Motorcoach Collision With Combination Vehicle After Traffic Break on Interstate 10 Palm Springs, California October 23, 2016

Accident Report

NTSB/HAR-17/04
PB2018-100195

National
Transportation
Safety Board

NTSB/HAR-17/04
PB2018-100195
Notation 57128
Adopted October 31, 2017

Highway Accident Report

Motorcoach Collision With Combination Vehicle
After Traffic Break on Interstate 10
Palm Springs, California
October 23, 2016

National
Transportation
Safety Board

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

National Transportation Safety Board. 2017. ***Motorcoach Collision With Combination Vehicle After Traffic Break on Interstate 10, Palm Springs, California, October 23, 2016.*** **Highway Accident Report NTSB/HAR-17/04. Washington, DC**.

Abstract: On October 23, 2016, about 5:16 a.m., a motorcoach ran into the rear of a stopped combination vehicle in the westbound lanes of Interstate 10 (I-10), outside Palm Springs, California. About 9 minutes before the crash, the California Highway Patrol (CHP) initiated a traffic break for both eastbound and westbound traffic on I-10 in support of utility work being performed west of the crash location. At that time, a combination vehicle was traveling westbound on I-10. It stopped when it reached the traffic queue that had formed as a result of the break. After a break that lasted about 7 minutes, the CHP released westbound traffic. The combination vehicle remained stopped and was stationary as westbound traffic resumed normal flow. About 2 minutes after the traffic break ended, a 47-passenger motorcoach was traveling on westbound I-10 in the lane in which the combination vehicle was stopped. The motorcoach, which was occupied by a driver and 42 passengers, struck the rear of the combination vehicle's semitrailer. As a result of the crash, the bus driver and 12 passengers died, and the truck driver and 30 passengers were injured. The crash investigation focused on the following safety issues: traffic break policies, obstructive sleep apnea and diabetes in commercial vehicle drivers, oversight of commercial vehicle drivers and carriers, emergency egress, and collision avoidance systems. The National Transportation Safety Board (NTSB) makes new safety recommendations to the Federal Highway Administration, Federal Motor Carrier Safety Administration (FMCSA), Tri-State Collision LLC, American Trucking Associations, Owner-Operator Independent Drivers Association, Commercial Vehicle Safety Alliance, International Association of Chiefs of Police, and National Sheriffs' Association. The NTSB reiterates recommendations to the FMCSA, the National Highway Traffic Safety Administration, and commercial vehicle manufacturers. The NTSB reiterates and reclassifies one recommendation to the FMCSA.

Contents

Figures and Tables

Acronyms and Abbreviations

AMR	American Medical Response
ANPRM	advance notice of proposed rulemaking
ATSSA	American Traffic Safety Services Association
BASIC	Behavior Analysis and Safety Improvement Category [FMCSA]
BMI	body mass index
Caltrans	California Department of Transportation
CAS	collision avoidance system
CDL	commercial driver’s license
CFR	*Code of Federal Regulations*
CHP	California Highway Patrol
CMV	commercial motor vehicle
CVSA	Commercial Vehicle Safety Alliance
CWS	collision warning system
DOT	US Department of Transportation
ECM	engine control module
EMS	emergency medical services
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FMVSSs	*Federal Motor Vehicle Safety Standards*
FOV	field of view
GPS	global positioning system
GVWR	gross vehicle weight rating
HOS	hours-of-service

I-10	Interstate 10
IC	incident command(er)
kg/m^2	kilograms per square meter
MCI	Motor Coach Industries International Inc.
MCMIS	Motor Carrier Management Information System [FMCSA]
MCSAC	Motor Carrier Safety Advisory Committee
mg/dL	milligrams per deciliter
MRB	Medical Review Board
MUTCD	*Manual on Uniform Traffic Control Devices for Streets and Highways*
MVARS	mobile video/audio recording system
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
OOS	out-of-service
OSA	obstructive sleep apnea
PSFD	Palm Springs Fire Department
SCE	Southern California Edison Company
TMP	transportation management plan

Executive Summary

Investigation Synopsis

The crash occurred on Sunday, October 23, 2016, in dark conditions, about 5:16 a.m. Pacific daylight time, when a motorcoach ran into the rear of a stopped combination vehicle near mile marker 32.5 in the westbound lanes of Interstate 10 (I-10), outside Palm Springs, California.

About 5:07 a.m. (9 minutes before the crash), the California Highway Patrol (CHP) initiated a traffic break for both eastbound and westbound traffic on I-10 in support of utility work that was being performed about 1.5 miles west of the crash location. (A traffic break is a method of temporary traffic control that is used to slow or stop traffic, most typically to allow for completion of construction activities.) At that time, a 2015 International Prostar truck-tractor in combination with a 2012 Utility semitrailer, operated by Tri-State Collision LLC, was traveling westbound on I-10. The combination vehicle stopped when it reached the traffic queue that had formed as a result of the break. About 5:14 a.m., after a traffic break that lasted about 7 minutes, the CHP released westbound traffic to start moving again. Despite the release, however, the combination vehicle remained stopped in the center-right lane of the four-lane westbound roadway and, according to witnesses, was stationary as westbound traffic resumed normal flow.

About 2 minutes after the traffic break ended, a 1996 Motor Coach Industries International Inc. (MCI) 47-passenger motorcoach, operated by USA Holiday, was traveling at highway speed on westbound I-10 in the lane in which the combination vehicle was stopped. The motorcoach, which was occupied by a 59-year-old driver and 42 passengers, struck the rear of the semitrailer, intruding about 13 feet into the semitrailer and pushing the combination vehicle 71 feet forward before coming to a stop. As a result of the crash, the bus driver and 12 passengers died, and the truck driver and 30 passengers were injured.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the Palm Springs, California, crash was (1) the California Department of Transportation's inadequate transportation management plan for the traffic break, which resulted in a hazardous traffic situation in which law enforcement did not detect the combination vehicle's lack of movement after the traffic break ended and the bus driver did not receive any advance warning of potential traffic stoppage ahead; (2) the truck driver's not moving his combination vehicle after the traffic break ended, most likely due to his falling asleep as a result of his undiagnosed moderate-to-severe obstructive sleep apnea; and (3) the bus driver's lack of action to avoid the crash due to his not perceiving the combination vehicle as stopped, as a result of his fatigue and the fact that he did not expect to encounter stopped traffic.

Safety Issues

The crash investigation focused on the following safety issues:

- ***Traffic break policies:*** In its process for approving permits for temporary traffic breaks, the California Department of Transportation did not require that law enforcement use advance warning devices when conducting the breaks. Such devices could have adjusted the bus driver's expectations regarding potential traffic stoppage. Moreover, had additional law enforcement vehicles been used to conduct the break, the officers could have monitored the movement of the westbound traffic after the break ended and possibly realized that the stopped truck did not resume operation; they could then have alerted the driver to rejoin traffic.
- ***Obstructive sleep apnea and diabetes in commercial vehicle drivers:*** The crash evidence indicates that the truck driver fell asleep during the traffic break of about 7 minutes' duration. Although he was severely obese and at a very high risk for obstructive sleep apnea (OSA), the truck driver had not been tested for the condition. Although the Federal Motor Carrier Safety Administration (FMCSA) Medical Review Board has developed guidance for screening for OSA, the FMCSA has not disseminated this guidance to the examiners that it certifies to perform commercial driver's license medical examinations.

  The investigation revealed that the bus driver had untreated diabetes. Although he had a positive glucose urine test during his medical certificate examination, the medical examiner did not diagnose the bus driver's diabetes or refer the driver for further testing. The FMCSA does not provide any guidance to certified medical examiners about what to do when drivers test positive for urine glucose.
- ***Oversight of commercial vehicle drivers and carriers:*** The truck driver had violated hours-of-service regulations for several days prior to the crash. The motor carrier Tri-State Collision did not use its available advanced driver-monitoring system to verify its truck drivers' compliance with hours-of-service regulations, which could have improved overall carrier safety. With respect to motor carrier oversight, because of its ineffective process of approving and monitoring new entrant motor carriers, the FMCSA missed an opportunity to address Tri-State Collision's deficient compliance with safety regulations.
- ***Emergency egress:*** The extent of the bus's intrusion into the semitrailer created limited evacuation space on the bus, which prolonged extrication and evacuation efforts. Had a secondary door been available for use as an emergency exit, the bus evacuation might have been expedited.
- ***Collision avoidance systems:*** Neither vehicle was equipped with crash prevention technology. A collision avoidance system could have alerted the bus driver about the stopped combination vehicle.

Recommendations

As a result of this investigation, the National Transportation Safety Board (NTSB) makes new safety recommendations to the Federal Highway Administration, the FMCSA, Tri-State Collision LLC, the American Trucking Associations, the Owner-Operator Independent Drivers Association, the Commercial Vehicle Safety Alliance, the International Association of Chiefs of Police, and the National Sheriffs' Association. The NTSB reiterates recommendations to the FMCSA, the National Highway Traffic Safety Administration, Daimler Trucks North America LLC, Fuji Heavy Industries USA Inc., Hino Motors Manufacturing USA Inc., MCI, Navistar Inc., PACCAR Inc., Van Hool NV, and Volvo Group North America LLC. The NTSB reiterates and reclassifies one recommendation to the FMCSA.

1 Factual Information

1.1 Crash Narrative

On Sunday, October 23, 2016, about 5:16 a.m. Pacific daylight time, a crash occurred when a motorcoach ran into the rear of a stopped combination vehicle near mile marker 32.5 in the westbound lanes of Interstate 10 (I-10), outside Palm Springs, California.[1]

About 5:07 a.m. (9 minutes before the crash), in dark conditions, the California Highway Patrol (CHP) initiated a traffic break for eastbound and westbound traffic on I-10 in support of utility work that was being performed about 1.5 miles west of the crash location.[2] According to video evidence, as a result of the traffic break, the westbound traffic was stopped, and a queue began forming about 1.2 miles east of the utility work. Westbound traffic was sparse. One CHP vehicle in each direction of I-10 conducted the traffic break.

When the traffic break began, a 2015 International Prostar truck-tractor in combination with a 2012 Utility semitrailer, operated by Tri-State Collision LLC, was traveling westbound on I-10, having departed from Ehrenberg, Arizona, with the destination of Rancho Cucamonga, California. The truck stopped in the center-right lane of the four-lane westbound roadway as it reached the end of the traffic queue.[3] According to the evidence of communication between the utility work crew and CHP officers, the traffic break lasted about 7 minutes and ended about 5:14 a.m. When the single CHP vehicle conducting the break for westbound I-10 released the westbound traffic, the combination vehicle remained stopped and, according to witness statements, stayed stationary in the center-right lane of the four-lane roadway while the westbound traffic resumed highway speed.

About this time, a 1996 Motor Coach Industries International Inc. (MCI) 47-passenger motorcoach, operated by USA Holiday, was traveling westbound on I-10, approaching the area of the traffic break.[4] The bus, which was occupied by the 59-year-old driver and 42 passengers, had left the Red Earth Casino in Thermal, California—where the driver and the passengers had spent about 5 hours—at 4:23 a.m. to travel to Los Angeles, California (see figure 1).

---

[1] See appendix A for additional information on this National Transportation Safety Board (NTSB) investigation.

[2] A traffic break is a method of temporary traffic control that is used to slow or stop traffic, most typically to allow for completion of construction activities. For additional information, see section 1.4.2.

[3] Throughout this report, the vehicle consisting of the truck-tractor in combination with a semitrailer is interchangeably referred to as the "truck" or the "combination vehicle."

[4] Throughout the report, the motorcoach involved in this crash is interchangeably referred to as the "bus" or the "motorcoach."

Figure 1. Map showing the bus and truck travel routes and the crash location.

About 2 minutes after the westbound traffic break ended, the bus, which was traveling in the center-right lane, collided with the rear of the combination vehicle's semitrailer. Video from two nearby security cameras showed that five other vehicles—staggered about 10 seconds apart—traveled ahead of the bus after the traffic break ended; based on the video information, investigators were able to estimate that the bus was traveling about 67 mph approximately 12 seconds before the impact. According to witness statements, a precrash CHP video, and the security camera video, moments before the combination vehicle was struck, it was stopped in the lane with its flashing hazard lights off, while sparse traffic flowed around it at highway speed. (See section 1.4.2 for additional details about the video sources and precrash events.)

The contact damage on the vehicles was consistent with the bus striking the semitrailer at a slight angle—about 5º—and intruding about 13 feet into the rear of the semitrailer.[5] The road evidence consisted of tire friction marks, roadway surface scars, and fluid debris stains that extended about 110 feet (see figure 2). Some tire and scar marks exhibited a leftward movement, and some partially entered the left-center travel lane.

[5] For additional details on the extent of the intrusion into the semitrailer and the damage to both vehicles, see section 1.5.

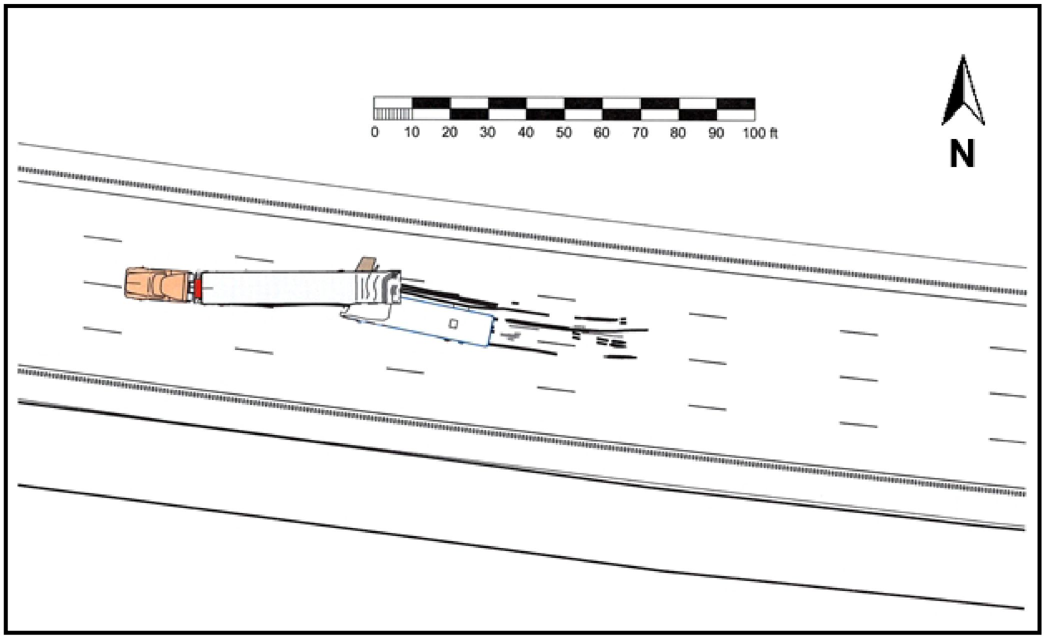


Figure 2. Postimpact positions of the combination vehicle and the bus, and the road friction marks created by the truck-tractor as it was being pushed by the bus.

Investigators found no precollision tire friction marks from the bus that could indicate an evasive braking maneuver. The impact by the bus moved the truck-tractor about 71 feet west, with friction marks terminating at the truck-tractor's drive axle. At rest, both vehicles partially occupied the left-center and right-center travel lanes (see figure 3).

At the time of the crash, it was dark, and the road surface was dry. The posted speed limit in the area was 70 mph.

