMCSA inspection on April 28, 2016, for two violations: (1) motorcoach or other passenger-carrying vehicle equipped with prohibited, nonautomatically folding seats in the aisle or jump seat in the entrance aisle (49 *CFR* 393.91-FS); and (2) no or defective brake warning device, low air pressure warning device inoperable, neither audible nor visual (49 *CFR* 393.51).

[42] SR-99 begins at Interstate 5 near the base of the Tehachapi Mountains in Kern County, California, and ends at State Route 36 near Red Bluff, a distance of 425 miles.

[43] A 4-inch-wide solid white line separates the rightmost northbound travel lane from the paved shoulder. A 4-inch-wide solid yellow line, with raised yellow lane delineators at 48-foot intervals, separates the leftmost travel lane from the paved shoulder.

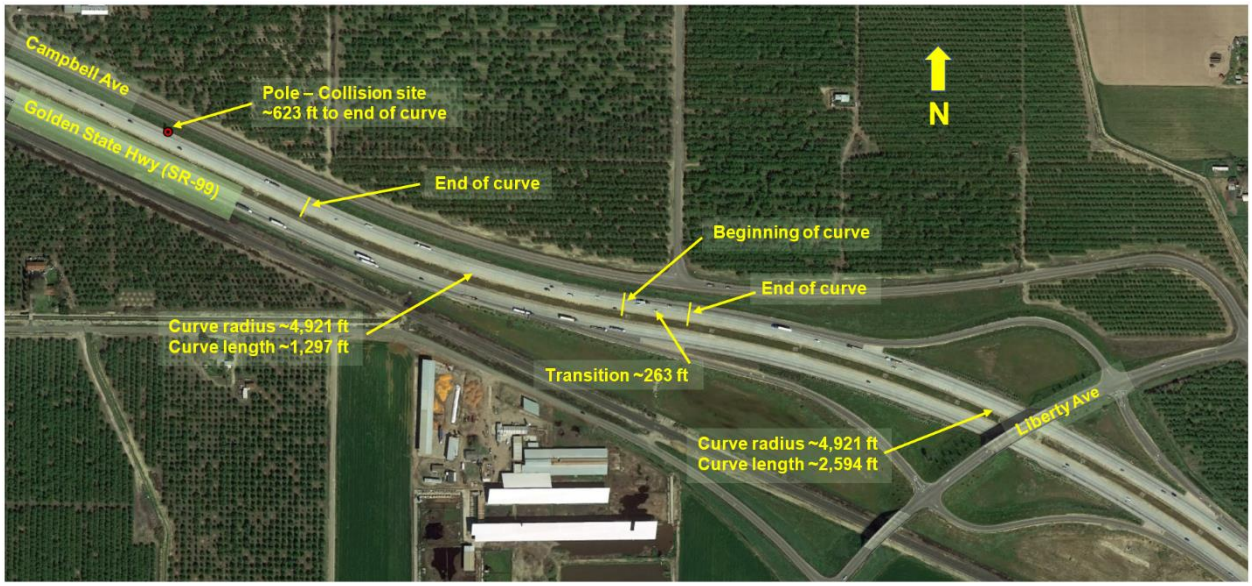

Figure 7. Curvature and alignment of SR-99 on approach to crash site. (Source: Google Earth image dated March 2016)

This section of SR-99 had no rumble strips. However, Caltrans has since installed rumble strips on the paved shoulders adjacent to the median and adjacent to the rightmost travel lane at the crash location. Vertical flexible-post retroreflective markers along the inside and outside of the highway curve that precedes the tangent segment also delineate the lanes and roadway.

1.7.2 Speed Limit, Traffic Characteristics, and Accident Data

The posted speed limit for SR-99 in the vicinity of the crash site is 65 mph, including for commercial passenger vehicles; 55 mph for trucks with three axles or more; and 55 mph for all vehicles when towing. Caltrans has a performance measurement system that provides detailed traffic data.[44] It recorded an average speed per day of 66.6 mph in the vicinity of the crash from August 16 through 23, from 6:00 a.m. to 6:00 p.m.

According to Caltrans records, the most recent average traffic count for this portion of SR-99 was 54,000 vehicles per day in 2015. On July 26, 2016, Caltrans conducted a 24-hour vehicle classification count for SR-99 north in the vicinity of the crash site. Buses and trucks accounted for 9,276 vehicles, or 15.1 percent of the total volume of traffic.[45] Trucks with five axles or more accounted for 69.2 percent of the bus and truck traffic.

Between June 23, 2009, and June 30, 2014, a total of 72 crashes—29 injury crashes and 43 property-damage crashes—occurred on SR-99 north within a 2.5-mile radius of the crash site. No

[44] Traffic data are collected in real time from 39,000 detectors that span the freeway system across all major metropolitan areas of the state.

[45] A 2015 daily truck traffic volume annual summary report indicates that trucks accounted for 20 percent of the total traffic volume per day. See the 2015 Caltrans-DOT report, accessed April 25, 2017.

fatalities were associated with the 72 crashes. Three of the crashes involved a vehicle striking the guardrail. Appendix C presents additional Caltrans traffic data.

1.7.3 W-Beam Guardrail

1.7.3.1 Description. After departing the travel lanes and crossing the paved right shoulder, the motorcoach struck a W-beam guardrail. The American Association of State Highway and Transportation Officials (AASHTO) defines a strong-post blocked-out W-beam guardrail as follows:[46]

> Consists of steel posts or wood posts that support a W-beam rail element that is blocked-out from the posts with routed timber, steel, or recycled plastic spacer blocks. These blocks minimize vehicle snagging on the posts and reduce the likelihood of a vehicle vaulting over the barrier by maintaining rail height during the initial stages of post deflection.[47]

The AASHTO *Roadside Design Guide* (RDG) states that the "primary purpose of roadside barriers is to prevent a vehicle from leaving the traveled way and striking a fixed object or terrain feature that is less forgiving than the barrier itself" (AASHTO 2011). The front of the guardrail at the Hammatt Avenue signpost was flush with the edge of the paved shoulder (adjacent to the rightmost travel lane) and offset from the edge of the travel lane by 10 feet. The lateral distance from the front of the guardrail to the centerline of the vertical signpost was 64.3 inches, as shown in figure 8.[48]

[46] AASHTO represents highway and transportation departments in the 50 states, the District of Columbia, and Puerto Rico. It sets standards for all phases of highway system development, including the design and construction of highways and bridges.

[47] The combination of the tensile and flexural stiffness of the rail and the bending or shearing resistance of the posts accounts for the resistance in this and all strong post systems.

[48] To determine the condition of the subject metal W-beam guardrail, NTSB investigators documented the guardrail system that shields the "Hammatt Ave, Winton Pkwy, and Collier Rd" overhead sign structure support, located 1,300 feet northwest of the crash site, and reviewed the Caltrans as-built drawings for the "Hammatt Ave" overhead sign structure support.

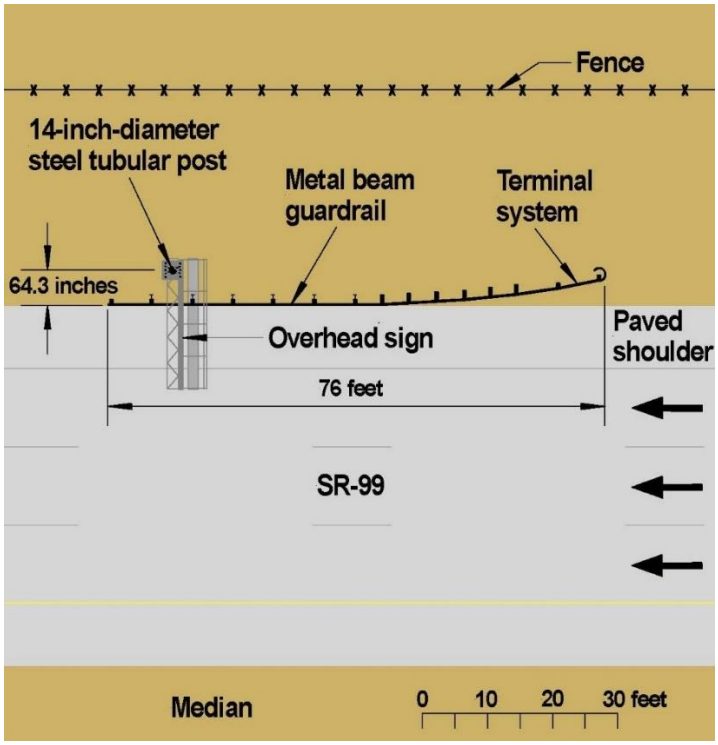

Figure 8. Plan view of metal W-beam guardrail.

The 76-foot-long metal W-beam guardrail had a gated flared terminal end with a rolled buffer, or "bull nose," end piece.[49] An 8-inch-wide by 24-inch-long white- and amber-colored retroreflective delineator marker (type L-1) was mounted on top of the rigid post. Wood posts 6 feet long and 6 inches wide by 8 inches deep provided vertical support for the guardrail system. The posts were spaced about 6 feet 3 inches apart and embedded 3.5–4 feet. The horizontal W-beam section was 12 inches high and raised 17 inches from the paved shoulder surface, for a total height to the top of the W-beam rail element of 29 inches (see figure 9). The Caltrans *Traffic Manual* indicates that the standard height for installation of a metal beam guardrail is 29 inches; this type of guardrail is typical for embankment and fixed object shielding (Caltrans 2012).[50]

[49] CHP identified the guardrail end treatment as a slotted rail terminal (SRT-31).

[50] The guidance allows for a tolerance of +1–1¼ inch.

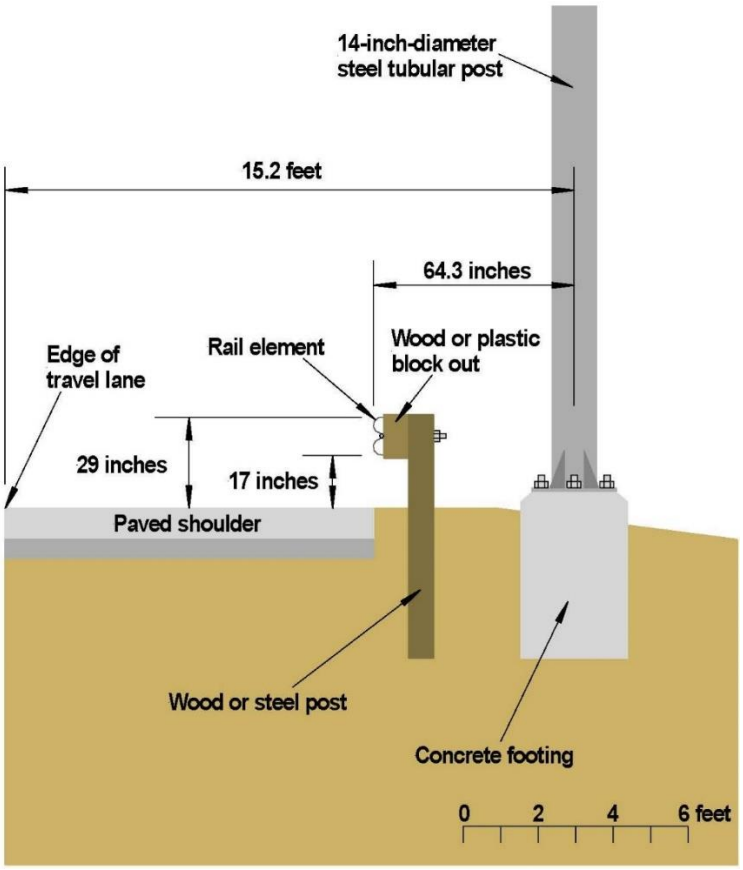

Figure 9. Cross-section diagram of crash site metal W-beam guardrail and steel tubular post with concrete footing.