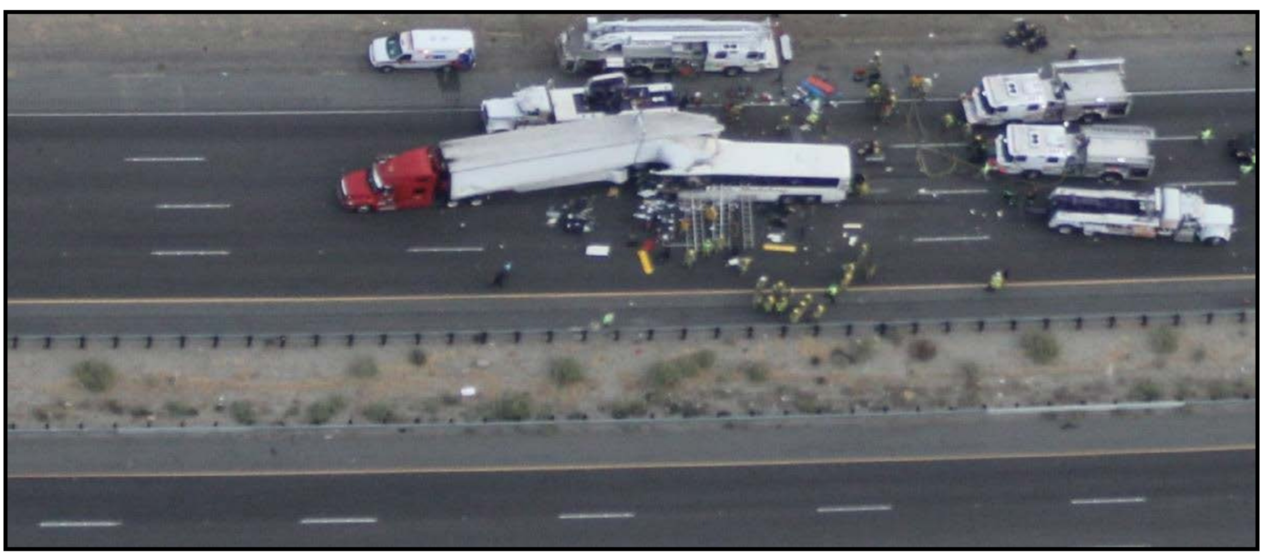


Figure 3. Combination vehicle and bus at rest. (Source: California Highway Patrol)

1.2 Injuries

As a result of this crash, the bus driver and 12 passengers died, 11 passengers sustained serious injuries, and 19 passengers received minor injuries. The passengers ranged in age from 37 to 72 years. The truck driver sustained minor injuries. Table 1 summarizes the distribution of injury severity.

Table 1. Injury levels for the bus and truck occupants.[a]

	Fatal	Serious	Minor	TOTAL
Truck driver	--	--	1	1
Bus driver	1	--	--	1
Bus passengers	12	11	19	42
TOTAL	13	11	20	44

[a] Although 49 *Code of Federal Regulations (CFR)* Part 830 pertains 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, 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.

The bus driver and the 12 passengers who died sustained multiple blunt force injuries to multiple body regions, as well as fractures and lacerations. One of the passengers who died was ejected. Eleven of the passengers who died were seated in the first four rows of the bus, and one was seated in row 7.

The 11 seriously injured passengers sustained rib, extremity, and spinal fractures, as well as lacerations and abrasions. The 19 passengers with minor injuries generally sustained contusions and abrasions.[6]

The distribution of injury severity shows that nearly all the bus passengers—9 of 11—who sustained serious injuries were seated in rows 3–7. Only two passengers in the rear half of the bus—those in rows 8–12—sustained serious injuries; the rest of those seated in the rear received minor injuries. Based on interviews with the surviving passengers, NTSB investigators determined the seating positions for all 42 passengers. Figure 4 shows the seating locations and injury classifications for the bus occupants.

[6] Medical records for a passenger seated in row 9 in the window seat on the right side of the bus were not available. In his interview with the CHP, this passenger stated that he had been injured and was treated in a hospital.

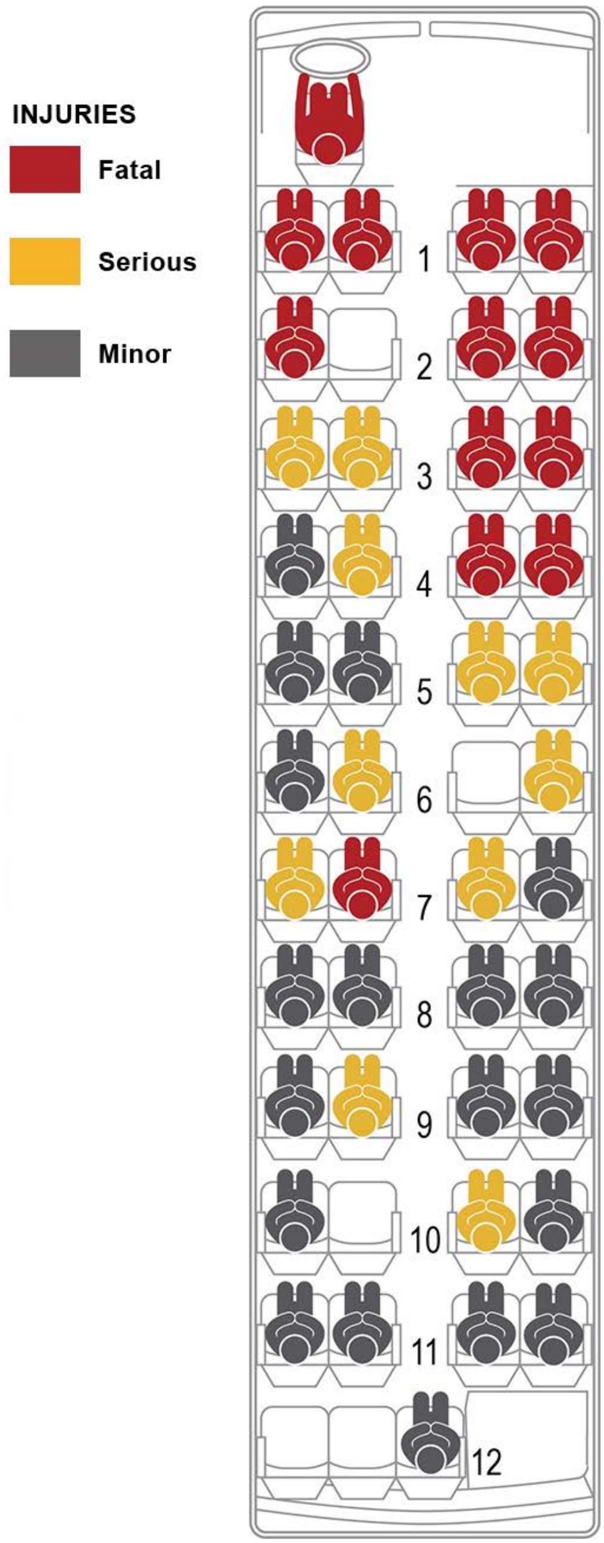


Figure 4. Bus seating chart, showing the injury classifications for the driver and 42 bus passengers.

1.3 Emergency Medical Services

1.3.1 Initial Response

A CHP dispatcher was notified of the crash at 5:17 a.m. and immediately assigned a patrol unit, which arrived on scene at 5:22 a.m.[7] All westbound lanes of I-10 were closed at 5:29 a.m.; I-10 was completely closed shortly after closure was requested at 5:34 a.m.

The Palm Springs Fire Department (PSFD) was informed of the crash at 5:20 a.m. and dispatched its initial units 2 minutes later; the first engine unit arrived on scene at 5:34 a.m. The captain of the first engine unit assumed the role of incident commander (IC) upon arrival and declared a mass casualty incident. At 5:40 a.m., while approaching the crash scene, the PSFD chief requested additional extrication resources and inquired about the availability of air emergency medical services (EMS); the chief assumed the IC role after arriving on scene. The PSFD dispatched 21 units, including 2 chief units, 4 engine units, 1 truck, and 1 incident support unit. All units, except the two chief units, were staffed with paramedics.

As part of the mutual aid response, the Cathedral City Fire Department and Cathedral City EMS sent one fire engine and one medical response unit at 5:32 a.m.; both arrived on scene at 5:55 a.m.[8] The Riverside County Command Center dispatched two Cal Fire engine units at 5:21 a.m.; the units arrived on scene at 5:57 a.m.

American Medical Response (AMR), which is the contracted emergency service provider for the area surrounding the crash, dispatched its initial ambulance at 5:23 a.m.; this unit arrived on scene at 5:34 a.m. The AMR ultimately responded with nine units—two of which made double runs—and transported 29 bus occupants and the truck driver to three area hospitals. Cathedral City EMS transported two bus occupants to an area hospital.

1.3.2 Evacuating the Bus Occupants

Due to the bus's intrusion into the semitrailer, the bus's loading door was unavailable as a means of egress. Consequently, when first responders arrived from the PSFD, they used ladders to access the bus passenger windows, by which time bystanders had broken out two of the windows. The first responders stated that the emergency exit windows were difficult to use because they would not remain open and kept swinging shut.[9] By the time the first PSFD units arrived, about 10 passengers had evacuated.[10] Several of the about 20 surviving passengers who were still on the bus when the PSFD arrived required extrication or assistance with evacuation. PSFD responders considered separating the semitrailer from the bus to gain easier access to the passengers, but

[7] The two CHP units that had conducted the traffic break were still in the crash area and were maneuvering to reach the scene. See section 1.4.2 for more information on the traffic break.

[8] The Cathedral City EMS is housed within the Cathedral City Fire Department.

[9] The emergency exit windows on the motorcoach were hinged at the top. To open the windows, a user released a latch at the base, and the window rotated up toward the motorcoach roof. There was no mechanism to keep the window open.

[10] These passengers self-evacuated or evacuated with bystander assistance.

because of concerns about the vehicles' structural support, they determined that doing so would present an unacceptable risk to those still inside the bus.

Because of the intrusion of the semitrailer and deformations inside the bus, which also resulted in displacement of luggage racks rearward and into the passenger compartment area, the available space for passenger extrication and evacuation was limited. Emergency responders faced considerable challenges when lifting the injured passengers up to window level and then climbing down the ladders.[11] To speed the evacuation, the PSFD units decided to cut access holes in the sides of the bus down to the floor level. They encountered difficulties when cutting through the sidewall and seat attachments inside the bus.[12] Once the access points were created, the extrication and evacuation of the remaining passengers proceeded more quickly. About 8 passengers evacuated by climbing down the ladders, and 10 were lifted out on backboards. The last three passengers, one of whom sustained serious injuries, were transported from the scene at 7:58 a.m.

1.4 Highway Factors

1.4.1 Description and Characteristics

This crash occurred in the westbound lanes of I-10 near mile marker 32.5. At this location, both the eastbound and westbound directions of travel consisted of four 12-foot-wide lanes. The two directions of travel were separated by a thrie-beam guardrail in the center median.[13] The westbound roadway had a 10-foot-wide paved right shoulder with rumble strips and an 8-foot-wide left shoulder; the right and left shoulders were delineated from the travel lanes by solid 4-inch-wide white and yellow lines, respectively. The travel lanes were delineated by 4-inch-wide, broken white lines.

There was no safety lighting near the crash location. The nearest sources of highway lighting were two highway light poles at the end of the westbound on-ramp from the North Indian Canyon Drive/Indian Avenue interchange; the nearest was about 1,600 feet east of the crash location.[14]

[11] The bottoms of the motorcoach windows were about 8 feet above the ground.

[12] The PSFD units initially used general-purpose saws to cut the sidewall and then tried hydraulic pinchers; neither tool was effective. Finally, by employing gas-powered rotary cutters, the PSFD was able to cut the sidewall and seat attachments. Although the use of this gas-powered tool resulted in sparks and smoke, which created potential safety issues, it did not negatively affect the health of the occupants or first responders. For more information, see the Survival Factual report in the NTSB docket for this investigation.

[13] A thrie-beam is a steel beam rail element shaped like a "W" with an additional undulation in it. The height of the rail from the ground to the top of the rail was about 32 inches.

[14] The highway lighting along the westbound on-ramp consisted of a 310-watt high-pressure sodium luminaire mounted on a mast arm that extended about 15 feet. The mast arm was attached to a single pole that was about 35 feet above the finished grade.

In the vicinity of the crash, the horizontal alignment consisted of a 6,000-foot radius curve to the right in the westbound direction of travel. The crash occurred about 651 feet into the 1,412-foot-long curve. The curve was preceded by about 2,800 feet of straightway before the roadway began to curve to the right. The westbound roadway also had a slight upgrade slope of 0.16º.

The average daily traffic in the westbound direction of I-10 was about 41,000 vehicles in 2014. In response to a request from NTSB investigators, the California Department of Transportation (Caltrans) examined the 5-year crash history—from 2010 to 2014—for the 10-mile section of westbound I-10 surrounding the crash location.[15] The examination showed that there had been 212 crashes, the most prominent of which were impact-with-a-fixed-object (70), sideswipe (51), and rear-end crashes (40). Four fatal crashes took place during that period, all of which involved rear-end impacts.

1.4.2 Utility Work and Precrash Events

The Southern California Edison Company (SCE) was performing utility work on the day of the crash.[16] The work occurred at milepost 31.1, about 1.36 miles west of the crash location. It consisted of transferring six transmission lines from an H-frame wood structure on the north side of I-10 to a new tubular steel pole, located beside the H-frame (see figure 5).

The utility work was to be conducted in three stages: (1) transferring the top three transmission lines onto the new steel pole; (2) transferring the bottom three transmission lines; and (3) removing the H-frame wood structure. The first two stages involved the possibility of transmission lines falling across I-10; consequently, the plan was to stop traffic on I-10 for the duration of these two stages.

[15] Due to the lag time in the reporting of traffic data and crash history, Caltrans has not yet finalized traffic and crash data for 2015 and later.

[16] The SCE is an electricity supply company that provides electric power to most of southern California.

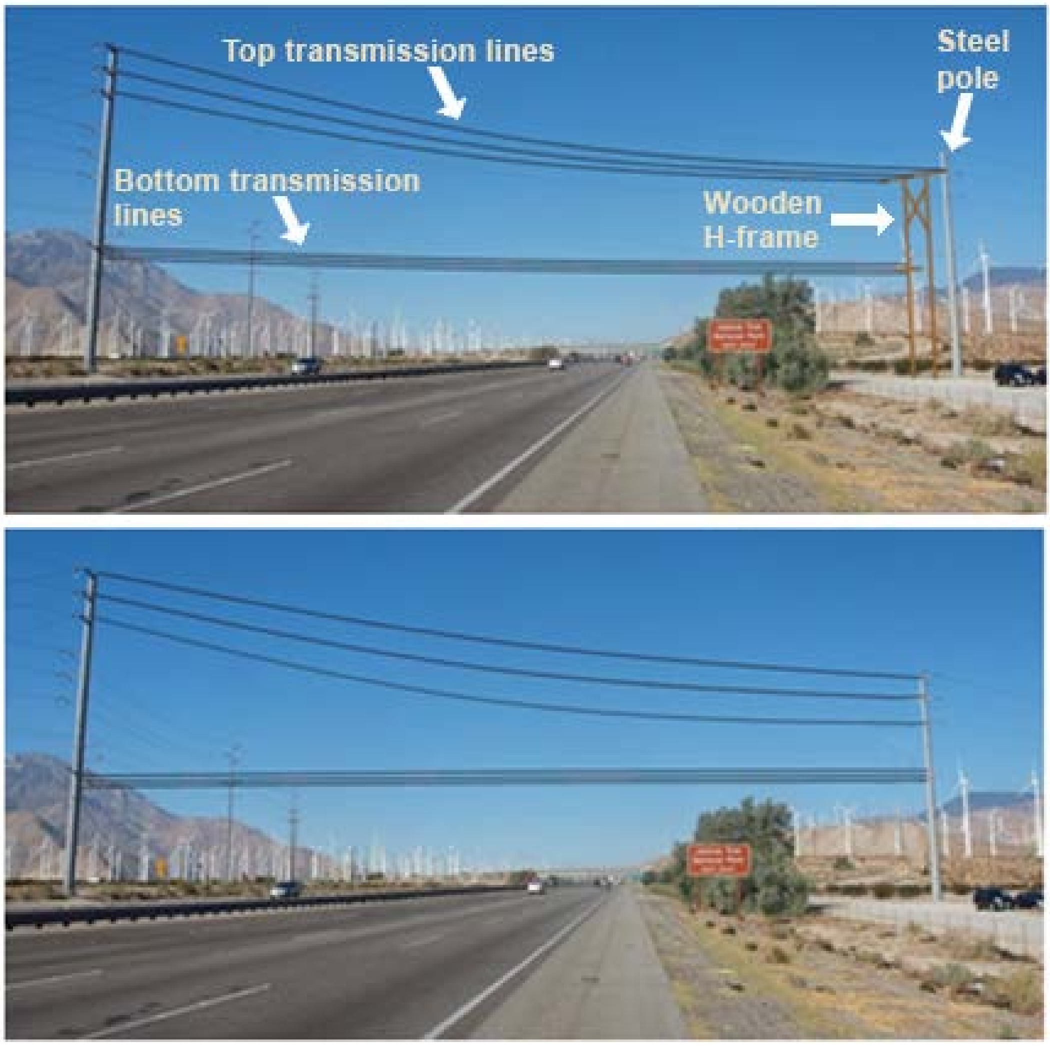


Figure 5. Utility work conducted across I-10. The top illustration depicts the conditions before the work began, and the bottom illustration shows the transferred transmission lines.