1.7.3.2 Crashworthiness and Roadside Barrier Guidance. The Hammatt Avenue barrier system, located about 10 feet from the rightmost travel lane, had been hit twice in the last 5 years.[51] The Caltrans *Traffic Manual* states the following (Caltrans 2012):

> Concrete barrier is generally damage-resistant and can be used in place of metal w-beam guardrail to decrease maintenance worker exposure. Criteria for this use are when the guardrail is within 14 feet of the traveled way and it has been struck three or more times in any 12 consecutive months during a three-year period.

The Hammatt Avenue barrier did not meet these criteria. The SR-99 corridor includes 258 similar metal W-beam guardrail treatments that shield vertical signpost structures: 61 in Caltrans district 10, in which the crash occurred; 49 in district 3; and 148 in district 6 (north and south of the crash site, respectively).[52]

[51] In December 2012, the guardrail was damaged, and the end rail and one post were replaced. In November 2015, 50 feet of damaged guardrail was replaced (end treatment and rail.)

[52] District 10 operates and maintains 3,500 lane miles in eight counties.

A W-beam guardrail is considered a test level (TL)-3 roadside barrier when the W-beam rail element is blocked-out from the posts with routed timber or recycled plastic spacer blocks, as applicable at the Hammatt Avenue signpost. Full-scale crash testing for barriers involves six levels of structural integrity, as noted in appendix D. At heights up to 29 inches, a TL-3 barrier has the capability of redirecting a 2,420-pound passenger vehicle or a 5,000-pound pickup truck. It is not designed to redirect heavy vehicles, such as a motorcoach (AASHTO 2016).[53]

1.7.4 Clear Zone and Point Hazards

The vertical signpost structure consisted of a 14-inch-diameter steel tubular post anchored to a steel base plate. The signpost measured 19 feet 8 inches high from the base plate to the bottom of the overhead sign.[54] The vertical signpost is considered a fixed-base support, which is designed to not yield or break away on impact.

The clear zone concept recommends providing a traversable and unobstructed roadside area beyond the traveled way for use by errant vehicles. The clear zone is usually set at a nominal width of 30 feet for freeways with flat roadsides and speeds of 60 mph.[55] If an obstacle is located within the clear zone, it generally should be removed, relocated, redesigned, or shielded by traffic barriers or crash cushions. The accident signpost was located 64.3 inches from the face of the W-beam guardrail element, offset from the edge of the rightmost travel lane by 15.2 feet—within the clear zone. The distance from the edge of the northbound lanes of SR-99 to the paved edge of the parallel frontage road, Campbell Avenue, is 47 feet. Although the vertical signpost could have been moved closer to Campbell Avenue, there is no scenario in which it could be located outside of the clear zone for both SR-99 and Campbell Avenue (see figure 10).

[53] In 2016, AASHTO issued the second edition of the *Manual for Assessing Safety Hardware* for use in evaluating the structural adequacy of barrier systems based on updated test vehicles and impact conditions.

[54] The 8-foot 4-inch-high by 18-foot-wide overhead sign structure was cantilevered over the paved shoulder and extended over a portion of the rightmost travel lane. The outside dimension of the steel base plate was 31 by 27 inches. The outside dimension of the concrete foundation was 38 by 34 inches.

[55] The clear zone is measured from the edge of the paved traveled way or the intersection of the paved traveled way and shoulder. The nominal clear zone width increases with increased speeds and steeper roadside slopes.

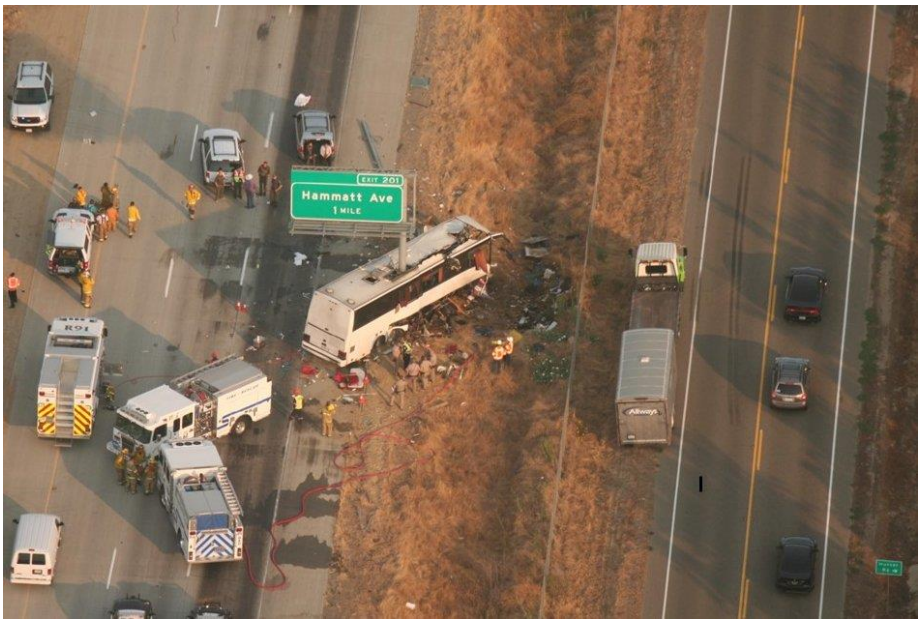

Figure 10. Aerial view of motorcoach postcrash showing vertical signpost location in clear zone and adjacent Campbell Avenue frontage road at right. (Source: California Highway Patrol)

Per National Cooperative Highway Research Program (NCHRP) Report 638, *Guidelines for Guardrail Implementation*, the 14-inch-diameter steel tubular vertical highway signpost located in the 30-foot clear zone would be considered a moderately severe point hazard (Transportation Research Board [TRB] 2009), as specified in table 6.[56]

Table 6. Hazard classification examples from NCHRP Report 638.

Category	Severe Hazard	Moderately Severe Hazard	Moderate Hazard
Point hazard	3-foot-diameter bridge pier	10-inch-diameter utility pole	6-inch-diameter tree
Long slope hazard	1.5:1 slope, 26 feet deep	2:1 slope, 20 feet deep	2.5:1 slope, 13 feet deep

NCHRP Report 638 discusses the following regarding guardrail shielding of point hazards versus long slope hazards (TRB 2009):

> Guardrail shielding of long hazards was found to be much more cost beneficial than treatment of point hazards. When viewed in terms of the benefits associated with a higher barrier test level, this finding is not surprising. As noted above, the benefit

[56] A point hazard is typically a sign, tree, utility pole, or other roadside feature that can reasonably be approximated as a point in space. A long slope hazard is typically a steep roadside slope or embankment.

of increasing test level is primarily related to the risk of a vehicle striking a roadside hazard after penetrating through or over the barrier. When a vehicle penetrates through or over the portion of any guardrail placed upstream of an object, the risk of the vehicle continuing on to strike the hazard is still relatively modest. When a vehicle penetrates through a barrier immediately adjacent to an obstacle, however, it will almost certainly encounter the hazard. Because of the significantly different risks of a vehicle penetrating through or over the barrier and then striking the hazard, higher test level barriers are shown to be much more cost beneficial when placed adjacent to long hazards.

1.7.5 Physical Evidence at Crash Site

The motorcoach made no tire marks on the travel lanes to indicate braking or evasive steering by the driver. Roadway evidence consisted of postcrash damage to the guardrail and signpost. The entire length of the guardrail was displaced northward, parallel to the roadway, with 33 feet of the southern end displaced 60 feet northward and a portion of the guardrail overrun by the motorcoach (this segment remained under the vehicle at its position of rest). Forty-four feet of the guardrail was relatively undamaged except for some kinking along a 6-foot section that separated the severely damaged and undamaged segments. The concrete base of the signpost was fractured, particularly on the north side, and the signpost showed significant contact evidence from the motorcoach.

The intrusion path of the signpost, the location of vehicle and guardrail debris, and the postcrash orientation of the motorcoach indicate that it followed a shallow departure angle from the roadway—then an initial heading parallel to the pavement as it struck the guardrail (at an angle of 3–7 degrees), was redirected parallel to the roadway, and struck the signpost. The motorcoach rotated clockwise about 27 degrees as the signpost entered the vehicle (see figure 11).

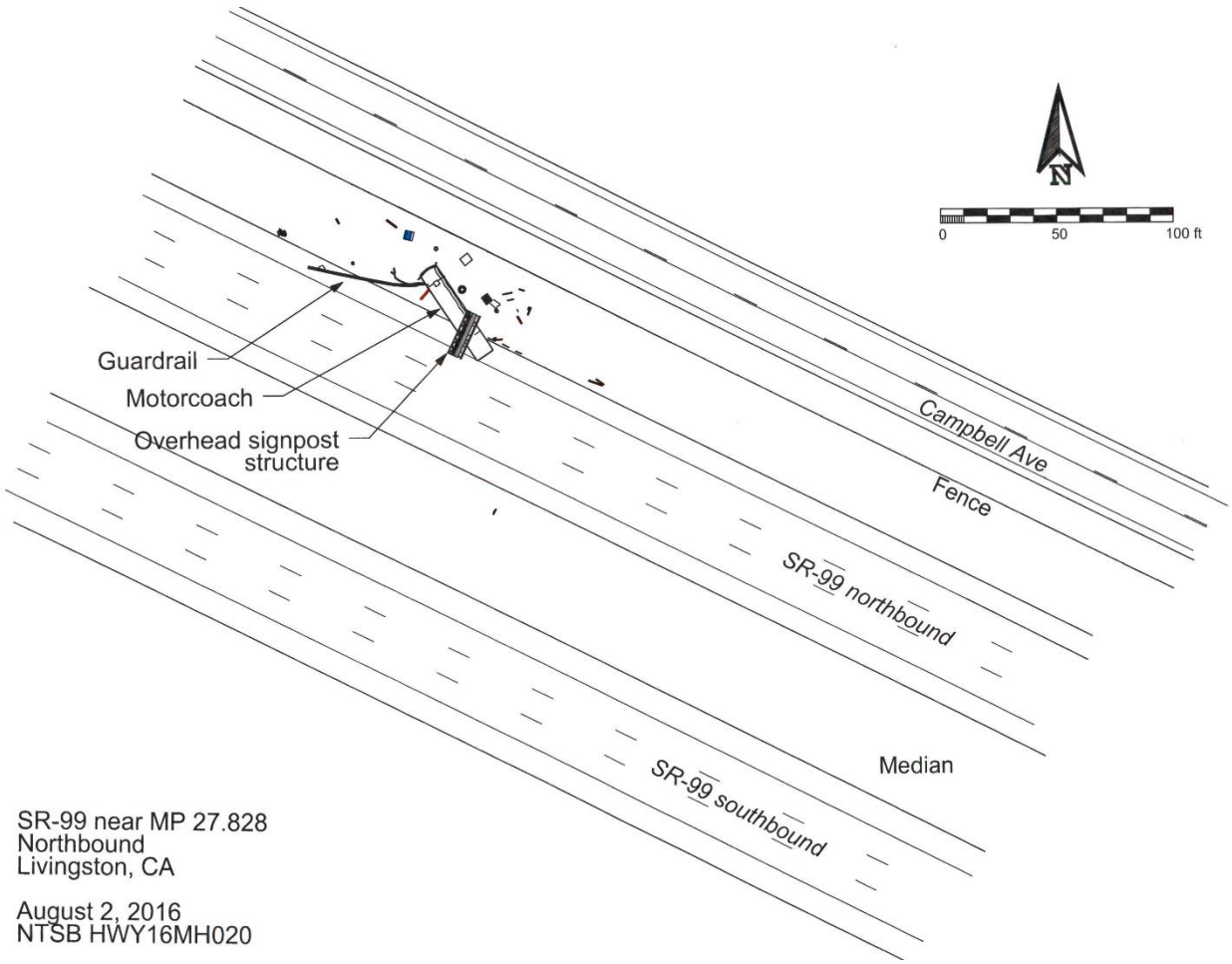

Figure 11. Crash diagram depicting final rest position of motorcoach, guardrail damage, and adjacent Campbell Avenue frontage road with fence.

1.8 Weather

Between 3:13 and 3:18 a.m. on the day of the crash, weather station KCALIVIN2 (located about 2.8 miles from the crash site) reported a temperature of 65°F, clear conditions, winds from the south–southwest between 2 to 3 mph, and visibility unrestricted at 10 miles.[57] Astronomical data from the US Naval Observatory showed civil twilight beginning at 5:40 a.m., with sunrise at 6:09 a.m.[58] The crash occurred at 3:18 a.m.

[57] Data obtained from The Weather Company website, accessed April 25, 2017.

[58] See the US Naval Observatory data services webpage, accessed June 6, 2017.

1.9 Similar NTSB-Investigated Motorcoach Crashes

1.9.1 New York City Crash

On March 12, 2011, about 5:38 a.m., a 1999 Prevost 56-passenger motorcoach, operated by World Wide Travel of Greater New York, was traveling on Interstate 95 (I-95) en route from Uncasville, Connecticut, to New York City (NTSB 2012b). In the vicinity of MP 3.2, the motorcoach departed the travel lanes to the right at a 7-degree angle, traversing the rumble strips on the right shoulder edge. No tire marks were made on the travel lanes to indicate braking or evasive steering. The motorcoach then crossed the 10-foot-wide paved shoulder and struck a strong-post W-beam guardrail, traveling about 480 feet alongside and on the guardrail, before finally overturning 90 degrees onto its right side and flattening the guardrail.[59] The front of the vehicle subsequently collided with a vertical highway signpost consisting of two 8-inch-diameter steel tubular poles linked by cross-beam diagonal metal supports (see figure 12).

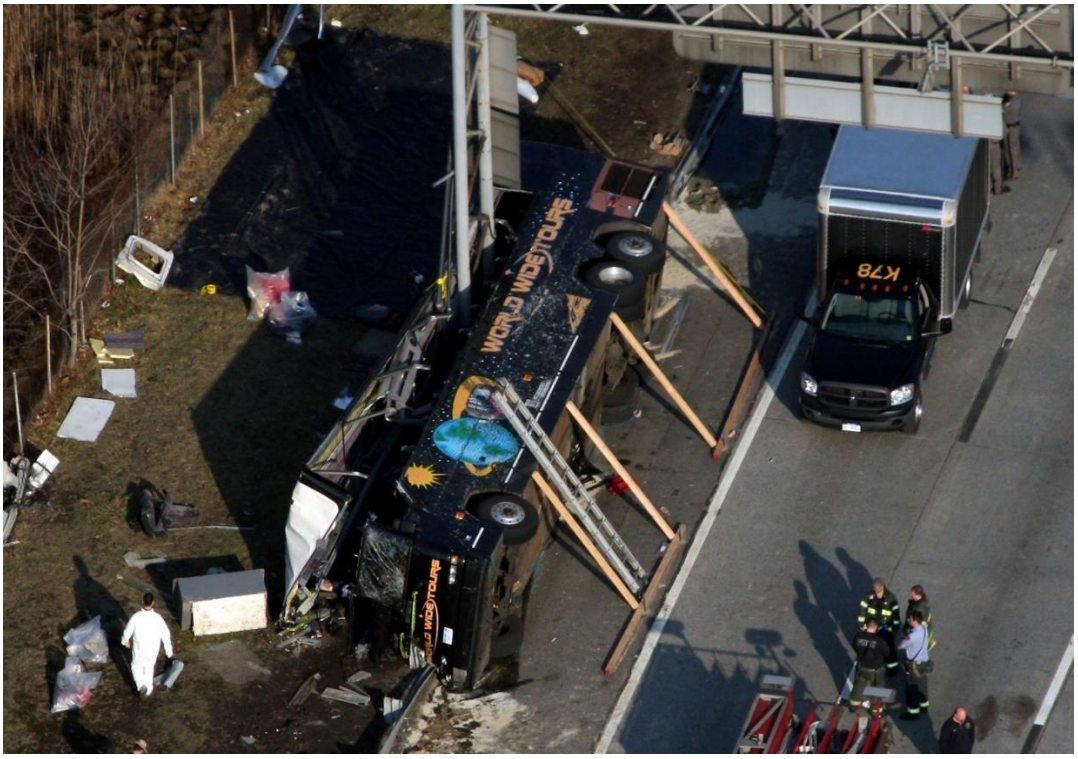

Figure 12. Aerial view of New York City crash scene, March 12, 2011. (Source: Frank Becerra, *USA Today, The Journal News*)

[59] Postcrash examination of ECM data revealed that the motorcoach was traveling a minimum 64 mph for at least 10 seconds before it struck the guardrail.

The two steel tubular poles entered the passenger compartment along the base of the passenger windows. The impact tore the roof panel from the bus body for almost the entire length of the bus. Fifteen of the 32 passengers died, and 17 sustained serious-to-minor injuries; the bus driver received minor injuries.

While examining driver fatigue, NTSB investigators determined that the motorcoach driver was experiencing both acute sleep loss and cumulative sleep debt at the time of the crash.[60] In the days leading to the crash, the driver had a cumulative sleep opportunity of only 4 hours. Circadian factors related to his inverted work schedule and the time of day at which the crash occurred, about 5:38 a.m., exacerbated the effects of fatigue.[61] Investigators also determined that the motor carrier did not adequately oversee its drivers—such as in failing to adhere to HOS requirements and improperly addressing speeding.

The NTSB determined that the probable cause of the New York City crash was the driver's failure to control the motorcoach due to fatigue resulting from failure to obtain adequate sleep, poor sleep quality, and the time of day at which the crash occurred. Contributing to the crash were the following:

- Inadequate safety oversight of the accident driver by World Wide Travel management.
- The speed of the motorcoach and a guardrail that was not designed to redirect the heavy vehicle or to prevent it from colliding with the vertical highway signpost.
- The extensive intrusion of the signpost into the passenger compartment.

1.9.2 Doswell, Virginia, Crash

On May 31, 2011, about 4:55 a.m., a 2000 Setra 59-passenger motorcoach, operated by Sky Express, Inc., was traveling north on I-95 in the right lane near Doswell, Virginia (NTSB 2012a). The motorcoach drifted from the highway to the right; struck a low-tension, three-cable longitudinal barrier; rotated counterclockwise around its vertical axis; overturned to the right; and rolled onto its roof (see figure 13). Four of the 58 passengers died, 14 were seriously injured, and 35 passengers and the driver received minor injuries.[62]

[60] ECM data also indicated that the driver did not apply the brakes in the 60 seconds before leaving the travel lanes, crossing the shoulder, and striking the guardrail.

[61] Circadian rhythms are patterns of physiological variables and performance that are linked to a 24-hour cycle.

[62] The injury status of five passengers was unknown.

Figure 13. Overturned motorcoach at crash scene near Doswell, Virginia, May 31, 2011.

Postcrash, while being interviewed by the Virginia State Police, the driver stated that he had been tired and had fallen asleep. He also stated that when he awoke, he steered the vehicle hard to the left, and it rolled over. The driver made similar statements to an FMCSA representative.

The NTSB determined that the probable cause of the Doswell crash was the failure of the motorcoach driver to maintain control of the vehicle due to his falling asleep while driving because of fatigue resulting from acute sleep loss, poor sleep quality, and circadian disruption; and the failure of Sky Express, Inc., to follow adequate safety practices and to exercise safety oversight of the driver. Contributing to the crash were the following:

- FMCSA's lack of adequate oversight of Sky Express, Inc., which allowed the company to continue operations despite known safety issues.

- Lack of a comprehensive occupant protection system, including systems for providing passenger restraint and for ensuring sufficient roof strength.

2 Analysis

2.1 Introduction

The crash sequence began when an Autobuses Coordinados motorcoach, traveling on SR-99 north near Livingston, California, departed the travel lanes, crossed the paved shoulder, struck a guardrail, and collided with a vertical highway signpost. Four passengers were fatally injured, 19 received serious-to-minor injuries, and one was not injured. The bus driver was seriously injured.

The analysis portion of this investigative report discusses the motorcoach driver's fatigue due to his acute sleep loss and circadian factors, which caused him to drift from the travel lanes and the motorcoach to run off the road (see section 2.2). In addition, we discuss the following safety issues and related safety recommendations:

- Poor safety management controls by Autobuses Coordinados (section 2.3.1).
- Inadequate safety ratings for passenger motor carriers with a pattern of driver and vehicle violations (section 2.3.2).
- Highway barrier systems incapable of safely redirecting heavy commercial passenger vehicles from point hazards (section 2.4).