1.4.2.1 Permit. On October 7, 2016, Caltrans approved an encroachment permit for the SCE to conduct this utility work. The permit stated that "Traffic breaks are required while transferring conductors onto the new pole and shall be provided by the California Highway Patrol (CHP) during non-peak hours. Each traffic break SHALL NOT exceed 5 minutes and no more than 5 breaks in the same day." During the preconstruction meetings held between the SCE and Caltrans in the week before the crash, they determined that the utility work would occur between 2:00 a.m. and 5:00 a.m. on October 23.[17]

In response to a postcrash inquiry from NTSB investigators, Caltrans clarified the planned conduct of the traffic break and stated that "The intent of the traffic break is that traffic would be required to come to a complete stop on I-10, and the 5 minutes start when the traffic comes to a

[17] The CHP was not included in the preconstruction meeting. The CHP was informed of the work through an agreement between the SCE and the CHP dated October 14, 2016. The SCE e-mailed the CHP agreement to Caltrans on October 17, 2016.

complete stop."[18] Although the permit and preconstruction meetings specified many details concerning the traffic breaks, they did not indicate the manner in which the CHP should conduct the breaks, the location on I-10 where the breaks would begin, or how near to the utility work the stopped traffic would be permitted.

1.4.2.2 Completion. About 5:00 a.m., the SCE foreman contacted CHP units and requested that they begin the first traffic break. To implement the traffic break, CHP units conducted rolling roadblocks on both the eastbound and westbound travel lanes of I-10.[19] To initiate the rolling roadblock for westbound traffic, a single CHP unit entered westbound I-10 at the North Indian Canyon Drive ramp, 2.04 miles east of the utility work, and began to drive west while gradually decelerating from highway speed and performing a serpentine maneuver across all four travel lanes—weaving from the left shoulder to the right shoulder in a controlled manner with the patrol car's emergency lights activated (see figure 6). The emergency lights and serpentine movement were intended to alert the traffic behind the patrol car to slow down and remain behind it. The CHP unit conducted the rolling roadblock for 2 minutes 51 seconds before gradually coming to a stop about 1.2 miles east of the utility work, about 650 feet west of the crash location. This was the only rolling roadblock that the CHP conducted for westbound traffic before the crash. The SCE work crew completed the relocation of the top three transmission lines within about 5 minutes; including the time used for communication between the CHP officers and the SCE foreman, the total stoppage of westbound traffic lasted about 7 minutes. Another CHP vehicle simultaneously performed a rolling roadblock in the same manner on the eastbound lanes of I-10.

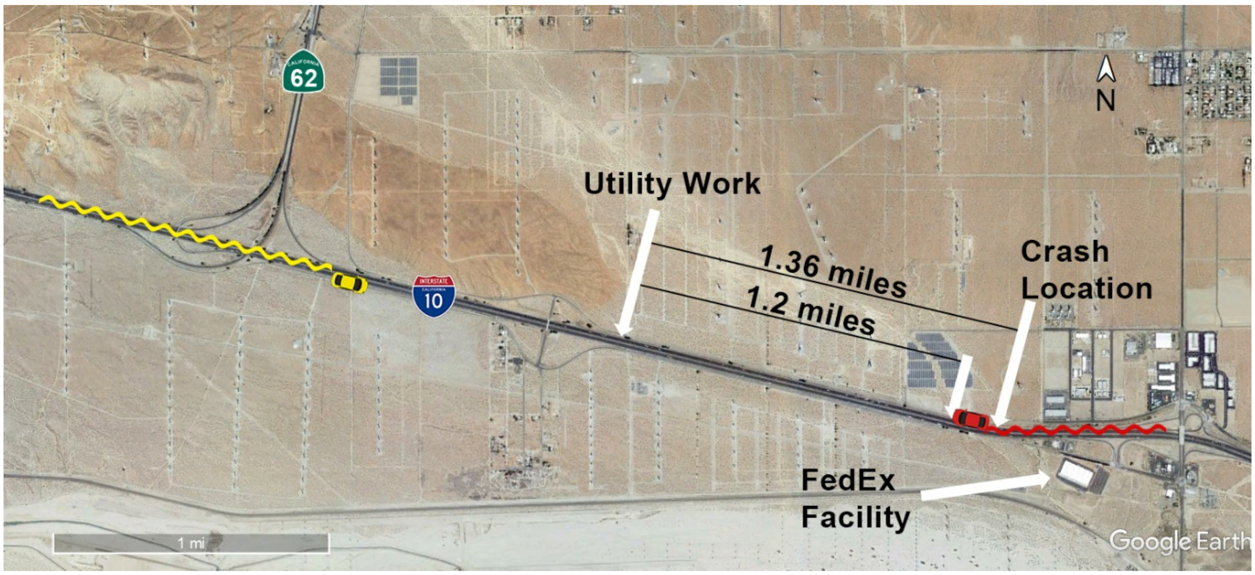


Figure 6. Map indicating the movements of the CHP vehicles (westbound rolling roadblock in red and eastbound rolling roadblock in yellow) on I-10, and the locations where the utility work and crash took place, the location of the FedEx facility, and the location where the westbound CHP vehicle stopped (white arrows).

[18] The quoted material is from an e-mail sent by Caltrans to NTSB investigators on May 8, 2017.

[19] A rolling roadblock is a method of temporary traffic control used to slow or stop traffic.

1.4.2.3 Video and Witness Evidence. After the crash, NTSB investigators discussed the plans for, and execution of, the utility work and traffic breaks with Caltrans, the SCE, and the CHP, and examined multiple data sources to determine the sequence of events that led to the crash. NTSB investigators obtained videos from two security cameras located at a FedEx facility adjacent to I-10 (to the southeast of the crash location, see figure 6). The cameras were positioned about 700 feet south of the eastbound lanes of I-10, and their field of view (FOV) covered an area spanning about 200–1,650 feet east of the crash location. Although the crash was not visible from these cameras, the videos were used to determine the relative timing of the truck's and bus's motions on approach to the crash location and the presence of a traffic queue. The truck's final stopping position—the crash location—was about 650 feet east of the CHP vehicle, and the video from the FedEx security cameras showed that the queue extended about 200 feet behind the location of the truck.

Additionally, NTSB investigators obtained videos from the mobile video/audio recording systems (MVARS) from the CHP vehicles. After releasing the eastbound traffic, the patrol car that had conducted that traffic break continued eastbound toward North Indian Canyon Drive. The MVARS recording from that CHP car showed that the combination vehicle was stationary in the westbound roadway with its parking lights illuminated, but its headlights and hazard flashers were off. The CHP officer operating the car later said that he did not notice the stopped combination vehicle in the westbound roadway.

The CHP interviewed a motorist who observed the combination vehicle after the traffic break had ended but before the crash occurred. This witness reported traveling westbound about 70 mph on I-10 in the vicinity of the crash location when, in the distance, he noticed "amber lights that looked like a semi-truck in my lane." The witness reported that, as he approached the vehicle, he had to abruptly change lanes to the left when he realized that the vehicle was a parked combination vehicle. The CHP interviewed another motorist who observed the combination vehicle and the bus in the moments before and during the crash. This witness reported traveling eastbound on I-10 as a CHP car initiated a rolling roadblock. The driver reported being stopped for about 8 minutes before the patrol car released the eastbound traffic. The witness stated that shortly after being released, as he was traveling about 60 mph, he saw a little farther ahead on the opposite side of the interstate a parked "semi-truck" without illuminated headlights. He said he observed the combination vehicle for several moments and then noticed the headlights of another vehicle approaching the stopped truck; he reported then seeing debris and dust from the impact.

Table 2 shows the sequence of events pertaining to the westbound traffic break, including the movements of the truck and the bus.

Table 2. Sequence of events on October 23, 2016, concerning utility work and traffic break.

Time (a.m.)[a]	Event	Source
2:01 & 2:02	SCE foreman calls CHP dispatch and requests two patrol units	Phone records/interview
5:01	SCE foreman calls CHP units and requests that they begin the first traffic break	Phone records/interview
5:04:25	CHP vehicle initiates the rolling roadblock for westbound traffic upon entering I-10 at North Indian Canyon Drive ramp	MVARS
5:06:31	CHP vehicle exits FedEx cameras' FOV	FedEx
5:07:16	Westbound traffic is stopped about 1.2 miles east of the utility work	MVARS
5:08	CHP officer calls SCE foreman to begin utility work	Phone records/interview
⇳	Westbound traffic slows down	FedEx[b]
	Stationary traffic queue extends to about 500 feet from the crash location	FedEx
5:11:55	Crash truck enters the cameras' FOV about 1,650 feet east of the crash location and approaches the end of the traffic queue; headlights and marker lights are visible, but flashing hazard lights are not	FedEx
5:12:24	Crash truck comes to a near stop before leaving the cameras' FOV about 200 feet east of the crash location; brake lights are visible	FedEx
	Another combination vehicle following 11 seconds behind the crash truck stops before leaving the cameras' FOV and activates its hazard flashers; stationary queue remains visible from this point	FedEx
5:13	Crash truck comes to a complete stop	Fleetmatics[c]
5:13	SCE foreman calls CHP vehicle in the westbound lanes to state that the first part of the utility work is complete and that the traffic break should end	Phone records/interview
5:14:29	Westbound CHP vehicle ends the traffic break and starts moving toward the next exit	MVARS

5:15:30	Stationary queue is no longer visible	FedEx
	Five vehicles enter cameras' FOV, about 10 seconds apart[d]; vehicles' brake lights are visible as they leave cameras' FOV	FedEx
5:16:28	Crash bus enters cameras' FOV and departs it 12 seconds later; headlights and side and rear marker lights are visible, but brake lights are not	FedEx
About 5:16:45	Crash occurs, but it was not captured on any video source—crash occurred a few seconds after the crash bus left the cameras' FOV	
	A vehicle traveling 18 seconds behind the crash bus noticeably reduces speed as it leaves cameras' FOV; subsequent vehicles also decelerate	FedEx

[a] For the sources that include more precise timing, timing to seconds is provided. Although the clocks from different sources were not synchronized to one another, the MVARS data was synchronized to local time, and NTSB investigators determined that the clock from the FedEx cameras was reasonably consistent with other data sources.

[b] NTSB investigators could differentiate vehicles in the video—commercial from passenger—and the sequence and times of their approach; however, it was not possible to discern vehicles' lanes of travel.

[c] Fleetmatics is a global positioning system (GPS) tracking system that motor carriers can use to monitor the locations of their vehicles (see section 1.5.1.7).

[d] The last of the five vehicles was a passenger car; it traveled about 2 seconds ahead of the bus.

1.4.3 Safety Policies for Temporary Work Zones

1.4.3.1 Transportation Management Plan. Both the Federal Highway Administration (FHWA) and Caltrans regulate work zone safety. Their requirements vary depending on the type of work conducted and whether the work meets the criteria for a significant work project.

According to the FHWA Rule on Work Zone Safety and Mobility—23 *CFR* Part 630 Subpart J—significant work projects have sustained impacts on traffic and can range from (1) projects occurring in major metropolitan areas that have a high level of public interest; to (2) longer projects, such as bridge repair, that affect a moderate number of travelers; to (3) shorter projects, such as shoulder repair, that affect a low number of travelers. Per the FHWA rule, nonsignificant projects affect traffic for less than 3 days, have limited impact on travelers, and occur at nighttime or during off-peak hours. According to the Caltrans Transportation Management Plan Guidelines, any work project that incurs more than 30 minutes of traffic delay for the duration of that project is considered a significant project (Caltrans 2015, A-1 and -2).

In response to inquiry by NTSB investigators, the FHWA stated that the work project conducted at the crash location did not constitute a significant project according to FHWA guidelines or Caltrans's policy defining significant projects.

According to both the FHWA and Caltrans, all scheduled roadwork projects must be accompanied by a transportation management plan (TMP). TMPs for significant work projects are required to include plans for temporary traffic control, traffic operations, and public information.

The TMP guidelines for nonsignificant work projects are less stringent. The FHWA recommends that TMPs for nonsignificant work zones include a temporary traffic control plan and encourages state agencies to implement traffic operations and public information plans as well. Caltrans does not have a standard TMP policy for nonsignificant work projects.

1.4.3.2 Policies for Rolling Roadblocks. Between 2014 and 2015, Caltrans issued 461 permits for traffic breaks that involved rolling roadblocks. For calendar year 2016, until the day of this crash, Caltrans had issued 230 such permits; all but 2 were issued for the purpose of utility work.[20] Although it frequently approved permits for traffic breaks involving rolling roadblocks, Caltrans did not have a standard TMP policy for conducting rolling roadblocks. Because rolling roadblocks typically affect traffic only for short periods, Caltrans considered them nonsignificant projects.

In 2013, the FHWA, in collaboration with the American Traffic Safety Services Association (ATSSA), developed work zone safety guidelines for rolling roadblocks (FHWA 2013). The guidelines include a requirement that at least two vehicles be used to conduct a rolling roadblock: a pacing vehicle that slows and stops the traffic, and a lead vehicle that verifies that traffic between the stopped vehicles and the work area has cleared. The guidelines also suggest staging an additional law enforcement vehicle with activated emergency lights at the end of the traffic queue and providing a means of notifying the public of the work zone, such as by portable changeable message signs.

1.5 Vehicle Factors

1.5.1 Truck

1.5.1.1 General. The combination vehicle consisted of a 2015 International Prostar truck-tractor and a 2012 Utility refrigerated semitrailer. The truck-tractor was equipped with a Navistar N13 430-horsepower diesel engine and an Eaton Fuller 10-speed manual transmission. At the time of manufacture, the truck-tractor had a gross vehicle weight rating (GVWR) of 52,350 pounds; the GVWR of the semitrailer was 65,000 pounds. The truck-tractor was electronically limited to a maximum speed of 68 mph.

1.5.1.2 Damage. The truck-tractor did not sustain any external damage during the crash. Although the truck-tractor's tires were not damaged, the tires on axles 2 and 3 had longitudinal scuffing and abrasions. The semitrailer, which was 53 feet long, sustained extensive damage to the rear. With their steel frame, the rear doors were displaced and found in debris at the inspection location. The rear bumper and rear impact guard were rolled downward and forward, and they ended below the floor of the semitrailer (see figure 7). The flooring was buckled upward, and crossmembers under the floor were displaced forward, farther on the left, and separated from their mounting positions. Portions of the rear sidewalls were displaced and found in debris. The ceiling on the rear of the semitrailer had collapsed.

The front of the bus underrode the semitrailer up to the semitrailer's rear axles, about 13.4 feet—the maximum forward distance that showed evidence of contact damage. The rear

[20] Two of the permits were issued for filming purposes.

axle—axle 5—was displaced forward, farther on the left, with the left tires and wheels resting on top of the left tires and wheel of axle 4.