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

- ***Mechanical condition:*** NTSB investigators examined the motorcoach and found no preexisting mechanical conditions that could have contributed to the circumstances of the crash.
- ***Driver licensing, experience, alcohol or other drug impairment, medical conditions, or distraction:*** The motorcoach driver held a current CDL with appropriate endorsements and had been operating motorcoaches for over 10 years. His postcrash toxicology test results were negative. The NTSB investigation found no evidence of medical conditions that would have affected the driver's performance. Although he had been using his cell phone while operating the motorcoach, he was not using it at the time of the crash. There is no evidence that the driver was distracted by other factors.
- ***Weather:*** The weather was clear, there was no precipitation, and the roadway was dry.
- ***Visibility:*** Although sunrise would not occur for nearly 2 hours, postcrash observations indicated that illumination from the motorcoach headlights should have provided adequate visibility of the roadway. Postcrash photographs and remnants of retroreflective delineator markers, similar to those identified on the exemplar barrier system, indicated that the barrier at the crash scene had been similarly marked and would have been visible during nighttime conditions. Visual observations through the

area during hours of darkness revealed no sight line obstructions. The lanes and roadway were further delineated by raised retroreflective lane markers and by vertical flexible-post retroreflective markers along the inside and outside of the highway curve that preceded the tangent segment.

The NTSB, therefore, concludes that none of the following were factors in the crash: (1) mechanical condition of the motorcoach; (2) driver licensing, experience, alcohol or other drug impairment, medical conditions, or distraction; (3) weather conditions; or (4) visibility.

The allocation of emergency response resources from CHP and from fire and medical emergency response agencies was sufficient. CHP officers and first responders arrived on scene within minutes of the event, and patient transport to four hospitals was coordinated and efficient. The NTSB concludes that the emergency response to the crash was timely and effective.

2.2 Motorcoach Driver Fatigue

2.2.1 Driver Performance and Fatigue Assessment

As the motorcoach driver departed the travel lanes, he provided no steering or braking input, crossed the outside shoulder at a shallow departure angle, struck the roadside W-beam guardrail, and collided with the vertical highway signpost. Driver fatigue can cause a lack of responsiveness to external stimuli, such as a roadway departure.

Although many factors may affect driver fatigue, as outlined in NTSB investigative protocols, investigators focused on the following elements to assess whether the driver was impaired by fatigue at the time of the crash:

- Length of sleep
- Circadian factors.

2.2.1.1 Length of Sleep. Fatigue is generally caused by insufficient sleep. Fatigued drivers may experience slower reaction times, inability to process information, loss of concentration and perception, and reduced vigilance. NTSB investigators determined that, in the almost 40 hours preceding the crash (from 11:21 a.m. on July 31 until 3:18 a.m. on August 2), the motorcoach driver had a total rest opportunity of 9 hours. However, based on cell phone records showing usage during this time and interviews with at least one passenger who contacted the driver for pickup information, he had a sleep opportunity of only 5 hours.[63] The driver was experiencing acute sleep loss at the time of the crash.

[63] NTSB investigators could not verify whether the driver used the entire time for sleep.

The American Automobile Association (AAA) Foundation for Traffic Safety has found significantly elevated crash rates among the following (AAA 2016):

- Drivers who usually sleep less than 5 hours daily.
- Drivers who have slept less than 7 hours in the past 24 hours.
- Drivers who have slept 1 or more hours less than their usual amount of sleep in the past 24 hours.

The AAA Foundation for Traffic Safety also notes that, with driving after only 4–5 hours of sleep (compared with 7 hours or more), the estimated rate ratio for crash involvement is similar to US government estimates of the risk associated with driving with a blood alcohol concentration equal to or slightly above the legal limit in the United States (AAA 2016).

2.2.1.2 Circadian Factors. The driver had been working daytime shifts for at least 30 days prior to the crash, up until July 30. He switched to a nighttime (inverted) shift on July 31–August 1. As a result, he had to then adapt to a nighttime driving schedule and daytime sleep, which is the opposite of the human norm. Inverted sleep schedules have been shown to have a negative impact on sleep quality and quantity, resulting in shortened sleep lengths, higher subjective wake-time sleepiness, and degraded performance (Goel, Van Dongen, and Dinges 2011). Moreover, the crash occurred at 3:18 a.m., approaching the lowest ebb of alertness in the circadian cycle. Jovanis, Wu, and Chen (2011) report an increased crash risk during the early morning hours near 6:00 a.m.

2.2.1.3 Fatigue Summary. The Livingston crash involves a situation that the NTSB has addressed on numerous occasions: an overnight motorcoach trip with a commercial driver who has recently inverted his work schedule and, in so doing, does not obtain adequate sleep prior to his shift.[64] When people are impaired by fatigue, they are more likely to experience lapses in judgment, slowed reaction times, and reduced vigilance (Goel and others 2009; Lamond and Dawson 1999). Fatigue affects a wide range of human performance, including vigilance and executive attention, psychomotor and cognitive speed, and working memory (Goel and others 2009). Research on how sleep deprivation affects speed and accuracy in several cognitive categories shows that the largest effects are in lapses of attention and reaction times, two critical behaviors for safe driving (Lim and Dinges 2010).

The driver did not respond to departing the SR-99 travel lanes. Because there were no tire marks, NTSB investigators had no physical evidence (such as braking or corrective steering input) that the driver reacted prior to striking the guardrail. The NTSB concludes that the motorcoach driver was impaired by fatigue at the time of the crash due to acute sleep debt and circadian factors, and that the lack of evasive braking or corrective steering action as the motorcoach drifted off the roadway is consistent with fatigue-induced performance impairment.

[64] Night-shift driving requires obtaining sleep during the day, which is not as restorative as nighttime sleep (Belenky and others 2012).

2.2.2 Hours-of-Service Regulations

As discussed earlier in this report, the Livingston crash is strikingly similar to the New York City and Doswell, Virginia, crashes—which occurred at 5:38 a.m. and 4:55 a.m., respectively. In all three crashes, the scheduled routes involved trips that began in the evening and required the drivers to work through the overnight hours. A substantial body of research confirms the risks of fatigued driving and degraded vehicle operator performance during the early hours of the morning, from 2:00 to 6:00 a.m. (Dewar and Olson 2007).[65] The FMCSA has reported that drivers are particularly affected by fatigue and drowsiness in the early morning and near the end of their shifts (Barr and others 2011). Each of these risks applied to the accident driver.

In its 2011 HOS rulemaking revision for property-carrying drivers, the FMCSA acknowledged that research has long demonstrated that daytime sleep is shorter in duration and lower in quality than nighttime sleep.[66] Regardless of whether the overnight trip occurs in property-carrying CMVs or passenger-carrying buses, fatigue science has confirmed the dangers posed by degraded operator performance during the nighttime window of circadian low. Moreover, the unique job functions and work environments that set bus and motorcoach drivers apart from other CMV drivers include a variety of nondriving duties (such as loading luggage) and interacting with passengers (Belenky, Hanowski, and Jovanis 2013). Adding to the accident driver's workload was the responsibility of communicating with passengers both before the trip and while driving to discuss pickup locations and times.

2.2.3 Safety Recommendation

As a result of the Doswell crash investigation, involving a fatigued motorcoach driver operating on an inverted schedule, the NTSB recommended that the FMCSA (NTSB 2012a):

> Incorporate scientifically based fatigue mitigation strategies into the HOS regulations for passenger-carrying drivers who operate during the nighttime window of circadian low. (H-12-30)

Safety Recommendation H-12-30 is classified "Open—Acceptable Response."

The US Department of Transportation (DOT) has begun to address human circadian variability in its HOS regulations. For example, to help compensate for commercial passenger airline pilots being awake during the circadian low, the Federal Aviation Administration reduced the maximum flight duty period during nighttime hours.[67]

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[65] This 4-hour period is referred to as the nighttime window of circadian low.

[66] See *Federal Register* (*FR*) notice 81133 (December 27, 2011), accessed August 25, 2017.

[67] See Airline Safety and Federal Aviation Administration Extension Act of 2010 (Public Law 111-216, H.R. 5900, August 1, 2010).

The FMCSA has been examining the need to change HOS requirements for drivers of passenger-carrying vehicles.[68] Although the agency has funded research reports and received recommendations from its Motor Carrier Safety Advisory Committee, as well as participant support from two listening sessions, it has not taken action on passenger-carrying hours of service.[69] The NTSB concludes that the CMV HOS regulations for motorcoach and bus drivers would be more effective if they addressed the scientifically established risk of drivers operating during the nighttime window of circadian low. The NTSB, therefore, reiterates Safety Recommendation H-12-30 to the FMCSA and reclassifies it "Open—Unacceptable Response."

2.3 Federal Oversight of Compliance

The FMCSA has a primary mission of reducing crashes, fatalities, and injuries involving large trucks and buses. The agency is tasked with overseeing the safety of motor carrier operations, a duty that it performs primarily by establishing and enforcing safety regulations for the industry. The FMCSA requires that a motor carrier meet the safety fitness standards by demonstrating that it has adequate safety management controls in place to reduce operational risks, such as those associated with the use of drivers who are fatigued or who violate HOS rules.

2.3.1 Carrier and Driver Safety Responsibilities

The motorcoach driver reported for duty—a round-trip, long-distance drive of more than 600 miles—without adequate rest.[70] Autobuses Coordinados had a responsibility to recognize the inherent potential for the driver to be fatigued while operating the motorcoach because of the following factors:

- The driver's responsibility as the point of contact for passengers regarding pickup and drop-off times during his off-duty rest period.
- Length of the driving task.
- Hours on duty for this scheduled route.

The carrier is responsible for establishing routes and scheduling to comply with the HOS regulations. It also has a responsibility to not allow the operation of a commercial vehicle in a circumstance when a driver is likely to become fatigued. Title 49 *CFR* 392.3 specifies that:

> No driver shall operate a commercial motor vehicle, and a motor carrier shall not require or permit a driver to operate a commercial motor vehicle, while the driver's ability or alertness is so impaired, or so likely to become impaired, through fatigue,

[68] In December 2012, the FMCSA began examining evidence reports related to HOS requirements for motorcoach and bus drivers, and convened a panel of experts to discuss the risks associated with fatigue.

[69] The FMCSA held two public listening sessions—one in January 2012 at the American Bus Association Marketplace in Grapevine, Texas; and the second in October 2012 at the California Bus Association Annual Convention in Santa Barbara—to solicit information on driving time, on-duty time, time-on-task function, and cumulative fatigue.

[70] Drivers have both an individual and a professional responsibility to report for work rested and able to perform their duties as required by the *FMCSRs.*

illness, or any other cause, as to make it unsafe for him/her to begin or continue to operate the commercial motor vehicle.