Figure 7. Semitrailer postcrash, showing extensive rear damage. (Source: California Highway Patrol)

1.5.1.3 Occupant Protection. The driver seat was equipped with a three-point restraint.[21] The restraint was functional, and postcrash examination did not show any marks on the seat belt webbing. In a postcrash interview with an NTSB investigator, the truck driver said that he experienced back strain and contusions from the seat belt.[22] The driver seatback was deformed rearward about 80º, such that it was nearly horizontal to the seat pan.

1.5.1.4 Mechanical Inspection. NTSB investigators performed functional checks of the braking, suspension, and electrical systems, and they checked the wheels and tires. All eight tires on axles 2 and 3 of the truck-tractor displayed a single contact mark from roadway abrasion. Examination of tire tread depth revealed that the treads on all the tires on the truck-tractor and semitrailer were above the minimum required depth. The examination of the braking system showed that the pushrod strokes on axle 4—on the semitrailer—exceeded the maximum limit.[23]

1.5.1.5 Lights and Reflectors. All external lighting on the truck-tractor was functional. The vehicle followed 49 *CFR* 393.11(a) regarding the number and position of lamps and retroreflective devices. All the lighting on the semitrailer was of the light-emitting diode type. Lights were

[21] A three-point restraint is a lap and shoulder seat belt.

[22] The truck driver was not admitted to a hospital, so no medical records were available for him.

[23] According to the 2016 Commercial Vehicle Safety Alliance (CVSA) Out-of-Service Criteria, Part II, section 1a, to be considered an out-of-service condition, at least 20 percent of the brakes would have to be defective. The combination vehicle had 10 brakes, 2 on each of 5 axles. Because two of the brakes exceeded the maximum pushrod stroke limit, the vehicle met the out-of-service criteria.

mounted at the following locations on the semitrailer: (1) six lights on the rear bumper—three on each end—for turn, brake, and tail lights; (2) a single midpoint turn signal on each side; (3) five marker lights across the top of the rear—one on each end and three in the middle; (4) nine marker lights along the top edge, from front to rear; and (5) eight marker lights and one combination marker/turn signal light on each side along the bottom edge, from front to rear.

To determine the functionality of the lights on the semitrailer, NTSB investigators reconnected the electrical connections between the semitrailer and the truck-tractor. Five of the six lights on the rear bumper could be activated; the sixth lamp was displaced from its mounting location and could not be powered. The midpoint turn signals on the sides of the semitrailer were operational, as were the nine marker lights along the top edge on the sides of the semitrailer. The five marker lights mounted across the top of the rear of the semitrailer were displaced and inoperable. The eight marker lights along the bottom edge on the sides of the semitrailer were not operational, but the combination marker/turn signal lights were functional.

The semitrailer had retroreflective material along its sides and rear as required by 49 *CFR* 393.11(b). NTSB investigators analyzed a sample of the retroreflective material and found it in compliance with the regulation.[24] The surface of the semitrailer's cargo door consisted of non-glaring stainless steel with a diamond-shaped pattern, designed to increase conspicuity.

1.5.1.6 Inspection, Maintenance, and Safety Recalls. Carrier records showed that the truck-tractor and semitrailer had regular annual inspections and maintenance. There were no safety recalls or warranty service bulletins for the truck-tractor. There were no safety recalls for the semitrailer; one warranty bulletin was issued—to replace the side skirt attachment to a spring bracket—but it was not completed.[25]

1.5.1.7 Data Recording Systems. The truck-tractor's engine control module (ECM) controls engine timing, fuel injection, and other operational factors based on onboard sensors. The ECM also records engine hours—daily, monthly, and lifetime of the engine—and has the capacity to record and store diagnostic information associated with engine or sensor faults. The system can also record and store vehicle parameters, such as vehicle and engine speed when triggered by sudden acceleration or deceleration events.[26] The data extracted from the ECM included five diagnostic fault codes, none of which was associated with the timing of the crash. No sudden acceleration or deceleration events were associated with the impact.

The ECM can also record and store last-stop events, which are recorded when the truck stops and idles for at least 2 minutes or when it stops and powers off. The extracted data from the ECM included a last-stop event that showed that the truck stopped at 5:12:29 a.m. This event captured 2 minutes of vehicle data about the time that the truck stopped—105 seconds before and 15 seconds after (see table 3). The last data point was captured about 4 minutes before the crash.

---

[24] The retroreflective tape along the top side of the rear was not in compliance; investigators attributed the noncompliance to crash damage.

[25] Unlike recall repairs, which emerge from safety issues and are mandatory, repairs in warranty service bulletins are recommended rather than required.

[26] The threshold for triggering a sudden deceleration or acceleration event is a 7.4-mph change in speed in 1 second.

Table 3. Selected parameters recorded by the truck-tractor's ECM.

Time (a.m.)	Vehicle Speed (mph)	Engine Power	Parking Brake
5:10:14	59	ON	OFF
5:10:37	59	ON	OFF
⇕	59–1[a]	ON	OFF
5:12:29	0	ON	OFF
5:12:44	0	ON	OFF

[a] The combination vehicle was slowing to a stop during this period.

The truck-tractor was also equipped with Fleetmatics, a GPS system that records the position of a vehicle and transmits that information to the carrier.[27] NTSB investigators obtained the truck-tractor's Fleetmatics data for the 30-day period between September 24 and October 23, 2016. The data showed that, on the morning of the crash, the combination vehicle stopped at 5:13 a.m.; its speed remained at 0 mph until 5:16 a.m., when the data indicated that the truck moved about 60 feet westward, followed by engine shutdown.[28] For additional information on the Fleetmatics data, see section 1.6.1.4.

1.5.2 Bus

1.5.2.1 General. The 47-passenger 1996 MCI 102D3 motorcoach was equipped with a Detroit Diesel Series 60 470-horsepower engine and an Allison B500 automatic transmission. The bus had a GVWR of 44,400 pounds and was electronically limited to a maximum speed of 79 mph. The bus had 12 rows of passenger seats on the left side and 11 rows on the right side. The first 11 rows on both sides had two-person seats. The last row on the left side had three seats; two of them were in line and behind the row 11 seats, and the third seat was located at the end of the center aisle.

1.5.2.2 External Damage. The bus sustained catastrophic front-end damage (see figure 8). The entire windshield, with the right-side rearview mirror, was displaced and missing. The front body panels, the right-front headlamp, and left- and right-side turn signal assemblies were also displaced and missing. The left-side low- and high-beam headlights were damaged but remained in their mounting locations. The analysis of the low-beam filament by the NTSB Materials Laboratory could not conclusively determine whether the headlights were turned on at the time of the crash. Based on the video from the FedEx security cameras, the bus headlights were on in the moments before the crash.

[27] Although system specifications indicate that the vehicle position can be reported as frequently as every 90 seconds, based on data provided to NTSB investigators that show the vehicle location every 60 or 120 seconds, the time of the location data was most likely rounded to the whole minute. Due to the variability in the way that Fleetmatics records the times of various events, NTSB investigators were not able to synchronize Fleetmatics data with other sources of information (law enforcement or FedEx video).

[28] The 60-foot movement westward and engine shutdown at 5:16 a.m. are consistent with the timing of the crash.

Figure 8. Bus postcrash, showing extensive damage to the front of the vehicle.

The impact damage was offset toward the right side of the bus; the right front end was displaced rearward 3.4 feet (see figure 9). First responders had cut away a section of the sidewall from the front of the bus to the first two windows on the left side. The sidewall on the right side was also cut away at several locations, including a section from the front of the bus to below window 3, a section below window 5, and just forward of the rear wheels. The passenger entrance stepwell was crushed rearward, and the loading door was displaced and found in debris. The right side of axle 1 was crushed and displaced rearward by about 7 inches, trapping the tire and wheel inside the right-side wheel well.

The semitrailer's left sidewall had intruded into the bus and sheared about 13.7 feet from the roof panel along the left side of the bus, extending from the front of the bus to the second passenger windows and the fourth row of passenger seats.

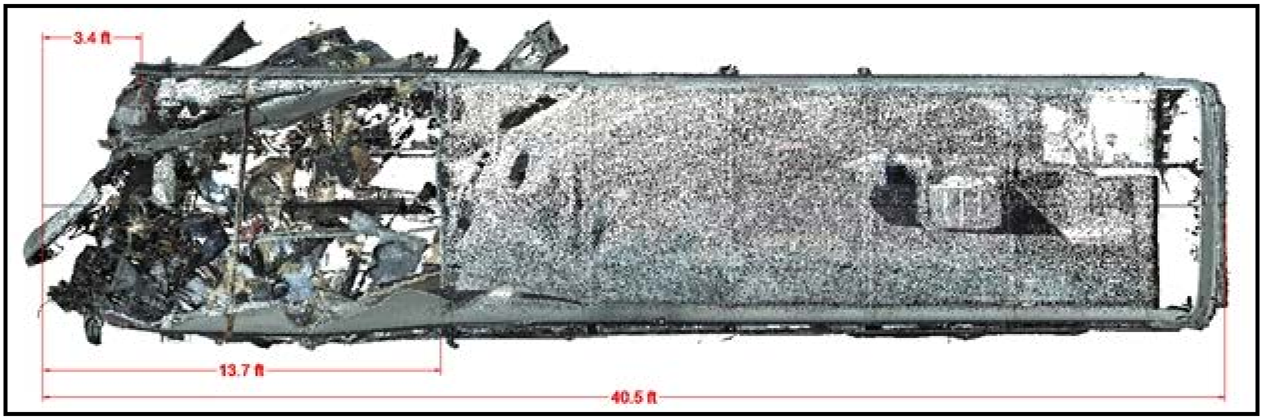


Figure 9. 3D point cloud image of the bus showing the extent of frontal displacement and roof intrusion in comparison to original dimensions. (Source: California Highway Patrol)

1.5.2.3 Interior Damage. The loading door area and the driver seat floor area were crushed and displaced and found in debris. The driver seat was extensively deformed from impact. The steering wheel and column were displaced and found in debris.

The semitrailer's intrusion displaced passenger seats and luggage racks rearward, as far back as row 6. As a result, the front half of the passenger cabin was significantly damaged, with privacy panels and seats displaced or cut away. The overhead luggage bins were displaced, and the mounting frames were fractured aft to about row 6 on the left side and row 7 on the right side.

1.5.2.4 Occupant Protection. The driver seat had a three-point seat belt. The restraint had extensive damage and was partially connected to the attachment points. The bus driver's injuries were consistent with the use of a three-point restraint. The passenger seats were not equipped with restraint systems.[29] Five of the passenger seats—four in the first row and the aisle seat in row 12—were exposed seats; that is, they did not have a seatback in front of them.

1.5.2.5 Windows. The bus was equipped with seven windows on each side. All but one—the rearmost window on the right side—were configured as emergency exit windows. First responders had either completely or partially cut away the frames on the first three windows on the left side. The remaining four windows on the left side were broken away, but the frames were intact. On the right side, the frames of three windows, including the first two windows, had been cut away. One of the remaining windows had its glass broken out, and three windows were intact. The bus was equipped with two roof hatches, one adjacent to the first passenger window and another adjacent to the sixth passenger window.

1.5.2.6 Mechanical Inspection. Damage to the bus affected all major mechanical systems. NTSB investigators performed functional checks of braking, suspension, and electrical systems, and examined wheels and tires. The steering wheel, steering wheel column, and instrument panel were displaced and found in debris. The steering gear was functional, but there were no impact marks

[29] Lap/shoulder belts have been required on new vehicles meeting motorcoach or over-the-road bus definitions since November 2016. See "Federal Motor Vehicle Safety Standards; Occupant Crash Protection," at 78 *Federal Register* 70416, November 25, 2013.

on the helical worm gear that could indicate the steering wheel angle at impact. The examination of the suspension system revealed no evidence of preexisting damage or defects.

Both axle 1 tires had tread depths below minimum requirements.[30] Two axle 2 tires and one axle 3 tire also had below-minimum tread depths.[31] The inadequate tread depths on these tires constituted out-of-service (OOS) conditions.[32]

The bus was equipped with pneumatic drum brakes. The brake pushrod stroke adjustments were within specifications, but two brake linings—the left brakes on axles 2 and 3—were below the minimum required thickness. These two brakes were OOS conditions.[33]

1.5.2.7 Inspection, Maintenance, and Safety Recalls. The bus passed its most recent annual inspection on December 18, 2015. Vehicle records document a variety of regularly scheduled preventive maintenance and repairs. There were no safety recalls for the bus, but there were three safety bulletins—redesign of the parking brake, update to the alternator frame, and electronic isolation of the engine control unit; it is unknown whether these nonmandatory safety bulletin repairs were made.

1.5.2.8 Data Recording Systems. The bus engine was controlled by a Detroit Diesel Electronic Control IV system, which also stores vehicle parameters and can record trip activity, including diagnostic information associated with engine or sensor faults. Although the data extracted included some engine information, the system did not record any crash-pertinent vehicle parameters.

1.6 Driver Factors

1.6.1 Truck Driver

1.6.1.1 Licensing, Experience, and History. The truck driver was a 50-year-old male who had been working as a commercial driver for Tri-State Collision since September 2016. He first obtained a commercial driver's license (CDL) in June 2001 when FedEx Freight employed him. The truck driver left FedEx Freight in 2004, and for the next 12 years, he worked as a commercial vehicle driver at two other carriers—Sunco Carriers and R.E. Garrison Trucking—until he was hired by Tri-State Collision in September 2016. At the time of the crash, he held a Georgia class "A" CDL with an endorsement for double and triple trailers.[34] In a postcrash interview with

[30] According to 49 *CFR* 393.75(b), the minimum tread depth for steer axle tires is 4/32 inch.

[31] According to 49 *CFR* 393.75(c), the minimum tread depth for tires on axles other than steer axles is 2/32 inch.

[32] See the CVSA Out-Of-Service Criteria, Part II, section 11a(1).

[33] According to the CVSA Out-Of-Service Criteria Part II, section 1a, when the number of defective brakes is equal or greater than 20 percent of the service brakes on the vehicle, the vehicle is out of service.

[34] A double/triple endorsement permits the license holder to operate a combination vehicle with two or three trailers where allowed.

NTSB investigators, the truck driver reported completing familiarization training before driving for Tri-State Collision.[35]

Georgia motor vehicle records show that the truck driver did not have any reportable crashes; however, records at one of the truck driver's former employers—Sunco Carriers—showed that he was involved in one preventable crash in August 2009.[36] NTSB investigators examined multiple sources to obtain the truck driver's history of traffic violations, including CDL information systems, Georgia Department of Motor Vehicle records, and driver qualification files from one of the truck driver's previous employers—R.E. Garrison. The records showed that since 2001, the truck driver had five traffic violations, three of which were for speeding; the most recent occurred in August 2016.[37] As a result of an inquiry with the truck driver's previous employers, NTSB investigators found that he had been terminated from R.E. Garrison after 5 years of commercial driving because of safety issues—specifically, because of a speeding conviction.

1.6.1.2 Medical Certification, Health, and Toxicology. The truck driver had obtained his most recent precrash CDL medical certificate on January 15, 2015; it was valid for 2 years. On December 1, 2016, a criminal complaint was issued against the certified medical examiner who issued this certificate.[38] The certified medical examiner was charged with issuing medical certifications without performing the examinations. As a result of that investigation, all medical certifications issued by this examiner were revoked.[39] The truck driver again obtained medical certification on January 7, 2017; this certificate was also valid for 2 years.

On both his 2015 and 2017 medical certificate applications, the truck driver reported that he did not have any illness or injury and that he had not taken any medications in the past 5 years.[40] He answered "no" to the question asking whether he had "sleep disorders, pauses in breathing while asleep, daytime sleepiness, loud snoring." For both exams, the driver's height was recorded as 6 feet 2 inches. His weight was recorded as 350 pounds in the 2015 exam and 355 pounds in the 2017 exam; the 2017 exam weight corresponds to a body mass index (BMI) of 45.6 kilograms per square meter (kg/m^2).[41] The driver's uncorrected vision on the 2015 exam was reported as 20/20; the 2017 exam also reported visual acuity as 20/20. The 2015 examiner indicated that the driver was markedly overweight, and the examiner in 2017 noted that the driver was "moderately obese, recommended usual physical with primary care provider." Neither examination documented the driver's neck circumference or recorded any comments about obstructive sleep apnea (OSA) risks. The driver's personal medical records showed a weight of 390 pounds and BMI of 50 kg/m^2 during a visit with his personal physician on April 25, 2015.