Autobuses Coordinados lacked any systematic approach to maintaining safety. The carrier provided only the minimum safety management required by the FMCSA to keep its operating authority. The HOS regulations are intended to address the fatigue of commercial drivers by governing the length of on-duty and off-duty hours. Although HOS compliance alone cannot mitigate all the factors that may result in fatigue, Autobuses Coordinados—by assigning trips that were unlikely to be completed within the hours of service—created a condition in which drivers would likely become impaired by fatigue.

The FMCSA should use its oversight authority to hold unsafe carriers accountable for repeated HOS violations. Upon completion of a CR, the FMCSA assigns the carrier a rating ("satisfactory," "conditional," or "unsatisfactory") in each of five safety areas, which then results in an overall rating that reflects the company's compliance with the *FMCSRs*. The CR program is intended to improve the safety of commercial vehicle operations through heightened awareness of safety regulations and enforcement (FMCSA 2008).

The condition of vehicles and the performance of drivers are among the most crucial factors in assessing the safety of a motor carrier's operation. However, current rules require that at least two of six factors be rated "unsatisfactory" before the FMCSA can issue an overall unsatisfactory rating.[71] Thus, a carrier could be "unsatisfactory" in either the vehicle or driver factor, yet still be permitted to operate. The NTSB has voiced its concern regarding the importance of driver (and vehicle) safety violations found during CRs and has stated that such serious violations should result in an unsatisfactory rating (NTSB 2012a).

2.3.2 Carrier Compliance Review History

FMCSR violations discovered during the five CRs conducted on Autobuses Coordinados over 8 years demonstrated its repeated lack of compliance. The carrier violated the HOS requirements intended to limit the number of hours motorcoach drivers can operate, which was directly causal to this crash. NTSB investigators found that Autobuses Coordinados was not monitoring or tracking driver hours of service. Drivers had exceeded the maximum driving limits and submitted false reports of records-of-duty status, with no ensuing disciplinary action. Although the FMCSA documented numerous other safety violations in driver and vehicle factors, the company received overall satisfactory ratings or conditional ratings and continued to operate.[72]

[71] The FMCSA may issue an overall unsatisfactory rating if a carrier has an unsatisfactory rating in one factor and more than two conditional ratings in any other factors—the six rating factors being "general," "driver," "operational," "vehicle," "hazardous materials," and "accident rate."

[72] Driver-related violations included the following: (1) failure to ensure that random drug and alcohol tests were unannounced (49 *CFR* 382.305(k)(1)); (2) use of a driver not medically examined and certified during the preceding 24 months (49 *CFR* 391.45(b)(1)); (3) failure to complete a record-of-duty status (49 *CFR* 395.8(e)); (4) failure to require the driver to prepare a record-of-duty status in the prescribed form and manner (49 *CFR* 395.8 (f)); (5) failure to obtain from a driver used for the first time or intermittently a signed statement providing total time on duty the preceding 7 days and the time last relieved from duty (49 *CFR* 395.8(j)(2)); (6) failure to ensure that driver vehicle inspection reports are complete and accurate (49 *CFR* 396.11(b)); and (7) failure to ensure that the driver signs the vehicle inspection report when defects or deficiencies are noted (49 *CFR* 396.13(c)).

Moreover, the CR conducted just prior to the fatal crash resulted in a satisfactory rating, despite the fact that the carrier failed to adequately oversee driver HOS compliance and did not have a safety management plan, a preventive maintenance program, a driver training handbook, or complete driver training files.

Although the FMCSA had detected safety problems with Autobuses Coordinados drivers and vehicles on a recurrent basis, it did not rate the carrier "unsatisfactory" or remove its operating authority until after the August 2, 2016, fatal crash. The NTSB concludes that despite numerous CR findings that provided Autobuses Coordinados with education and heightened awareness of safety regulations, the carrier failed to improve driver oversight and to ensure safe motorcoach operations. The carrier had essentially no written policies, programs, or practices; could not be described as having safety management controls in place; and continued to accrue violations in critical safety areas. The NTSB concludes that Autobuses Coordinados received satisfactory ratings from the FMCSA even though it had no safety management controls to ensure that it adhered to the *FMCSRs.*

2.3.3 Safety Recommendations

The NTSB is concerned that motor carriers with significant regulatory violations for drivers and vehicles are still receiving satisfactory and conditional ratings. The two key factors in safe motor carrier operations are the operational status of the vehicles (buses) and the performance of the drivers. Increasing the weight of performance data for vehicle and driver factors in CRs is important because such deficiencies are directly related to crashes. In a special investigation report on motorcoach issues, the NTSB recommended that the DOT (NTSB 1999):

> Change its safety fitness rating methodology so that adverse vehicle or driver performance-based data alone are sufficient to result in an overall unsatisfactory rating for the carrier. (H-99-6)

Particularly when a CR identifies critical violations directly linked to a crash—such as driver hours of service—the FMCSA should require the carrier to demonstrate a commitment to mitigating safety risks or face being placed out of service. As a result of our investigation of the 2011 New York City motorcoach crash, the NTSB made the following recommendation to the FMCSA (NTSB 2012b):

> Include safety measurement system rating scores in the methodology used to determine a carrier's fitness to operate in the safety fitness rating rulemaking for the new Compliance, Safety, Accountability initiative. (H-12-17)

On January 21, 2016, the FMCSA published a Notice of Proposed Rulemaking (NPRM) to amend the *FMCSRs* to revise the methodology for issuance of a safety fitness determination (SFD). The revision was intended to replace the current three-tier system of "satisfactory–conditional–unsatisfactory" with a single determination of either "fit" or "unfit." Carriers deemed "unfit" would be prohibited by statute from operating in interstate commerce or transportation that affects commerce. The proposed methodology is based on a carrier's on-road safety data in relation to five of the seven BASICs, an investigation, or a combination of on-road safety data and investigation information. When the NPRM was issued, the NTSB responded to the FMCSA that

it remained concerned that the language in the proposed rule did not fully address the intent of Safety Recommendation H-99-6, because the rating process may not appropriately value vehicle and driver factors in CR ratings. As a result of the NPRM's shortcomings and the limited progress of the FMCSA in implementing Safety Recommendation H-99-6, it is classified "Open—Unacceptable Response."

After the investigation of a multivehicle collision on Interstate 88 near Naperville, Illinois, the NTSB determined that the significant and continuing delays in enacting SFD rulemaking were depriving the FMCSA of the necessary tools to effectively address the safety risks posed by high-risk carriers (NTSB 2016). As a result of the Naperville investigation, the NTSB reiterated Safety Recommendation H-12-17, which is classified "Open—Acceptable Response."

On March 23, 2017, the FMCSA withdrew its NPRM to change the process for carrier SFDs and canceled its previously announced plans to develop a supplemental NPRM.[73] The FMCSA stated that it may file a modified proposal if it determines that changes to the SFD process are needed based on suggestions from a National Academies of Sciences, Engineering, and Medicine study, one of several provisions in the Fixing America's Surface Transportation Act.[74] The study is focused on reforming the CSA program and the safety measurement system methodology that drives the program. The FMCSA reported that it would assess "whether and, if so, what corrective actions are advisable," then complete additional analysis before determining whether further rulemaking action should be undertaken.

Immediately following the Livingston crash, the FMCSA issued an imminent hazard OOS order to Autobuses Coordinados to cease operations. However, the NTSB concludes that had the FMCSA changed the safety fitness rating methodology to give appropriate weight to vehicle and driver performance-based data, as the NTSB has recommended, it would have had additional evidence before the crash that Autobuses Coordinados was a habitually unsafe carrier. Further, because of the issues underpinning the CR safety ratings for Autobuses Coordinados, the NTSB concludes that the Livingston crash underscores the urgency for the FMCSA to move forward on implementing an SFD methodology to expedite shutting down unsafe carriers. The NTSB remains concerned about the delay in rulemaking and—considering the extended delay—reiterates Safety Recommendations H-99-6 and H-12-17 to the FMCSA. Additionally, Safety Recommendation H-12-17 is reclassified "Open—Unacceptable Response."

[73] See *FR* notice 14848 (March 23, 2017), accessed August 25, 2017.

[74] See the 2017 consensus study report, accessed July 12, 2017.

2.4 Highway

2.4.1 Roadside Barriers

2.4.1.1 Roadway Departure Crashes. In 2015, 18,695 fatalities were attributed to roadway departure crashes, which accounts for 53.3 percent of all traffic fatalities in the United States.[75] According to the Federal Highway Administration (FHWA), three countermeasures are critical to preventing or mitigating the severity of such crashes:

- Keeping vehicles on the roadway
- Establishing a clear zone
- Installing a roadside barrier system.

Installing rumble strips or improving pavement friction, visibility, or road markings are examples of countermeasures to keep vehicles on the roadway. Once a driver departs the travel lanes, the crash prevention strategy is to provide a clear zone (recovery area) to increase the likelihood of a roadway departure resulting in a safe recovery rather than a crash. Where a fixed object cannot be relocated outside of the clear zone due to limited right-of-way space, severe slopes, or other physical limitations, a roadside barrier system is necessary to shield the object. In this crash, at the location where the accident driver departed the roadway, a guardrail barrier was positioned to shield the vertical signpost—which was located 15 feet from the roadway edge and within the clear zone.

Barrier systems are designed to prevent or reduce the severity of crashes. The *Manual for Assessing Safety Hardware* provides guidance on selecting the appropriate test level barrier based on traffic type (AASHTO 2016).[76] Although the manual evaluates the structural adequacy of barrier systems based on full-scale crash testing, it does not provide site-specific guidance on barrier performance. The RDG presents the FHWA guidance on barriers, but it offers neither a standard nor a design policy. It is intended as a resource for state highway agencies in developing standards and policies (AASHTO 2011).

2.4.1.2 Crash Location Barrier System. The W-beam guardrail at the crash site is a TL-3 barrier. This level of barrier—with a height up to 29 inches—is intended to redirect passenger cars weighing up to 2,420 pounds and pickup trucks weighing up to 5,000 pounds that strike the barrier at speeds up to 62 mph and an angle of impact of no more than 25 degrees (AASHTO 2016). TL-3 barriers are the most commonly used highway barrier system and are not intended to redirect heavy commercial vehicles. Instead, highway engineers may consider several test levels of high-performance barrier systems in crash scenarios involving commercial vehicles, such as a straight truck or a tractor-trailer combination unit.

[75] See the FHWA website, accessed April 25, 2017.

[76] The AASHTO *Manual for Assessing Safety Hardware* documents the latest evolutions in barrier testing and is used to evaluate the structural adequacy of barrier systems based on updated test vehicles and impact conditions. It contains revised criteria for evaluating highway safety features based on changes in vehicle fleets.