[35] The familiarization training included learning about the carrier's policies and conducting a walk-around vehicle inspection and a road test.

[36] This was a minor crash that occurred at the Sunco Carriers terminal and was not reported. As such it did not show up on Georgia's records of motor vehicles.

[37] The two other violations were for an obscured license plate and an improper lane change. The Georgia motor vehicle records do not indicate whether the violations occurred while the driver was operating a commercial vehicle.

[38] The criminal complaint was not initiated in connection with this crash.

[39] For more information, see the Human Performance report in the NTSB docket for this investigation.

[40] The driver reported that he had lost half of his left middle finger in 1996. Both examiners noted the missing finger.

[41] BMI values higher than 40 kg/m^2 indicate an "Extremely High" level of obesity (Class III). For more BMI information, see National Institutes of Health BMI chart, accessed July 26, 2017.

After the crash, the NTSB offered to arrange for the truck driver to undergo a sleep study to test him for sleep disorders; the truck driver did not respond. The NTSB then contacted the Federal Motor Carrier Safety Administration (FMCSA) and asked the agency to have the truck driver tested for sleep disorders. In a July 12, 2017, communication to the NTSB, the FMCSA responded that, based on the agency's lack of authority, it could "not compel the commercial truck driver, who possesses a valid, recently issued medical examiner's certificate, to submit to a sleep test absent evidence or documentation that indicates he was asleep behind the wheel of the commercial motor vehicle." [42]

The truck driver submitted to preemployment urine drug tests by his current and previous employers; the results of those tests were negative. NTSB investigators did not find records of any other tests for alcohol or other drugs performed on this truck driver before this crash. Toxicology testing performed as required by US Department of Transportation (DOT) regulation found no alcohol in the truck driver's breath at 9:39 a.m.—about 4 hours after the crash. The DOT postcrash testing of his urine, which was collected at 11:21 a.m.—about 6 hours after the crash—was negative for alcohol and other drugs.[43]

1.6.1.3 Route History. The truck driver's trip originated on October 20, 2016, in Madisonville, Louisiana, where he picked up his cargo. He arrived in Ehrenberg, Arizona, about 4:00 p.m. on October 22, and departed about 3:00 a.m. the following morning for his final destination—Rancho Cucamonga, California. In a postcrash interview with NTSB investigators, the truck driver stated that he had not previously driven this section of I-10. He also reported not being familiar with handling traffic breaks or rolling roadblocks.

1.6.1.4 Activities Before the Crash. NTSB investigators used information obtained from interviewing the truck driver, the truck-tractor's GPS data, and employee records from Tri-State Collision to reconstruct the driver's activities before the crash.[44]

The truck driver reported that he sleeps in the sleeper berth of his truck-tractor while traveling across the country. During an interview with the CHP and NTSB investigators, he stated that he typically drives during the day and sleeps at night. For October 19–21, the truck driver was on duty and driving for 10–14 hours each day and had about 10–12 hours of opportunity for sleep those days. On October 22, after having an 11-hour opportunity for sleep the previous night, the truck driver began driving at 6:00 a.m.; he arrived in Ehrenberg, Arizona, about 4:00 p.m. that day.

[42] Although the FMCSA does not have the authority to revoke an individual's driver's license, it can inform state departments of transportation of specific crash circumstances. With sufficient evidence, a state department of transportation can revoke a driver's license or make the continued validity of the license contingent on the driver's submitting to a sleep study.

[43] Testing covers evidence of use of the following eleven substances: amphetamine, methamphetamine, MDMA, MDA, MDEA, tetrahydrocannabinol (THC, the active compound in marijuana), cocaine, codeine, morphine, heroin, and phencyclidine.

[44] NTSB investigators did not obtain cell phone records for the truck driver, and he reported that he did not have a cell phone.

On October 23, 2016, after having had an 11-hour opportunity for sleep, the truck driver began to drive again about 3:00 a.m. (When asked by NTSB investigators, the truck driver stated that he could not recollect how many hours of sleep he had had before starting to drive.) When the crash occurred, he had been on duty and driving for about 2.5 hours. Figure 10 shows the driver's activities for the 4 days before the crash. The truck driver's on-duty status was determined based on Fleetmatics records.

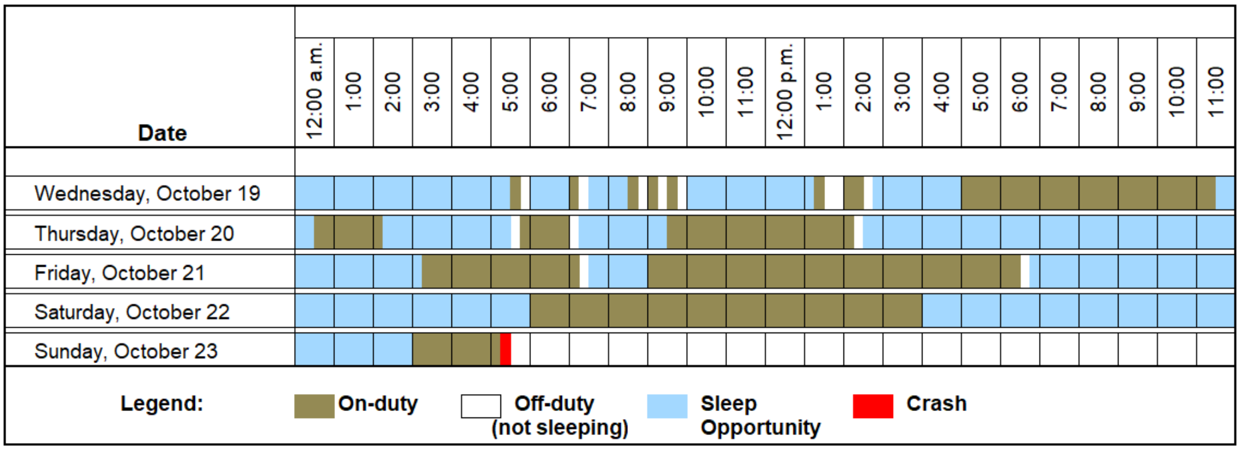


Figure 10. Precrash activities of the truck driver, October 19–23, 2016. (The shortest depicted interval is 15 minutes.)

During an interview, the truck driver stated that he had been traveling westbound on I-10 in the right lane when he observed traffic beginning to slow, at which point he noticed a police vehicle with its emergency lights flashing about 5 miles ahead. The driver stated that he then moved one lane to the left, slowed down, and turned on the flashing hazard lights. He also reported that once he stopped the combination vehicle, he set the parking brake on the truck-tractor and the semitrailer, and turned off the flashing hazard lights. He further reported that he was stationary for 25–30 minutes before he noticed traffic moving again. He stated that, at that time, he released the parking brake and placed the transmission into gear, at which point he felt an impact.

CHP officers recovered the truck driver's logbook, which contained hours-of-service (HOS) records for several days before the crash. According to the truck driver's logbook, he was within the HOS limits at the time of the crash, as well as for several days prior to the crash. However, when examining the GPS data from the truck-tractor's Fleetmatics system, NTSB investigators discovered multiple inconsistencies between the logbook entries and the GPS data in the days before the crash (see table 4).

Table 4. Comparison of truck driver's on-duty driving hours as recorded in his paper logbook and by the Fleetmatics system.

Date	Source of On-Duty Driving Hours	
	Logbook	Fleetmatics
October 14	7.25	7.25
October 15	11.0	14.75[a]
October 16	10.5	15.0[a]
October 17	10.5	12.25[a]
October 18	6.75	5.25
October 19	0	5.0
October 20	10.75	9.75
October 21	10.75	13[a]
October 22	11.0	9.25
October 23	2.25	2.25

[a] Violation of 49 *CFR* 395.3(a)(3)(1) regarding driving no more than 11 hours in 1 day.

According to Fleetmatics data, the truck driver violated the following two HOS regulations repeatedly between October 15 and 21:[45]

- Four violations of the 11-hour rule (maximum of 11 hours of driving in 1 day).
- Daily violation of the 70-hour rule (maximum of 70 hours of driving within 8 consecutive days).

1.6.2 Bus Driver

1.6.2.1 Licensing, Experience, and Driving History. The bus driver was a 59-year-old male who had been the owner of USA Holiday Inc. since 2004. At the time of the crash, he held a California class "B" CDL with a passenger endorsement and no restrictions. The bus driver was issued his first California CDL in March 1992.

California motor vehicle records show that the bus driver had six reportable crashes since December 1998. The most recent crash occurred in June 24, 2016, when the bus driver was a

[45] As stated in 49 *CFR* 395.3, a motor carrier cannot permit a driver to operate a property-carrying commercial vehicle for "more than 11 hours following 10 consecutive hours of duty" or after "having been on duty 70 hours in any period of 8 consecutive days if the employing motor carrier operates commercial motor vehicles every day of the week."

victim of a hit-and-run accident while operating a passenger vehicle.[46] The records also show that since March 2002, the driver had nine traffic-related violations, one of which was for speeding.[47]

1.6.2.2 Medical Certification, Health, and Toxicology. The bus driver had an examination for CDL medical certification on July 6, 2016. During the exam, the driver reported not having any illness or injury in the past 5 years and not taking any medications. His height was recorded as 5 feet 7 inches and his weight as 242 pounds (representing a BMI of 37.9 kg/m^2).[48] His uncorrected vision was 20/30. According to the examiner, a chiropractor, the remainder of the physical examination was normal or unremarkable. However, the bus driver's urine dip test revealed glucose. The driver was asked to return for a recheck of his urine before August 20, 2016. He returned the following day—July 7, 2016—at which time his urine dip test was negative for glucose or any other abnormality. The bus driver received a 2-year CDL medical certificate.

The bus driver did not have employer-obtained medical insurance, and investigators found no record that he had a primary care physician. The bus driver's son stated that he was not aware of any health issues that his father might have had or any medications that he might have been taking.

NTSB investigators were unable to find any records of previous drug or alcohol tests that the bus driver had completed. The investigators obtained the bus driver's postmortem blood sample and requested that the Federal Aviation Administration Civil Aerospace Medical Institute Bioaeronautical Sciences Research Laboratory perform toxicology testing. This analysis for alcohol and other drugs was negative.[49] Clinical testing of the bus driver's blood showed that the driver's hemoglobin A1C was 11.4 percent. Hemoglobin A1C levels below 5.4 percent are normal; those above 6.5 percent indicate diabetes.[50] The analysis of the bus driver's postmortem urine sample showed a glucose level of 281 milligrams per deciliter (mg/dL), which indicates diabetes.[51]

1.6.2.3 Route History. NTSB investigators interviewed the bus driver's family and the staff at the Red Earth Casino to assess the driver's familiarity with the route traveled during the crash trip.

[46] Because California does not retain detailed crash records for more than 5 years, the other five crashes most likely occurred before 2012.

[47] Of the driver's eight remaining violations, three were lane violations, and he had one each of the following violations: stop sign/signal, license class, backing on highway, an open container, and cell phone use. Two of the lane violations resulted in additional "commercial motor vehicle violations," but the records do not specify the type of vehicle the driver was operating when the other seven traffic violations occurred.

[48] (a) See National Institutes of Health BMI Calculator, accessed July 26, 2017. (b) BMI values between 35 and 40 kg/m^2 indicate a "Very High" level of obesity (Class II). For more BMI information, see National Institutes of Health BMI chart, accessed July 26, 2017.

[49] Analyses conducted by the laboratory detect amphetamines, opiates, marijuana, cocaine, phencyclidine, benzodiazepines, barbiturates, antidepressants, antihistamines, and commonly used over-the-counter and prescription drugs.

[50] Hemoglobin A1C is a measure of the percentage of hemoglobin molecules that have a glucose molecule attached to them (that is, the percentage that has been glycosylated). It is used as a measure of average blood glucose over the preceding several weeks. Nondiabetic levels are below 5.4 percent. Levels between 5.5 percent and 6.4 percent are considered "pre-diabetes." Levels above 6.5 percent indicate diabetes. For diabetic individuals, levels below 7.0 percent are considered diabetes in "good control."

[51] Normal glucose levels in urine are 0–15 mg/dL. See MedlinePlus Urine Glucose Test page, accessed July 26, 2017. When the blood glucose is higher than about 180–200 mg/dL, the kidneys respond by allowing glucose to spill into the urine.

Since 2014, the bus driver had operated the route between Los Angeles and the casino about four times per week. His typical schedule included picking up passengers from a location in the Los Angeles area (the location varied), departing about 7:00 p.m., and arriving at the casino about 11:00 p.m. The outgoing trip was about 160 miles long and, depending on traffic conditions, required 3–5 hours to complete. Per an agreement between the casino and USA Holiday, the bus would remain at the casino for at least 4 hours before the bus driver would begin the return trip back to Los Angeles.

1.6.2.4 Activities Before and During the Crash. NTSB investigators used information from an interview with the bus driver's family, cell phone records, and surveillance video from the Red Earth Casino to reconstruct the driver's activities in the days before the crash.

The bus driver typically left home for work about 5:00 p.m. and returned the following morning about 10:00 a.m.[52] Casino records indicate that the bus driver's last trip to the Red Earth Casino before this crash occurred on October 18, 2016; the driver returned to the Los Angeles area by 5:00 a.m. on October 19 and had a 5-hour window of opportunity for sleep that afternoon. Nothing indicated that he worked the two nights of October 19–20 and October 20–21, 2016. In each of those two nights, he had about a 9–11-hour window of opportunity for sleep. Cell phone records also showed that the bus driver used his phone near the casino on October 21, 2016, at 11:25 p.m., which is consistent with the driver's family's statement that he worked the night of October 21–22.

On October 22, the day before the crash, the bus driver returned home about 10:00 a.m. His family reported talking to him until about noon, at which time he went to bed. His cell phone records indicate that he engaged in phone activity until 1:33 p.m. The bus driver's son reported waking the driver at 4:45 p.m. Surveillance video from the Red Earth Casino showed the bus arriving at the casino at 11:22 p.m. on October 22, 2016. The video also showed the bus driver inside the casino until 2:32 a.m.—the early morning of October 23—at which time he left the casino and entered the bus. In interviews with NTSB investigators, several passengers reported knocking on the bus door shortly before 4:00 a.m., and they stated that they believed that the driver was asleep at the time. The video showed the bus driver moving the bus to the front of the casino at 4:03 a.m. to pick up the passengers. Figure 11 depicts the bus driver's activities on the day of the crash and for the 4 days before the crash.

[52] The bus driver would commute about 45 minutes to where his bus was parked and then proceed to a pickup/departure location in the Los Angeles area.

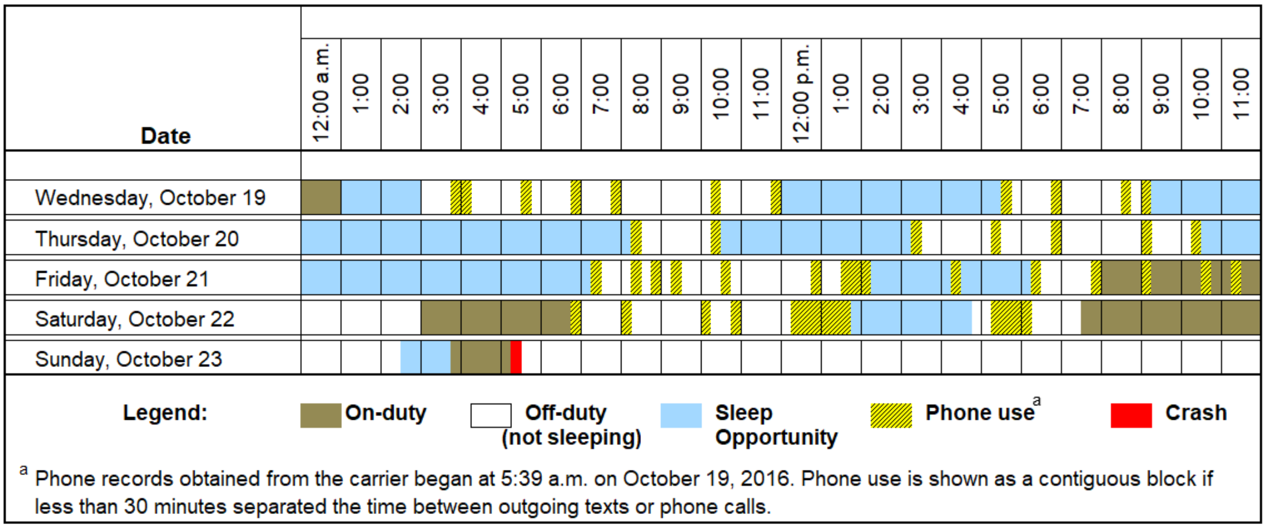


Figure 11. Precrash activities of the bus driver, October 19–23, 2016. (The shortest depicted interval is 15 minutes.)

According to a part-time driver for USA Holiday, the bus driver used paper logbooks to record his hours of service.[53] NTSB and CHP investigators were unable to find any HOS records in the bus or the crash debris. Assuming that the driver followed the regular departure time for the trip from Los Angeles, and given the bus's known arrival time at the casino, the first segment of the trip lasted about 4.5 hours. Had the crash not occurred, the on-duty driving time for the entire trip—including the return from the casino to Los Angeles—would most likely have consisted of about 8–9 hours of driving. According to 49 *CFR* 395.5, passenger-carrying commercial drivers are permitted to drive a maximum of 10 hours in a day.

1.7 Motor Carrier Operations

1.7.1 Truck Carrier Tri-State Collision

Tri-State Collision LLC, domiciled in Eufaula, Alabama, began operating as an interstate for-hire motor carrier of freight in May 2010. According to the motor carrier identification report, the carrier had 10 truck-tractors and 12 semitrailers, and it employed 10 drivers. The carrier operated routes throughout the southeast and western United States.

1.7.1.1 Carrier Training Program. NTSB investigators' examination of Tri-State Collision records showed that the carrier provided only basic training for newly hired drivers, which consisted of how to perform a walk-around vehicle inspection and a road test. The carrier used the road test to make the final hiring decision by examining the new driver's ability to maintain lane position and to change gears using a manual transmission. Tri-State Collision did not provide any remedial, annual, or specialized training for its drivers and did not have a threshold for the number

[53] Although the carrier was registered as being owner-operated, the investigation uncovered another, unreported, driver. See section 1.7.2 for more information.

or type of disqualifying traffic-related offenses. The carrier requires potential new drivers to have a minimum of 2 years of experience.

The carrier provided NTSB investigators with a written seat belt use policy and documentation of the truck driver's acknowledgement of the policy. Although Tri-State Collision did not report having any other written safety policies, it did offer monetary incentives to its drivers for passing roadside inspections without violations.

1.7.1.2 Driver Oversight. Tri-State Collision required its drivers to use paper logbooks to record their hours of service. The carrier relied on an outside safety consulting company to verify the logbooks and ensure drivers' compliance with HOS regulations. NTSB investigators determined that the consulting company audited the logbooks by checking the on-duty status from the logbooks against fuel receipts. The Tri-State Collision fleet of truck-tractors was equipped with Fleetmatics, a GPS tracking system described in section 1.5.1.7. Neither the consulting company nor Tri-State Collision used the Fleetmatics GPS data to verify drivers' HOS compliance.

1.7.1.3 FMCSA Compliance. Tri-State Collision had never been subject to a compliance review. The FMCSA conducted a new entrant audit of the carrier on September 22, 2011; the carrier failed the audit due to deficiencies in drug and alcohol testing procedures, as well as in record-keeping. Because of the failed new entrant audit, the FMCSA issued a warning letter stating that the carrier would be suspended in 60 days unless it took corrective action. On October 11, 2011, Tri-State Collision submitted a plan of corrective action, which the FMCSA approved. As a result, the FMCSA did not revoke the carrier's operating authority. The FMCSA did not conduct any follow-up inquiry to determine whether the corrective action plan had been implemented.

According to the FMCSA Motor Carrier Management Information System (MCMIS), the carrier had two Behavior Analysis and Safety Improvement Categories (BASIC) in alert status at the time of the crash—HOS compliance and crash indicator.[54] Between December 9, 2010, and April 2, 2015, the carrier had 48 roadside inspections, which resulted in 19 percent of its drivers and 16 percent of its vehicles being placed in OOS status. The national average driver and vehicle OOS rates for freight-carrying motor carriers are 4.9 percent and 20.6 percent, respectively.[55] The MCMIS profile indicated that the carrier had four reportable crashes.

[54] The FMCSA uses data from roadside inspections—including all safety-based violations, state-reported crashes, and the Federal Motor Carrier Census—to quantify a carrier's performance in seven BASICs. These categories are (1) unsafe driving, (2) HOS compliance, (3) driver fitness, (4) controlled substances and alcohol, (5) vehicle maintenance, (6) hazardous materials compliance (if applicable), and (7) crash indicator. A carrier's rating for each BASIC depends on its number of adverse safety events, the severity of its violations or crashes, and when the adverse safety events occurred (more recent events are weighted more heavily).

[55] The CVSA establishes OOS criteria (CVSA 2016). The finding of an OOS condition by a qualified inspector precludes further operation by the driver or of the vehicle, as appropriate, until the condition is corrected. The 2016 roadside inspection OOS rates for freight-carrying motor carriers were retrieved from the 2016 roadside inspection OOS rates, accessed May 17, 2017.

After this crash, the FMCSA conducted a postcrash compliance review and issued a "conditional" safety rating to the carrier.[56] The rating was based on nine safety violations, two of which were critical, as follows:[57]

- Failure to maintain a driver qualification file on each driver employed, and
- Making or permitting a driver to make a false report regarding duty status.

1.7.2 Bus Carrier USA Holiday

USA Holiday, domiciled in Alhambra, California, began operating in 1999 when it registered as an interstate for-hire motor carrier of passengers. According to the motor carrier identification report, the carrier had only one motorcoach and employed one driver. During the investigation, NTSB investigators discovered an additional part-time driver employed by the carrier. The driver who operated the bus at the time of the crash was the owner of the company.

1.7.2.1 Carrier Training Program. The owner of USA Holiday died in the crash, and NTSB investigators were unable to locate any documentation pertaining to the carrier's safety and training practices. The part-time USA Holiday driver informed the investigators that the owner kept all carrier records in the bus's luggage compartment. A search of the bus, crash site, and debris failed to recover any recent records.[58]

1.7.2.2 CHP and FMCSA Compliance. According to the *California Vehicle Code*, the CHP is required to inspect the maintenance facilities and terminals of passenger carriers domiciled in California.[59] The most recent CHP inspection of USA Holiday's terminal was on April 16, 2016; it resulted in a "satisfactory" safety rating. Since 2007, the CHP performed 13 inspections of this terminal, 5 of which resulted in "unsatisfactory" ratings and 1 of which resulted in a "conditional" rating. Of the seven CHP inspections of this terminal conducted since August 2010, one resulted in an "unsatisfactory" rating.

The FMCSA had conducted three compliance reviews (one full, one focused, and one assessment) of the carrier before the crash. The full review occurred in January 2007 and resulted in a "satisfactory" safety rating. The focused review resulted in two violations, and the assessment

[56] A "conditional" rating means a motor carrier does not have adequate safety management controls in place to ensure compliance with the safety fitness standard in 49 *CFR* 385.5.

[57] The noncritical safety violations included the following: (1) requiring or permitting a property-carrying commercial motor vehicle (CMV) driver to drive after the end of the 14th hour after coming on duty (this Tri-State Collision driver was not the crash driver); (2) failing to ensure a CMV driver logs a 30-minute rest break on their records-of-duty status; (3) allowing a property-carrying CMV driver to drive after having been on duty 70 hours in 8 consecutive days; (4) making or permitting false records-of-duty status (inaccurate); (5) failing to require the driver to prepare records-of-duty status in the form and manner prescribed; (6) failing to preserve a driver's records-of-duty status for 6 months; and (7) failing to maintain evidence of an inspector's qualifications.

[58] NTSB investigators found only passenger manifests from 2005 and 2006.

[59] The *California Vehicle Code*, section 34501.12(a), regulates the inspection of motor carriers.

review did not reveal any violations.[60] According to the MCMIS, USA Holiday had no BASICs in alert status at the time of the crash.[61] Between December 9, 2010, and April 2, 2015, the carrier had five terminal and no roadside inspections. The inspections did not result in any driver or vehicle OOS conditions. The carrier's driver and vehicle OOS rates were both 0 percent—below the average OOS rates of 4.7 percent for drivers and 6.6 percent for vehicles for passenger-carrying carriers.[62] The MCMIS profile indicates that the carrier had no reportable crashes.

Because of this crash, the FMCSA initiated a focused crash investigation of the carrier and found the following two violations: (1) no preemployment drug testing (for the part-time driver) and (2) issues with drug and alcohol sample size and randomness.

1.8 Weather and Roadway Conditions

Data from the weather station at Palm Springs International Airport, located about 5 miles from the crash site, indicated that at 4:53 a.m. on October 23, 2016, the temperature was 69°F, there was no wind or precipitation, and the visibility was 10 miles. Civil twilight began at 6:33 a.m.—1 hour 16 minutes after the crash, indicating that the crash occurred in darkness.[63]

[60] (a) A focused review is a preliminary tool used by the FMCSA to evaluate the driver, vehicle, and motor carrier for potential compliance issues. Noncompliance could result in additional FMCSA interventions. (b) The purpose of an assessment review is to conduct a brief examination of a carrier due to a lack of data on the carrier in the FMCSA's Safety Measurement System. Based on the assessment review, the FMCSA determines the carrier's prioritization for future review. (b) Focused and assessment reviews are not rated. (c) During the focused review, conducted in May 2012, the FMCSA discovered that the USA Holiday driver—the driver from this crash—had been identified as operating the bus with a suspended license during a roadside inspection on November 17, 2011. The bus driver's license was suspended between November 15 and December 8, 2011, for non-safety-related violations.

[61] On January 19, 2016, the carrier's BASIC scores were as follows: unsafe driving (36 percent), HOS compliance (47 percent), driver fitness (56 percent), controlled substances and alcohol (0 percent), vehicle maintenance (14 percent), and crash indicator (48 percent). Each of these scores is within acceptable limits as set by the FMCSA. The thresholds in these six categories for passenger carriers are 50 percent for unsafe driving, HOS compliance, and crash indicator; and 65 percent for driver fitness, controlled substances and alcohol, and vehicle maintenance.

[62] The CVSA establishes OOS criteria (CVSA 2016). When a qualified inspector finds an OOS condition, further operation by the driver or of the vehicle, as appropriate, is precluded until the condition is corrected. The roadside inspection OOS rates for 2016 for passenger-carrying motor carriers were retrieved from 2016 roadside inspection OOS rates, accessed May 17, 2017.

[63] Civil twilight begins when the geometric center of the sun is 6º below the horizon and ends at sunrise—this is the moment when the sun's edge touches the horizon.

2 Analysis

2.1 Introduction

The sequence of events leading to the crash started when the combination vehicle encountered a traffic break on I-10 that the CHP was conducting in support of utility work. After the CHP ended the break and released traffic, the truck driver remained with his vehicle parked in a travel lane. Minutes later, the bus carrying 42 passengers struck the rear of the semitrailer of the combination vehicle. The bus driver and 12 passengers died, and the truck driver and 30 passengers sustained minor-to-serious injuries.

This analysis discusses why the truck driver did not move his vehicle after the traffic break ended and surrounding traffic had resumed normal highway speeds, why the bus driver did not make sufficient avoidance maneuvers before striking the combination vehicle, and the extent to which Caltrans's procedures for conducting the traffic break contributed to the circumstances of the crash. The discussion focuses on the following safety issue areas:

- Policies for conducting traffic breaks involving rolling roadblocks,
- OSA and diabetes in commercial vehicle drivers,
- Oversight of commercial vehicle drivers and motor carriers,
- Emergency egress, and
- Collision avoidance systems.

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

- ***Driver licensing or driving experience:*** Both drivers held current CDLs with appropriate endorsements, and each had more than 15 years of driving experience.
- ***Cell phone distraction and substance impairment:*** Cell phone records provided no indication that either driver was engaged in texting or cell phone conversation at the time of the crash. Postcrash toxicology test results revealed no evidence that either driver had used alcohol or other drugs before the crash.
- ***Vehicle:*** NTSB investigators examined the combination vehicle and found no preexisting mechanical conditions that would have contributed to the circumstances of the crash. Although the inspection of the bus revealed that several tires had treads that were below minimum depth requirements and two brake linings were below the minimum required thickness, those factors did not contribute to the circumstances of this crash. The bus driver did not brake the bus before the collision with the truck; consequently, the two OOS brakes could not have affected the impact velocity. And, given the dry roadway conditions, low tire tread depth would not have affected the bus's stopping distance had the driver applied the brakes.

- ***Weather:*** There was no precipitation at the time of the crash, and the road surface was dry.
- ***Emergency Response:*** First responders provided appropriate and efficient EMS, and they followed applicable communication and IC handover protocols.

The NTSB therefore concludes that none of the following were primary or contributory factors in the crash: (1) driver licensing or experience, (2) driver cell phone distraction or substance impairment, (3) mechanical condition of the truck or the bus, or (4) weather. The NTSB further concludes that the emergency response to the crash was timely and appropriate.

2.2 Driver Actions

2.2.1 Truck Driver Actions

In an interview with the CHP, the truck driver stated that, after stopping at the end of the traffic queue, he set the parking brake and waited 25–30 minutes until traffic began moving again. However, video and communication evidence shows that the traffic stoppage lasted only about 7–7.5 minutes, that the truck was stopped for about 4 minutes, and that the crash occurred about 2–2.5 minutes after traffic was released. The truck driver stated that he thought he had been stopped in the traffic break for nearly half an hour, which is so inconsistent with the actual timing of the break that it indicates that he was completely unaware of the break's true duration.

The truck driver also said that he released the parking brake when the traffic began to move and that he placed the transmission into gear as he felt the crash impact. The tires on axles 2 and 3 on the truck-tractor had single contact marks from roadway abrasion, indicating that the wheels had been locked and sliding on the pavement; this suggests that the parking brake was still set at the time of impact.[64]

The truck driver's recollections of the duration of the traffic break and whether the truck-tractor's parking brake was engaged are inconsistent with known facts. The most likely reason for such inconsistency is that the driver was asleep. The truck driver's logbooks indicate that he had sufficient opportunity for sleep the night before the crash, but he was unable to recall how much sleep he obtained that night.

The truck driver was a 50-year-old male with a BMI of at least 45.6 kg/m^2, indicating an extremely high level of obesity.[65] Overall, 40–90 percent of individuals with BMIs greater than 40 kg/m^2 have been reported to have moderate-to-severe OSA (Schwartz and others 2008). Recent research examining the prevalence of OSA among patients awaiting bariatric surgery showed that

[64] (a) The tires on the semitrailer did not have contact marks, indicating that the parking brake was not set for the semitrailer. The parking brakes for the truck-tractor and the semitrailer can be set independently. (b) The last data point captured by the ECM about 4 minutes before the crash showed that the parking brake was off, indicating that the truck driver engaged the parking brake sometime during that 4-minute period.

[65] Although this is the calculated result from the last CDL medical examination, it is unknown whether the weight documented was measured directly on the day of the exam or obtained verbally from the driver. All of the weights for the driver known to have been measured by his primary care doctor were 30–40 pounds higher than those recorded on his CDL exam forms.