2.4.1.3 High-Performance Barrier Systems. High-performance barrier systems are designed to protect a larger and heavier class of vehicles than TL-3 barriers. These systems include TL-4 barriers, typically 32 inches high and capable of redirecting a single-unit truck weighing up to 22,000 pounds; and TL-5 barriers, 42 inches high and capable of redirecting a tractor-van trailer weighing up to 79,300 pounds. However, these barrier systems have not been tested to determine their capability to redirect a modern motorcoach or other heavy commercial passenger vehicle. Crash tests using a commercial straight truck and a tractor-trailer combination unit have resulted in barrier designs capable of containing or redirecting these vehicle types (see table 7). However, both vehicle types differ substantially from a typical motorcoach or chassis-on-frame bus in terms of center-of-gravity and vehicle dynamics. Crash testing is needed to determine deflection and height characteristics for a barrier capable of redirecting a motorcoach or bus weighing at least 22,000 pounds.

Table 7. AASHTO-prescribed roadside barrier test levels.

Test Level	Test Vehicle	Weight (pounds)	Height of Barrier (inches)
1–3	Passenger car or pickup truck	2,420–5,000	27¾–29
4	Single-unit truck	22,000	32
Unknown	Motorcoach bus	22,000 and above	Unknown
5	Tractor-van trailer	79,300	42
6	Tractor-tanker trailer	79,300	90

Although current RDG guidelines reference the severe consequences associated with a large vehicle penetrating a barrier, they do not distinguish the consequences of a motorcoach crash from other commercial vehicle crashes (AASHTO 2011).[77] Regardless of the crash location, a single motorcoach or bus crash can expose large numbers of vehicle occupants to the risk of death or injury. When a commercial passenger vehicle departs the travel lanes and strikes a guardrail, the performance standards of that barrier system can significantly affect the outcome of the crash.

In the 2011 New York City crash investigation, the examination of barrier research and testing methods revealed the necessity for new barrier performance standards along with, possibly, new designs with height and deflection characteristics capable of safely redirecting heavy commercial passenger vehicles from fixed-base point hazards (NTSB 2012b). The most recent barrier testing was completed in 2009 and did not include commercial buses or motorcoaches, leaving a gap in determining which types of barrier system, if any, would best interact with the dynamics of the current fleet of these vehicle types. The NTSB concludes that, under circumstances similar to the 2011 New York City crash, the crash force of the accident motorcoach

[77] The RDG does not provide standards or design policy. It is a resource document for highway agencies to use in developing standards and policies.

exceeded the capability of the TL-3 strong-post, blocked-out W-beam guardrail barrier system, which was not designed to safely contain or redirect it.

2.4.1.4 Guidance for Selecting Barrier Systems. Objective warrants are needed in the selection of traffic barriers.[78] The RDG lists only subjective factors to be considered for the use of higher performance traffic barriers in new construction or safety upgrading, such as the following:

- High percentage of heavy vehicles in the traffic stream or high concentration of trucks at an interchange.
- Hazardous materials route.
- Adverse geometrics, such as sharp curvature, which is often combined with limited sight distance, or long downhill grades combined with horizontal curvature.
- Severe consequences associated with penetration of a barrier by a large vehicle, such as affecting multilevel interchange ramps; highly sensitive environmental areas; or critical highway components, such as nationally significant bridges or tunnels.

These factors reflect the systems-level approach generally used by highway engineers when considering road user safety and primarily address the consequences of crashes involving heavy freight-carrying commercial vehicles. They do not consider the potential catastrophic loss of life from crashes involving commercial passenger vehicles. Although a systems-level approach to highway design and safety focuses on roadway factors, the potentially high number of occupants in motorcoach crashes underscores the necessity to distinguish among vehicle types.

For example, the vertical signposts in both the Livingston and New York City crashes were fixed-base point hazards. One 14-inch-diameter steel tubular post—located 15 feet from the edge of the roadway, within the 30-foot clear zone—was in place at the Livingston crash site; and two 8-inch-diameter steel tubular poles were in place within the clear zone at the New York City crash site. Each of these crashes involved a single motorcoach and collectively resulted in 19 passenger fatalities and 36 injured, demonstrating the need to consider these vehicle types when evaluating a segment of highway for safety factors such as roadside barriers. The RDG does not currently list these types of hazards as subjective factors to be considered for the use of higher performance traffic barriers.

Using National Highway Traffic Safety Administration (NHTSA) Fatality Analysis Reporting System data from 2010 through 2015, NTSB investigators examined the event sequence of fatal crashes on high-speed roadways involving heavy vehicle collisions with guardrails. The data show a concentration of crashes in California, Texas, Florida, and the eastern United States.

[78] State transportation agencies may develop objective warrants for barrier placement, which—if exceeded—would indicate the need for a barrier. For example, in the case of median barriers, accident rate, average daily traffic, and percentage of heavy vehicle traffic could be used.

Figure 14 depicts the locations and concentrations of crashes involving heavy vehicles (excluding Livingston).[79]

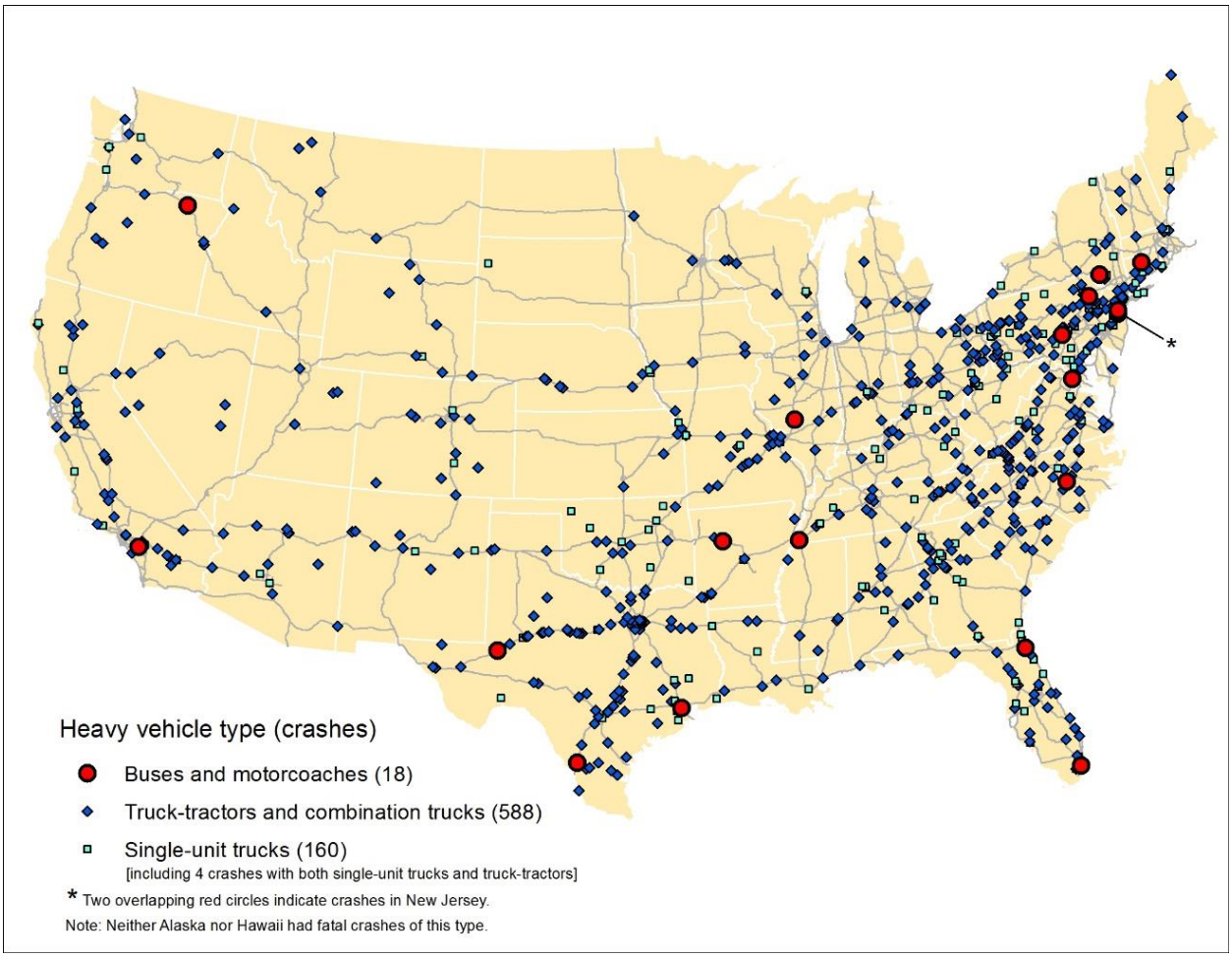

Figure 14. Fatal crash locations on high-speed roadways involving heavy vehicles colliding with guardrails (2010–2015).

Fatal motorcoach crashes involving guardrails are most likely to occur on roadways that are heavily used by commercial passenger vehicles. To address crashes along these limited segments of highway, two factors must be considered in developing guidelines for high-performance barriers to shield commercial passenger vehicles from hazards within the clear zone, including fixed-base point hazards:

- ***Commercial passenger vehicle traffic along heavily used corridors***: In the case of the Livingston and New York City crashes, both SR-99 and I-95, respectively, are heavily used traffic corridors. Along SR-99 approaching Livingston, the average daily traffic

[79] The map marks only those locations with known latitude and longitude. Otherwise, all such fatal heavy vehicle crashes for 2010–2015 total 20 for buses and motorcoaches, 598 for truck-tractors and combination trucks, and 163 for single-unit trucks or combination single-unit trucks and truck-tractors.

volume is 108,000 vehicles. Along I-95 through New York City, the average daily traffic volume is 107,000 vehicles. The average monthly volume of commercial passenger vehicles is 3,400 for SR-99 in Livingston and 2,000 for I-95 through New York City.

- ***Crash history of guardrail strikes***: The W-beam guardrail in the Livingston crash had been struck by vehicles three times in the last 5 years, including the subject motorcoach crash. The W-beam guardrail in the New York City crash had been struck by vehicles six times in the last 5 years, including the March 2011 fatal motorcoach crash that the NTSB investigated.

The systems-based approach for highway design and safety decisions has proven to be a useful method for engineering evaluation of elements such as barrier types and performance levels. However, a risk-based approach is needed to help prioritize locations along heavily used corridors where guardrails are intended to shield traffic hazards from commercial passenger vehicles. The NTSB concludes that a risk-based approach, based on considerations such as percentage of commercial passenger vehicle traffic and crash history, is essential to help state transportation agencies determine whether higher performance barriers are needed to shield hazards within the clear zone.

Although RDG guidelines mention the severe consequences associated with a large vehicle penetrating a barrier, they do not address the use of barriers to redirect vehicles such as motorcoaches and heavy commercial passenger vehicles. The NTSB concludes that the current RDG does not contain guidance for the use of higher performance traffic barriers to redirect larger commercial passenger vehicles, such as motorcoaches and buses.