56.1 percent of patients with BMIs greater than or equal to 40 kg/m^2 but less than 50 kg/m^2 had moderate-to-severe OSA (Duarte and Magalhães-da-Silveira 2015). Data from CDL medical certification examinations showed that drivers with BMIs of at least 35 kg/m^2 are 30 times more likely to report suffering from sleep disorders than drivers with normal BMIs (Thiese and others 2015). Untreated moderate-to-severe OSA results in frequent arousals during sleep that interfere with sleep processes and lead to daytime sleepiness even after sufficient time in bed (Slater and Steier 2012).

The NTSB concludes that, based on the evidence that the truck driver did not move his vehicle for more than 2 minutes after the traffic break ended and his reported belief that the break had lasted about four times its actual length, he was most likely asleep at the time of the crash, due to fatigue that, given his extremely high level of obesity, probably resulted from undiagnosed and untreated moderate-to-severe OSA.

The issue of OSA risk factors among commercial vehicle drivers is further explored in section 2.4 of this report.

2.2.2 Bus Driver Actions

Based on the video from FedEx security cameras, traffic was flowing normally when the bus approached the vicinity of the crash. The video showed only five other vehicles—staggered more than 10 seconds apart—ahead of the bus.[66] The crash occurred at the beginning of a wide curve, which, coupled with the sparse traffic, would have afforded the bus driver a nearly unobstructed view of the stopped combination vehicle for more than 20 seconds when traveling at the speed limit.

Although the semitrailer did not have its flashing hazard lights on at the time of the crash, it had functional tail and marker lights; it was marked with appropriately positioned retroreflective material; and its cargo door, which faced the bus, was retroreflective—made of non-glaring stainless steel with a diamond-shaped pattern. Thus, despite the dark conditions and the absence of safety lighting on the highway, the truck was conspicuous on the roadway.

However, without any passing vehicles to provide a reference point, or flashing lights on the semitrailer to designate it as a hazard, the "looming" of the combination vehicle represented the only perceptual cue that it was stopped rather than moving (DeLucia and Tharanathan 2009; Kennedy, Jentsch, and Smither 2001).[67] Although it can take several seconds to detect a looming object (Terry, Charlton, and Perrone 2008; DeLucia and Tharanathan 2009; Kennedy, Jentsch, and Smither 2001), especially for older adults and if the object is in the observer's peripheral vision (Regan and Vincent 1995), the bus driver had about a 20-second window of opportunity to observe the combination vehicle and determine that it was stopped.

[66] As well as a passenger vehicle that was traveling about 2 seconds in front of the bus, the video showed four other vehicles that were staggered more than 10 seconds ahead of that passenger vehicle.

[67] As it pertains to perception, "looming" refers to the visual expansion of an image on the retina, resulting in a physiological response to perceive the object as approaching (either the object is approaching the observer or the observer is approaching the object) rather than its being stationary or moving away.

Expectations and vigilance also affect a driver's response time to a roadway hazard. The response time to an unexpected or surprise hazard is longer compared to the response time to an expected or possible hazard (Davoodi and others 2012, Green 2000). There was no reason for the bus driver to expect to find stopped traffic in a travel lane. Sparse traffic coupled with the lack of any advance warning about a possible traffic stoppage would be a typical early morning traffic pattern on this section of I-10. Considering the time required to detect the combination vehicle as stopped, even with a level of vigilance appropriate for the typical traffic pattern, the bus driver had sufficient time to recognize the hazard. Having expectations of a possible traffic stoppage might have increased the bus driver's vigilance. Crash reconstruction did not show evidence of the bus driver's braking before impact, but it did indicate that he steered away from the travel path at the last moment before impact. The NTSB concludes that although the bus driver did not have an expectation of a traffic stoppage and looming was his only perceptual cue of vehicle movement, the truck was conspicuous, and the bus driver had sufficient time to observe it, determine that it was stopped, and take appropriate action to avoid the crash.

On the morning of the crash, the driver had an opportunity to obtain about an hour of sleep in the bus until shortly before 4:00 a.m., when passengers reported waking him. Combined with about 3 hours of sleep he obtained in the afternoon of the previous day, the bus driver had about 4 hours of sleep in the 35 hours before the crash. It is well established that having less than 5 hours of sleep in a 24-hour period impairs driving performance and increases crash risk (AAA 2016, Czeisler and others 2016). The NTSB concludes that the minimal action the bus driver took to avoid the collision and the 4 hours or less of sleep he obtained in the day and a half before the crash indicate that he was fatigued at the time of the crash, most likely as a result of acute sleep loss.

The postcrash toxicology tests conducted on the deceased bus driver showed high levels of glucose in urine and hemoglobin A1C in blood, indicating untreated diabetes. However, the investigation did not discover any evidence that the bus driver had been diagnosed with diabetes or had taken any medications for the condition. Individuals diagnosed with diabetes frequently report feelings of tiredness (Fritschi and Quinn 2010; DeLucia and Tharanathan 2009; Kennedy, Jentsch, and Smither 2001). Subjective reports of fatigue are more strongly associated with higher levels of hyperglycemia—typically above 200 mg/dL—when individuals often also experience diminished cognitive functioning and blurred vision (Sommerfield, Deary, and Frier 2004; DeLucia and Tharanathan 2009; Kennedy, Jentsch, and Smither 2001). The issue of DOT testing for diabetes in commercial vehicle drivers is further explored in section 2.4 of this report.

2.3 Highway Issues

2.3.1 Caltrans Policy on Traffic Breaks and Rolling Roadblocks

This crash occurred minutes after the CHP ended a traffic break in support of utility work performed across I-10. Although Caltrans frequently issues permits for traffic breaks that involve rolling roadblocks—it issued 230 such permits in 2016 before this crash occurred—the agency did not have a standard policy for establishing a TMP when conducting rolling roadblocks. Because the utility work did not meet the definition of a "significant work project," the Caltrans TMP for the traffic break did not require the use of advance warning devices, the involvement of enough law enforcement vehicles to monitor and respond to possible problem developments concerning the traffic queue, or the provision of early communication to the public about the temporary work zone.[68]

Because the combination vehicle stopped ahead of him in his lane most likely violated the bus driver's expectations during a period of sparse traffic that was flowing at highway speeds, advance warning devices notifying him of the rolling roadblock ahead could have influenced his expectations. Such warnings might have modified his expectations sufficiently to have prompted him to identify the truck as a stopped vehicle (Davoodi and others 2012, Green 2000). Had an additional law enforcement vehicle been used when conducting the westbound rolling roadblock, it could have provided two essential safety measures: (1) when positioned with its lights flashing at the end of the westbound traffic queue during the traffic break, it would have provided an additional warning to approaching vehicles of stopped traffic ahead; and (2) when the westbound traffic break was over, it would have been in a position to notice and respond to the truck driver's failure to move his combination vehicle.

The NTSB concludes that additional traffic management countermeasures, such as advance warning devices and an additional law enforcement vehicle with activated emergency lights at the end of the traffic queue, could have alerted the bus driver about the traffic break, possibly increasing his vigilance sufficiently to enable him to detect the stopped truck in time to prevent the crash. The NTSB also concludes that an expanded transportation management policy, such as one including the use of an additional law enforcement vehicle to conduct the rolling roadblock, could have provided greater opportunity for law enforcement to recognize that the truck had remained stopped in its lane after traffic was released, and to respond accordingly.

Since the crash, Caltrans has revised standard specifications for work zone activities that include traffic breaks and, on September 1, 2017, it distributed the standards to district directors. Caltrans is amending its interagency agreements with the CHP to include the procedures for conducting traffic breaks on the state highway system and is working with the Office of Encroachment Permits and Engineering Support to develop a special provision for conducting traffic breaks as part of the encroachment permit application. The revised standards contain some of the key components of the guidelines that the FHWA developed in collaboration with ATSSA, and they include the following requirements:

- Use of at least one portable changeable message sign, placed sufficiently upstream of the planned traffic break to provide advance notice to motorists of the change in traffic conditions.
- Use of a minimum of two CHP vehicles or other law enforcement vehicles for each direction of traffic; one vehicle to conduct the rolling roadblock, and the other to be stationed on the shoulder with its rear emergency lights active to caution motorists.
- Performance of utility work that involves transmission lines crossing lanes of traffic only on Sunday mornings (excluding holidays) from daybreak to 10:00 a.m.

[68] Rolling roadblock policies that include these safety elements are discussed in section 2.3.2.2.

2.3.2 Traffic Breaks and Rolling Roadblocks Across the Country

2.3.2.1 Prevalence. At the request of NTSB investigators, the FHWA asked state offices about each state's use of traffic breaks and rolling roadblocks and any associated policies. The inquiry obtained the following responses:

- 23 of the 28 states that responded indicated that they use traffic breaks or rolling roadblocks on at least an infrequent basis,
- Of these 23 states—
  - 16 said that they use traffic breaks or rolling roadblocks routinely (5 of these states do not have standard policies for implementing them),
  - 6 said that they use traffic breaks or rolling roadblocks on an infrequent basis (4 of these states do not have standard policies for implementing them), and
  - 1 said that it uses traffic breaks or rolling roadblocks on an ad hoc basis (this state does not have standard policies for implementing them).

Based on these responses, more than 40 percent of the responding states that use traffic breaks or rolling roadblocks at least infrequently do not have standard policies on how to implement them. At the time of the crash, California was one of at least five states that routinely used traffic breaks or rolling roadblocks but had no standard policies for conducting them.[69] The NTSB concludes that even though traffic breaks and rolling roadblocks are commonly used across the country, many states that use these methods of traffic control lack standard policies specifying how they should be implemented safely.

2.3.2.2 Advanced Policies. California is adopting new guidelines on how to conduct traffic breaks and rolling roadblocks, and many other states already have such policies in place. NTSB investigators contacted three states—Missouri, North Carolina, and Ohio—that frequently use rolling roadblocks and have a standard policy for traffic control management of these temporary work zones (see appendix B for an example of one of these policies). These three states all use changeable message signs in advance of, and during, rolling roadblocks to warn the public of the temporary work zone. Ohio and Missouri also use an additional law enforcement vehicle positioned on the shoulder at the start of the pacing procedure. This vehicle serves as an additional warning to drivers and also can move with the rear of the traffic queue to serve as an advance indicator to approaching vehicles of stopped traffic ahead.

Some variability in how traffic breaks and rolling roadblocks are conducted is to be expected among the states, but the lack of even basic safety management policies among some states that use these traffic control measures exposes the public to unnecessary risk. States without such policies that routinely or even infrequently use traffic breaks and rolling roadblocks could reduce the safety risks they pose by learning from the circumstances of this crash and implementing appropriate transportation management policies when they employ these traffic control measures. Therefore, the NTSB concludes that states that use rolling roadblocks would benefit from transportation management policies that include procedures for alerting drivers to

[69] The other 4 states (of the 23 who responded to the FHWA inquiry) were Delaware, Maryland, New York, and Tennessee.

upcoming roadblocks and for monitoring the formation and dispersal of traffic queues; procedures such as the use of advance warning devices and additional law enforcement vehicles can reduce the risks associated with sudden traffic breaks.

The FHWA can play a key role in both informing the states and advocating for adoption of transportation management policies on conducting traffic breaks. It can also implement changes to the *Manual on Uniform Traffic Control Devices for Streets and Highways* (*MUTCD*).

As an immediate measure, the FHWA can issue a policy guidance memorandum to its divisional offices to distribute exemplar guidance documents (such as those developed by ATSSA, Ohio, and Missouri) for conducting traffic breaks to state departments of transportation and urge the states to adopt them. Then, during the process reviews that the FHWA conducts every 2 years with the state departments of transportation, the FHWA can ask whether the state has a policy on traffic breaks and recommend that the state adopt an appropriate policy, if necessary.[70] Such steps on the part of the FHWA would serve as reasonable interim actions.

However, the FHWA's dissemination of exemplar guidance documents would not require a response by the state departments of transportation, and the FHWA's asking the state about its traffic break policy and recommending that it adopt an appropriate policy would not require the state to do so. In the long run, to ensure that states have access to the resources needed to develop and implement appropriate policies on traffic breaks, revisions to the *MUTCD* are needed.

The NTSB therefore recommends that the FHWA advise state department of transportation officials about the circumstances of this crash; distribute to them exemplar state and ATSSA guidance on the safe implementation of traffic breaks; and urge each state to adopt a policy for conducting traffic breaks that includes procedures similar to those used in other temporary traffic control operations, such as (1) providing drivers with advance notice of slowed or stopped traffic, and (2) monitoring the formation and dispersal of traffic queues. In addition, the implementation of the policy should be documented in every encroachment permit involving a traffic break in the state. The NTSB further recommends that the FHWA, during its next regular process review with each state department of transportation, ask about the state's policy for conducting traffic breaks and, if necessary, urge the state to adopt a policy that includes procedures similar to those used in other temporary traffic control operations, such as (1) providing drivers with advance notice of slowed or stopped traffic, and (2) monitoring the formation and dispersal of traffic queues. In addition, the implementation of the policy should be documented in every encroachment permit involving a traffic break in the state. Finally, to ensure that the states have the information necessary to develop uniform policies for conducting traffic breaks and rolling roadblocks across the nation, the NTSB recommends that the FHWA develop recommended guidance for traffic break operations based on exemplar state and ATSSA guidance on the safe implementation of traffic breaks, and include its recommended guidance in the next edition of the *MUTCD*.

Until state departments of transportation adopt policies for conducting traffic breaks, more could be done on the local level. Law enforcement officials across the country could benefit from

[70] The FHWA conducts regular biannual reviews with state departments of transportation as part of its program on "Implementing the Rule on Work Zone Safety and Mobility" (23 *CFR* Part 630 Subpart J, see FHWA Work Zone Rule Guide, accessed August 18, 2017), under section 7.0, "Implementation and Compliance" (see Section 7, Work Zone Rule Guide, accessed August 18, 2017).

increased awareness of the circumstances of this crash. Organizations such as the International Association of Chiefs of Police and the National Sheriffs' Association can communicate with local law enforcement officials and increase their awareness of the consequences of inadequate planning for temporary road closures. Therefore, the NTSB recommends that the International Association of Chiefs of Police and the National Sheriffs' Association inform their members of the circumstances of the Palm Springs, California, crash and about countermeasures that can be used to improve the safety of temporary road closures.

2.4 Medical Issues

2.4.1 Obstructive Sleep Apnea

2.4.1.1 FMCSA History. Screening, diagnosis, and treatment for OSA is critical for transportation safety. In 2009, based on several NTSB accident investigations involving operators with OSA, the NTSB issued the following two recommendations to the FMCSA:[71]

> Implement a program to identify commercial drivers at high risk for obstructive sleep apnea and require that those drivers provide evidence through the medical certification process of having been appropriately evaluated and, if treatment is needed, effectively treated for that disorder before being granted unrestricted medical certification. (H-09-15)
>
> Develop and disseminate guidance for commercial drivers, employers, and physicians regarding the identification and treatment of individuals at high risk of obstructive sleep apnea (OSA), emphasizing that drivers who have OSA that is effectively treated are routinely approved for continued medical certification. (H-09-16)

In 2010, the FMCSA responded that the agency was considering strengthening respiratory requirements for medical certification in response to recommendations from its Medical Review Board (MRB). Although progress since then has been slow, the agency has taken some steps toward more stringent requirements pertaining to assessing drivers' risk for OSA. As a result, Safety Recommendations H-09-15 and -16 were classified "Open—Acceptable Response."

In January 2015, the FMCSA issued an *FMCSA Bulletin to Medical Examiners and Training Organizations Regarding Obstructive Sleep Apnea* for CDL medical examiners, which reiterated the qualification requirements for respiratory systems, specifically for drivers diagnosed with OSA.[72] The bulletin reminded medical examiners not to certify drivers with diagnosed but untreated respiratory dysfunction. However, the bulletin did not provide any screening guidelines to identify drivers at high risk for OSA. It offered only a general statement that medical examiners should consider common OSA symptoms when assessing drivers for respiratory dysfunction.