2.4.2 Safety Recommendations

2.4.2.1 Barrier Systems. Crash test performance levels for barrier systems have evolved. With improvements, barriers could potentially safely redirect motorcoaches and buses, even in high-speed collisions. As a result of the New York City crash, the NTSB recommended that AASHTO (NTSB 2012b):

> Evaluate the adequacy of barrier systems currently approved through National Cooperative Highway Research Program Report 350 or the *Manual for Assessing Safety Hardware* for safely redirecting commercial passenger vehicles and, if warranted, develop new barrier designs incorporating appropriate height and deflection characteristics capable of safely redirecting commercial passenger vehicles. (H-12-26)

Safety Recommendation H-12-26 is classified “Open—Acceptable Response.” However, because it is essential that commercial passenger vehicles be protected from roadside hazards in the event of a run-off-the-road crash, the NTSB reiterates this recommendation and reclassifies it “Open—Unacceptable Response.” This change in classification is due to the AASHTO delay in (1) evaluating barrier system adequacy and developing new barrier systems designs (if warranted) for safely redirecting commercial passenger vehicles; and (2) revising the RDG to incorporate

guidance on the selection of high-performance barriers for shielding commercial passenger vehicles from roadside hazards, considering the unique aspects of point hazards.

As a result of the 2011 New York City crash investigation, the NTSB made the following recommendations to the FHWA and AASHTO, respectively (NTSB 2012b):

> Work with the American Association of State Highway and Transportation Officials to establish performance and selection guidelines for state transportation agencies to use in developing objective warrants for high-performance barriers applicable to new construction and rehabilitation projects where barrier replacement has been determined to be appropriate. (H-12-23)
>
> Work with the Federal Highway Administration to establish performance and selection guidelines for state transportation agencies to use in developing objective warrants for high-performance barriers applicable to new construction and rehabilitation projects where barrier replacement has been determined to be appropriate. (H-12-25)

Although new TRB projects address fixed objects within the clear zone (NCHRP 17-82) and safety performance-based guidelines for the RDG (NCHRP 15-65), they do not consider the adequacy of barrier systems to safely redirect commercial passenger vehicles.[80] At the same time, it is apparent that the RDG does not properly capture the current fleet of commercial buses. Safety Recommendations H-12-23 and -25 are classified "Open—Acceptable Response."

The highway design community is increasingly interested in incorporating risk-based approaches to highway safety improvements, as demonstrated by recent initiatives of the AASHTO Technical Committee on Roadside Safety. A risk-based approach will help prioritize cost-effective solutions in selecting high-performance barriers to shield fixed-base point hazards. The AASHTO Technical Committee and highway design community did not consider a risk-based approach in responding to Safety Recommendation H-12-25 (NTSB 2012b). Therefore, the NTSB reclassifies both Safety Recommendations H-12-23 and -25 "Closed—Superseded."

The NTSB recommends that the FHWA work with AASHTO to develop recommended guidelines, using a risk-based approach, for state transportation agencies to use in formulating objective warrants for high-performance barriers applicable to new construction and rehabilitation projects where barrier replacement has been determined to be appropriate. At minimum, the guidelines should include factors such as the percentage of commercial passenger vehicle traffic, crash history, and shielding requirements associated with fixed-base point hazards. The NTSB makes a corresponding recommendation to AASHTO.

2.4.2.2 Clear Zone. Motorcoaches transport 750 million passengers annually throughout the United States. Unlike other heavy commercial vehicles, a single bus or motorcoach can expose large numbers of people to the risk of death or injury. The NTSB concludes that though the risk of a motorcoach or bus striking a moderately severe point hazard in the clear zone is low compared

[80] See the pending proposed RDG guidance on fixed objects, NCHRP 17-82, accessed May 17, 2017; and the TRB request for proposals on RDG performance-based guidelines, NCHRP 15-65, accessed May 17, 2017.

to encountering a long slope hazard, the potential intrusion of a point hazard into the passenger compartment would, nonetheless, expose a large number of people to the risk of death or injury.

As a result of the 2011 New York City crash, the NTSB recommended that AASHTO (NTSB 2012b):

> Once barrier testing has been completed and selection guidelines have been developed, revise chapter 5 of the *Roadside Design Guide* to incorporate guidance for the selection of high-performance barriers used in new construction and rehabilitation projects; this guidance should specifically address the unique considerations of shielding commercial passenger vehicles from point hazards. (H-12-27)

After the New York City crash, AASHTO published the 2011 RDG, which included one additional subjective factor to consider when recommending higher performance traffic barriers.[81] Safety Recommendation H-12-27 is classified "Open—Acceptable Response." However, the 2011 RDG does not contain objective warrants for the use of higher performance traffic barriers.

The NTSB concludes that the severity of the Livingston crash is directly attributable to the motorcoach striking the vertical highway signpost located within the clear zone, despite a barrier system being in place. Therefore, the NTSB reiterates Safety Recommendation H-12-27 to AASHTO and reclassifies it "Open—Unacceptable Response."

2.5 Motorcoach Occupant Protection

The severe interior damage to the motorcoach was caused by the intrusion of the vertical signpost as it moved rearward and tore through the floor and up through the roof. The intrusion destroyed or displaced aft all seat rows on the passenger side, except for the last row, which compromised the survival space. Four rows of passenger-side seats (starting at the loading door) were displaced, compressed, and pushed rearward to just in front of the sleeper berth at row 10. Emergency responders found some fatally and seriously injured passengers trapped in the interior compartment wreckage within the intrusion area.

Motorcoach occupants seated on the passenger side were positioned in the area of the vertical signpost intrusion. The fatal and serious injuries sustained by these passengers were caused by the intrusion, and a front seat passenger was ejected from the vehicle.[82] The NTSB concludes that survival space was compromised as the vertical highway signpost traversed the motorcoach interior from the front stairwell for almost the entire length of the vehicle.

Passengers who sustained minor or no injuries were seated in the rear or on the driver side of the motorcoach, where the seating area was not compromised by the intrusion of the signpost. For those seated near the front and middle of the motorcoach on the driver side, serious injuries

[81] The 2011 revision was a regularly scheduled update, which generally occurs every 4–5 years.

[82] The driver sustained serious injuries; however, it cannot be established whether his injuries occurred from being ejected (reported by emergency responders), being struck by a vehicle postcrash when he was outside of the motorcoach (reported by bus passengers), or being struck by the unrestrained passenger seated behind him. The modesty panel located behind the driver seat showed evidence of forward deformation from passenger impact.

were related to their movement from the seating compartment. The 1998 motorcoach was equipped with lap belts for the front four seats and the last row center seat only.

As of November 2016, newly built motorcoaches are required to have lap and shoulder restraints for all seating positions. However, had the motorcoach been equipped with three-point restraints and had the passengers been wearing them properly, it is still likely that those passengers seated in the area of catastrophic intrusion damage would have sustained fatal and serious injuries. The NTSB concludes that the use of lap and shoulder belts may have prevented some of the serious injuries to passengers seated closer to the frontal impact location but outside of the intrusion area.

3 Conclusions

3.1 Findings

1. None of the following were factors in the crash: (1) mechanical condition of the motorcoach; (2) driver licensing, experience, alcohol or other drug impairment, medical conditions, or distraction; (3) weather conditions; or (4) visibility.

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

3. The motorcoach driver was impaired by fatigue at the time of the crash due to acute sleep debt and circadian factors, and the lack of evasive braking or corrective steering action as the motorcoach drifted off the roadway is consistent with fatigue-induced performance impairment.

4. The commercial motor vehicle hours-of-service regulations for motorcoach and bus drivers would be more effective if they addressed the scientifically established risk of drivers operating during the nighttime window of circadian low.

5. Despite numerous compliance review findings that provided Autobuses Coordinados with education and heightened awareness of safety regulations, the carrier failed to improve driver oversight and to ensure safe motorcoach operations.

6. Autobuses Coordinados received satisfactory ratings from the Federal Motor Carrier Safety Administration even though it had no safety management controls to ensure that it adhered to the *Federal Motor Carrier Safety Regulations*.

7. Had the Federal Motor Carrier Safety Administration changed the safety fitness rating methodology to give appropriate weight to vehicle and driver performance-based data, as the National Transportation Safety Board has recommended, it would have had additional evidence before the crash that Autobuses Coordinados was a habitually unsafe carrier.

8. Because of the issues underpinning the compliance review safety ratings for Autobuses Coordinados, the Livingston crash underscores the urgency for the Federal Motor Carrier Safety Administration to move forward on implementing a safety fitness determination methodology to expedite shutting down unsafe carriers.

9. Under circumstances similar to the 2011 New York City crash, the crash force of the accident motorcoach exceeded the capability of the test level-3 strong-post, blocked-out W-beam guardrail barrier system, which was not designed to safely contain or redirect it.

10. A risk-based approach, based on considerations such as percentage of commercial passenger vehicle traffic and crash history, is essential to help state transportation agencies determine whether higher performance barriers are needed to shield hazards within the clear zone.

11. The current *Roadside Design Guide* does not contain guidance for the use of higher performance traffic barriers to redirect larger commercial passenger vehicles, such as motorcoaches and buses.

12. Although the risk of a motorcoach or bus striking a moderately severe point hazard in the clear zone is low compared to encountering a long slope hazard, the potential intrusion of a point hazard into the passenger compartment would, nonetheless, expose a large number of people to the risk of death or injury.

13. The severity of the Livingston crash is directly attributable to the motorcoach striking the vertical highway signpost located within the clear zone, despite a barrier system being in place.

14. Survival space was compromised as the vertical highway signpost traversed the motorcoach interior from the front stairwell for almost the entire length of the vehicle.

15. The use of lap and shoulder belts may have prevented some of the serious injuries to passengers seated closer to the frontal impact location but outside of the intrusion area.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of the Livingston, California, crash was driver fatigue resulting from acute sleep loss and circadian factors. Contributing to the cause of the crash were the inadequate safety practices of Autobuses Coordinados; and the Federal Motor Carrier Safety Administration's lack of oversight of Autobuses Coordinados, which allowed the company to continue operations despite known safety issues. Contributing to the severity of the crash were the guardrail, which was not designed to redirect the motorcoach and did not prevent it from colliding with the vertical highway signpost; and the extensive intrusion of the signpost into the passenger compartment.

4 Recommendations

4.1 New Recommendations

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

To the Federal Highway Administration:

> Work with the American Association of State Highway and Transportation Officials to develop recommended guidelines, using a risk-based approach, for state transportation agencies to use in formulating objective warrants for high-performance barriers applicable to new construction and rehabilitation projects where barrier replacement has been determined to be appropriate. At minimum, the guidelines should include factors such as the percentage of commercial passenger vehicle traffic, crash history, and shielding requirements associated with fixed-base point hazards. (H-17-44)

To the American Association of State Highway and Transportation Officials:

> Work with the Federal Highway Administration to develop recommended guidelines, using a risk-based approach, for state transportation agencies to use in formulating objective warrants for high-performance barriers applicable to new construction and rehabilitation projects where barrier replacement has been determined to be appropriate. At minimum, the guidelines should include factors such as the percentage of commercial passenger vehicle traffic, crash history, and shielding requirements associated with fixed-base point hazards. (H-17-45)

4.2 Previously Issued Recommendation Reiterated in This Report

As a result of its investigation, the National Transportation Safety Board reiterates the following safety recommendation.

To the Federal Motor Carrier Safety Administration:

> Change your safety fitness rating methodology so that adverse vehicle or driver performance-based data alone are sufficient to result in an overall unsatisfactory rating for the carrier. (H-99-6)

4.3 Previously Issued Recommendations Reiterated and Reclassified in This Report

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

To the Federal Motor Carrier Safety Administration:

> Incorporate scientifically based fatigue mitigation strategies into the hours-of-service regulations for passenger-carrying drivers who operate during the nighttime window of circadian low. (H-12-30)
>
> Include safety measurement system rating scores in the methodology used to determine a carrier's fitness to operate in the safety fitness rating rulemaking for the new Compliance, Safety, Accountability initiative. (H-12-17)

In addition, both Safety Recommendations H-12-30 and -17 are reclassified "Open—Unacceptable Response" in sections 2.2.3 and 2.3.3 of this report, respectively.

To the American Association of State Highway and Transportation Officials:

> Evaluate the adequacy of barrier systems currently approved through National Cooperative Highway Research Program Report 350 or the *Manual for Assessing Safety Hardware* for safely redirecting commercial passenger vehicles and, if warranted, develop new barrier designs incorporating appropriate height and deflection characteristics capable of safely redirecting commercial passenger vehicles. (H-12-26)
>
> Once barrier testing has been completed and selection guidelines have been developed, revise chapter 5 of the *Roadside Design Guide* to incorporate guidance for the selection of high-performance barriers used in new construction and rehabilitation projects; this guidance should specifically address the unique considerations of shielding commercial passenger vehicles from point hazards. (H-12-27)

In addition, both Safety Recommendations H-12-26 and -27 are reclassified "Open—Unacceptable Response" in section 2.4.2 of this report.

4.4 Previously Issued Recommendations Reclassified in This Report

As a result of its investigation, the National Transportation Safety Board reclassifies both Safety Recommendations H-12-23 and -25 "Closed—Superseded" in section 2.4.2 of this report.

To the Federal Highway Administration:

> Work with the American Association of State Highway and Transportation Officials to establish performance and selection guidelines for state transportation agencies to use in developing objective warrants for high-performance barriers applicable to new construction and rehabilitation projects where barrier replacement has been determined to be appropriate. (H-12-23)

To the American Association of State Highway and Transportation Officials:

> Work with the Federal Highway Administration to establish performance and selection guidelines for state transportation agencies to use in developing objective warrants for high-performance barriers applicable to new construction and rehabilitation projects where barrier replacement has been determined to be appropriate. (H-12-25)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

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Member

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Member

Adopted: October 13, 2017

Appendix A: Investigations

The National Transportation Safety Board (NTSB) was notified of the Livingston, California, crash on August 2, 2016, and dispatched an investigative team to the site. The NTSB established groups to investigate human performance; motor carrier operations; and highway, survival, and vehicle factors.

Parties to the investigation were the Federal Motor Carrier Safety Administration, the California Highway Patrol, and the California Department of Transportation.

Appendix B: Autobuses Coordinados Compliance Review Violations

Table B-1: Autobuses Coordinados violations from six FMCSA compliance reviews.

CFR Violation	Compliance Review Date and Rating Result					
	01/11/08 Satisfactory	12/12/11 Satisfactory	04/30/13 Satisfactory	11/06/15 Conditional	05/17/16 Satisfactory	Postcrash OOS
391.11(a): Critical			✓		✓[a]	
395.8(i): Critical	✓[b]					✓
395.8(k)(1): Critical				✓		
396.11(a): Critical						✓
396.17(a): Critical						✓
383.37(a): Acute						✓
391.21(a)	✓			✓		
391.23(a)	✓		✓			
391.23(e)(1)			✓		✓	
391.51(b)(7)			✓			
395.5(a)(1)		✓		✓	✓	✓
395.5(a)(2)		✓				
395.5(b)(2)					✓	
395.8(e)		✓	✓✓		✓	✓
395.8(f)	✓				✓	✓
396.3(a)				✓	✓	
396.3(a)(1)	✓					
396.3(a)(2)	✓					✓
396.3(b)(1)			✓			
396.3(b)(2)	✓					✓
396.9(d)(2)				✓		
396.9(d)(3)				✓	✓	
396.19(b)						✓
396.25(c)			✓			

CFR Violation	Compliance Review Date and Rating Result					
	01/11/08 Satisfactory	12/12/11 Satisfactory	04/30/13 Satisfactory	11/06/15 Conditional	05/17/16 Satisfactory	Postcrash OOS
390.15(b)(1)						✓
382.303(d)						✓
382.305(i)(2)					✓	
382.401(c)(6)	✓				✓	
382.403					✓	
382.413						✓
382.601			✓			

[a] Not critical in May 2016 CR; critical in April 2013 and postcrash CRs.

[b] Not critical in January 2008 CR; critical in postcrash CR.

49 CFR	**Violation Description**
383.37(a)	Driver with a suspended or revoked license – **Acute**
391.11(a)	Using a driver not medically examined or certified/ driver operating without a valid license – **Critical**
395.8(i)	Failing to submit records-of-duty status within 13 days – **Critical**
396.11(a)	Failing to have driver complete driver vehicle inspection reports – **Critical**
396.17(a)	Using an uninspected CMV – **Critical**
382.303(d)	Failing to document postcrash drug and alcohol testing
382.305(i)(2)	Random test availability
382.401(c)(6)	Failing to maintain semi-annual lab statistics/administrative record retention
382.403	Failing to prepare an annual calendar
382.413	Failing to investigate drug and alcohol history
382.601	Failing to provide employees with written policy
390.15(b)(1)	Failing to maintain accident register
391.21(a)	Incomplete/no employee application
391.23(a)	Failing to investigate driver's background
391.23(e)(1)	Failing to investigate driver's drug and alcohol history within previous 3 years
391.51(b)(7)	No medical certificate in qualification file
395.5(a)(1)	Requiring or permitting driver of a passenger CMV to drive more than 10 hours
395.5(a)(2)	Requiring or permitting driver of a passenger CMV to drive after 15 hours

395.5(b)(2)	Requiring or permitting driver of a passenger CMV to drive after having been on duty >70 hours in 8 days
395.8(e)	False report of records of duty status/failing to prepare records of duty status in proper form and manner
395.8(f)	Failing to prepare records of duty status in proper form and manner
395.8(k)(1)	Failing to retain supporting documentation for 6 months
396.3(a)	Failing to maintain fleet
396.3(a)(1)	Failing to inspect or maintain vehicle
396.3(a)(2)	Failing to inspect pushout windows every 90 days
396.3(b)(1)	Failing to maintain vehicle records with make, serial number, year, and tire size
396.3(b)(2)	Failing to keep maintenance records
396.9(d)(2)	Failing to correct violations or defects and to document repairs
396.9(d)(3)	Failing to keep inspection form for 12 months at PPOB
396.19(b)	Inspector qualifications
396.25(c)	Brake inspector qualifications

Appendix C: SR-99 Data

Table C-1. Caltrans data on objects struck on SR-99 north, within 2.5-mile radius of crash location, June 23, 2009–June 30, 2014.

Object Struck	Number of Accidents
Other vehicles	36
Embankment	6
Drainage ditch	6
Guardrail	3
Dike or curb	3
Overturned	3
Traffic sign/signpost	2
Wall	2
Fence	2
Median barrier	1
Guidepost	1
Cut slope	1
Other object on road	1
Call box	1
Other	4
Pole	0
TOTAL	**72**

Table C-2. Caltrans 24-hour vehicle classification count on SR-99 north, July 26, 2016.

Vehicle Classification		Volume	Percent of Traffic	Bus and Truck Traffic Percent/ Volume
Class 1:	Motorcycles	67	0.1	15.1% (9,276)
Class 2:	Passenger cars	39,694	64.9	
Class 3:	Other two-axle, four-tire single-unit vehicles	11,813	19.3	
Class 4:	Buses	85	0.1	
Class 5:	Two-axle, six-tire, single-unit trucks	2,099	03.4	
Class 6:	Three-axle single-unit trucks	312	0.5	
Class 7:	Four or more axle single-unit trucks	16	0	
Class 8:	Four or fewer axle single-trailer trucks	342	0.6	
Class 9:	Five-axle single-trailer trucks	5,081	8.3	
Class 10:	Six or more axle single-trailer trucks	11	0	
Class 11:	Five or fewer axle multitrailer trucks	1,091	1.8	
Class 12:	Six-axle multitrailer trucks	107	0.2	
Class 13:	Seven or more axle multitrailer trucks	22	0	
Class 14:	Five-axle truck and trailer combinations	110	0.2	
Class 15:	Errors/unknown	335	0.6	
TOTAL		**61,185**	**100**	

Appendix D: Roadside Barrier Test Conditions

Table D-1. Roadside barrier test conditions from AASHTO and TRB.

Test Level	Test Vehicle	Test Conditions[a,b]					
		Vehicle Weight (pounds)		Speed (mph)		Angle (degrees)	
		MASH	NCHRP Report 350	MASH	NCHRP Report 350	MASH	NCHRP Report 350
1	Passenger car	2,420	1,800	31	31	25	20
	Pickup truck	5,000	4,400	31	31	25	25
2	Passenger car	2,420	1,800	44	44	25	20
	Pickup truck	5,000	4,400	44	44	25	25
3	Passenger car	2,420	1,800	62	62	25	20
	Pickup truck	5,000	4,400	62	62	25	25
4	Passenger car	2,420	1,800	62	62	25	20
	Pickup truck	5,000	4,400	62	62	25	25
	Single-unit truck	22,000	17,600	56	50	15	15
5	Passenger car	2,420	1,800	62	62	25	20
	Pickup truck	5,000	4,400	62	62	25	25
	Tractor-van trailer	79,300	80,000	50	50	15	15
6	Passenger car	2,420	1,800	62	62	25	20
	Pickup truck	5,000	4,400	62	62	25	25
	Tractor-tank trailer	79,300	80,000	50	50	15	15

[a] AASHTO (American Association of State Highway and Transportation Officials). 2016. *Manual for Assessing Safety Hardware* (MASH).

[b] TRB (Transportation Research Board/National Cooperative Highway Research Program). 1993.

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