[71] The NTSB issued these recommendations based on findings from multiple investigations, three in the highway mode and four in other modes.

[72] See the bulletin for more information about the FMCSA guidance pertaining to OSA.

In March 2016, the FMCSA, with the Federal Railroad Administration, published an advance notice of proposed rulemaking (ANPRM) that requested information on the prevalence of OSA among commercial operators and the potential safety consequences for rail and highway operations.[73] The NTSB responded by stating that the rulemaking is necessary to adequately address the need to screen, diagnose, and treat OSA among commercial operators. Additionally, the NTSB provided research evidence indicating increased crash risk for drivers with OSA (Mulgrew and others 2008, Basoglu and Tasbakan 2014).

In August 2017, after reviewing the public comments, the FMCSA and the Federal Railroad Administration determined that there was insufficient information to support a rulemaking action. As a result, the agencies withdrew the rulemaking notice.[74]

2.4.1.2 Guidance on OSA Screening. Although the NTSB has been dissatisfied with the FMCSA's slow progress in initiating regulatory action pertaining to OSA and commercial operators, the March 2016 ANPRM represented a positive development. Consequently, the FMCSA's recent decision to abandon the regulatory process by withdrawing the ANPRM is disappointing, particularly considering the recommendations made by the MRB and the Motor Carrier Safety Advisory Committee (MCSAC). The FMCSA had tasked the MRB in July 2016 to review all the ANPRM comments made by medical professionals and institutions and to identify those factors that the FMCSA should consider when taking the next step on the OSA rulemaking.

In November 2016, the MRB and MCSAC submitted their recommendations on OSA and commercial operators to the FMCSA.[75] The recommendations addressed drivers who had been diagnosed with OSA and stated that they should receive a 1-year medical certification only if they have been effectively treated for the condition. The recommendations also specified the OSA risk factors and provided detailed guidance consisting of a two-tiered set of conditions for evaluating commercial drivers. They stated that commercial drivers should be further evaluated for sleep disorders if they meet the following criteria:

- Have a BMI of 40 kg/m^2 or above, or
- Have a BMI between 33 kg/m^2 and 39 kg/m^2 and meet at least 3 of 11 additional criteria, including age (42 years or above), gender (male or menopausal female), neck circumference (17 inches for males), and certain medical conditions.[76]

The MRB/MCSAC recommendations proposed that drivers who have not been diagnosed with OSA but who have been determined to be at risk for OSA be certified for 90 days, pending further

[73] See 81 *Federal Register* 12642–12647, March 10, 2016.

[74] See withdrawal of 2017 ANPRM on OSA among rail and highway operators for more information on the withdrawal of the ANPRM, accessed September 18, 2017.

[75] See the letter report from MCSAC and the MRB to the FMCSA Administrator providing their joint recommendations on OSA screening guidelines, accessed August 8, 2017.

[76] The 11 cited criteria are as follows: hypertension (treated or untreated); type 2 diabetes (treated or untreated); history of stroke, coronary artery disease, or arrhythmias; micrognathia or retrognathia; loud snoring; witnessed apneas; small airway; neck size > 17 inches (male), > 15.5 inches (female); hypothyroidism (untreated); age 42 and above; and male or postmenopausal female.

sleep study and treatment, if required. Following an effective treatment, such drivers would be eligible for a 1-year medical certification.

The NTSB considers that the MRB/MCSAC recommendations could help guide medical examiners in making decisions regarding OSA during CDL examinations. However, the FMCSA has not distributed the recommendations to certified medical examiners or made the guidance easily accessible on its website.[77] The NTSB concludes that although it has authoritative and useful guidance available on screening commercial drivers for OSA, the FMCSA has not publicized, distributed, or recommended this guidance to medical examiners; as a result, identification and effective treatment of drivers at high risk for OSA is unlikely to improve. Therefore, the NTSB recommends that the FMCSA make the 2016 MRB/MCSAC recommendations on screening for OSA easily accessible to certified medical examiners, and instruct the examiners to use the recommendations as guidance when evaluating commercial drivers for OSA risk. The NTSB also reiterates the related Safety Recommendation H-09-16 to the FMCSA.

Although the implementation of Safety Recommendation H-09-16 would provide certified medical examiners with appropriate guidance on how to effectively evaluate commercial drivers at risk for OSA, only a regulation would ensure that examiners fully apply such guidance. An effective regulation would set a standard that could considerably reduce the possibility that commercial drivers with undiagnosed OSA obtain medical certification. Such a regulation would have to be accompanied by meaningful guidance on how to identify commercial drivers at risk for OSA. The MRB/MCSAC November 2016 report letter provides such guidance.

Based on the most critical risk factor—BMI—commercial drivers as a group are at higher risk for developing OSA than are members of the general population. Data from CDL medical examinations conducted between 2005 and 2012 showed that more than half of commercial drivers are obese, with BMIs of a least 30 kg/m^2; about 27 percent have BMIs of at least 35 kg/m^2, trending toward higher BMIs (Thiese and others 2015).[78] By comparison, according to the estimate of the National Center for Health Statistics, based on 2011–2014 data, about 36.5 percent of US adults are obese, with BMIs of a least 30 kg/m^2 (Ogden and others 2015).

Compared to the MRB/MCSAC recommendations, the currently mandated medical certification process provides only limited guidance on identifying sleep-related issues. A 2008 study examined the effectiveness of the certification process in identifying drivers at risk for OSA by having physicians conduct additional OSA screenings during the regular CDL medical examination (Talmage and others 2008). Of the 1,443 commercial drivers the study examined, based on the results of the additional OSA screenings, 13 percent of drivers were referred for a sleep study. Of the drivers who consented to undergo a sleep study, 95 percent were diagnosed with OSA; 65 percent were diagnosed with moderate-to-severe OSA. None of the drivers who were referred for a sleep study had checked “yes” to the only question on the medical examination form that inquired about sleep issues, which asked if the driver had “Sleep disorders, pauses in breathing while asleep, daytime sleepiness, loud snoring.”[79] Based on the results of this study,

[77] The letter detailing the recommendations can be found on the FMCSA website only by using the website’s search function; there is no direct link to the letter on the FMCSA website.

[78] (a) For the 2005–2012 study period, about 53 percent of commercial drivers had BMIs greater than or equal to 30 kg/m^2. (b) In 2012, about 31 percent of commercial drivers had BMIs greater than or equal to 35 kg/m^2.

[79] The current CDL medical examination form asks the same sleep-related question.

these commercial drivers would not have been identified as being at high risk for OSA had only the standard medical certification examination form and currently mandated protocol been used.

The NTSB concludes that, given the high risk for OSA among commercial drivers, the currently mandated screening method is inadequate, and its continued use increases the possibility that commercial drivers with undiagnosed OSA will obtain CDL medical certification. Based on the FMCSA's recent decision to abandon the regulatory process to improve the identification of commercial drivers at high risk for OSA, the NTSB reclassifies Safety Recommendation H-09-15 "Open—Unacceptable Response." The NTSB also reiterates Safety Recommendation H-09-15 to the FMCSA.

2.4.2 Diabetes

2.4.2.1 Bus Driver. On his CDL medical examination form, dated July 6, 2016, the bus driver did not report having any medical conditions or taking any medications. His urine dip test on that day revealed glucose in his urine, and the medical examiner—a chiropractor—marked the determination as "pending" due to the urine glucose. He instructed the driver to return on another day for a follow-up test. The next day, the results of the bus driver's urine dip test were within the normal limits, and he obtained a 2-year medical certificate.[80]

When blood glucose is higher than about 180 mg/dL, the kidneys respond by allowing glucose to spill into the urine; thus, the positive urine glucose result on July 6 provided an indication of the bus driver's high glucose level on that day and that he had diabetes. Diabetes is defined as fasting blood glucose greater than or equal to 126 mg/mL. It is unknown whether the bus driver had been fasting before the medical examination on July 6. It is also unknown why the medical examiner told the driver to return on another day to repeat the urine test. Although a false positive result is possible in a glucose urine test, a positive result is usually an indicator of diabetes. As such, the appropriate and expected next step would be for the medical examiner to perform a blood test or to refer the driver to a medical specialist.

Postcrash testing showed that the bus driver had a hemoglobin A1C of 11.4 percent; levels above 6.5 percent indicate diabetes. The postcrash test results also show that glucose was spilling into his urine. This corresponds to an average blood glucose over the preceding several weeks of about 280 mg/dL.[81] The NTSB concludes that postcrash test results indicate that the bus driver had undiagnosed diabetes with significantly elevated average blood sugar in the several weeks before the crash. The NTSB further concludes that the medical examiner's failure to effectively pursue the bus driver's positive urine glucose result during his last CDL exam was a missed opportunity to diagnose and treat the driver's diabetes.

When blood glucose is elevated, it causes a variety of symptoms, including increased urine production, sugar in the urine, and increased hunger and thirst (Laffel and Svoren 2017). In severe cases, altered consciousness or coma can develop. Blurred vision is also common. This is because

---

[80] Adhering for 24 hours to a diet low in sugar and other carbohydrates and drinking a high volume of water could produce glucose-free urine even for a diabetic individual.

[81] See American Diabetes Association, Diabetes Professional eAG/A1C Conversion Calculator, accessed August 2, 2017.

the glucose is distributed throughout the body's fluids, including into the eye. As a result, the shape of the eyeball changes, and vision is affected. Blood glucose elevations to about 290 mg/dL have been demonstrated to make a person more nearsighted (myopic) by about two diopters (Furushima, Imaizumi, and Nakatsuka 1999). This degree of myopia is far greater than the muscles of the eye can compensate for, and blurred vision ensues. Because of microbial action, however, blood glucose measurements after death are an unreliable indicator of predeath blood glucose levels. Therefore, the NTSB concludes that the available information is insufficient to determine whether the bus driver had blurred vision due to his undiagnosed and poorly controlled diabetes or the extent to which it might have contributed to the crash.

2.4.1.2 Guidance on Diabetes Screening. Medical fitness for duty is an item on the NTSB's Most Wanted List of Transportation Safety Improvements, illustrating the importance of medical certification to the agency. The NTSB has also recommended that the FMCSA restrict its national registry of certified medical examiners to those examiners with prescription authority, an action that would disallow chiropractors from performing CDL medical examinations (Safety Recommendation H-13-27). In response to the recommendation, the FMCSA stated that it does not intend to implement such a restriction; as a result, the NTSB classified Safety Recommendation H-13-27 "Closed—Unacceptable Response" in June 2017.

With respect to the Palm Springs crash, the bus driver had poorly controlled diabetes. Although the medical examiner—a chiropractor—failed to identify the condition and recommend treatment by a physician, the investigation did not reveal clear evidence that those factors contributed to this crash. However, these events do illustrate deficiencies in the current medical certification process. Unlike medical doctors who can rely on their training, examiners without clinical expertise require guidance to interpret the results of urine dip tests and to take appropriate action.[82] Several years ago, the FMCSA published online a *Medical Examiner Handbook* that included the following instruction to medical examiners:

> Abnormal dip stick readings may indicate a need for further testing. As a medical examiner, you should evaluate the test results and other physical findings to determine the next step. For example, glycosuria may prompt you to obtain a blood glucose test [FMCSA 2013].

The handbook was removed from the FMCSA website on January 15, 2015. The website indicates that this handbook is "in the process of being updated" and that a "revised version will be published shortly."[83] Currently, the FMCSA provides no readily available guidance regarding best practices for evaluating drivers without a history of diabetes who test positive for glucose in their urine. The lack of such guidance is particularly problematic for medical examiners—such as chiropractors—who do not regularly diagnose or treat diabetes or other kidney diseases.

The NTSB concludes that because certified medical examiners without experience in diagnosing or treating diabetes cannot rely on their clinical expertise to interpret urine dip test results, they would benefit from readily accessible and appropriate guidance from the FMCSA. Therefore, the NTSB recommends that the FMCSA provide clear and readily searchable guidance

[82] Like OSA, diabetes not requiring treatment with insulin is not a disqualifying condition for CDL medical certification.

[83] See Medical Examiner Handbook update notification, accessed September 20, 2017.

for certified medical examiners to use when evaluating commercial drivers who are not known to have diabetes but who have glucose in their urine.

2.5 Motor Carrier Issues

2.5.1 Tri-State Collision Oversight of Its Drivers

At the time of the crash, Tri-State Collision had two alerts in its BASICs—those for HOS compliance and crash indicator. The HOS compliance indicator had been in alert since August 2013. According to his paper logbook, the truck driver had been meeting HOS requirements for the 10 days before the crash. However, data from the carrier's Fleetmatics technology—a GPS tracking system—showed that the truck driver had exceeded daily hours of service on 4 of the previous 10 days. He had also exceeded the maximum 8-day cumulative hours of service every day for the last 9 days of that period.

Tri-State Collision's entire truck-tractor fleet was equipped with Fleetmatics. The primary purpose of the system is to track the location of the carrier's vehicles, but it could also be used to monitor drivers' on-duty status. Tri-State Collision relied on a consulting company to ensure that it complied with regulatory requirements. Carriers are not required to use systems such as Fleetmatics, and the consulting company chose not to examine the Fleetmatics data to check HOS compliance. The consultant relied on drivers' paper logbooks and fuel receipts to confirm that Tri-State Collision drivers complied with HOS requirements. Regardless of whether the consulting company was as rigorous as it could have been to corroborate HOS compliance, it is ultimately the carrier's responsibility to ensure that its drivers adhere to safety regulations.

Tri-State Collision was aware that its drivers' compliance with HOS requirements was deficient, based on BASIC alerts in the HOS compliance category, and it had a readily available monitoring tool that would allow it to address this deficiency. The carrier elected not to use this tool to help improve its drivers' HOS compliance. The NTSB concludes that by not using the available data from its driver-monitoring systems, Tri-State Collision did not adequately oversee its drivers' compliance with HOS regulations. Therefore, the NTSB recommends that Tri-State Collision use data from all available driver-monitoring systems to improve its oversight of its drivers' compliance with safety regulations.

It is unlikely that this deficiency is limited to Tri-State Collision. Other freight-carrying commercial fleets would also benefit from using data from all available driver-monitoring systems to improve their driver oversight. Therefore, the NTSB recommends that the American Trucking Associations, Owner-Operator Independent Drivers Association, and CVSA advise their members of the circumstances of the Palm Springs, California, crash, and encourage them to use data from all available driver-monitoring systems to provide the best possible oversight of drivers' compliance with safety regulations.

2.5.2 FMCSA Oversight of Tri-State Collision

Since 2003, the FMCSA has been required to conduct safety audits of all new interstate motor carriers. The FMCSA is required to conduct the new entrant safety audit within 18 months of a carrier's receiving provisional approval of operating authority.[84] Tri-State Collision began operating as a new interstate freight-carrying motor carrier in May 2010. The FMCSA conducted a new entrant safety audit of the carrier in September 2011. During the safety audit, the FMCSA discovered that Tri-State Collision had not established drug and alcohol testing procedures and had inadequate record-keeping, which are deficiencies frequently found in new entrant safety audits. When a carrier fails the new entrant safety audit, the FMCSA issues a warning letter informing the carrier that, unless it acts within 60 days to remedy its safety management practices, the FMCSA will revoke its operating authority. Tri-State Collision submitted its corrective action plan to the FMCSA on October 11, 2011. The FMCSA approved the action plan but never conducted a follow-up inquiry to determine whether Tri-State Collision had implemented the plan. The regulations do not require the agency to conduct a compliance review on a carrier that fails the new entrant safety audit.

The FMCSA did not conduct any type of compliance review on Tri-State Collision until after this crash. During the postcrash review, the FMCSA found two critical violations. As a result of the review, Tri-State Collision received a "conditional" safety rating and retained its operating authority. One of the critical violations cited in the postcrash compliance review was for "making or permitting a driver to make a false report regarding duty status"; this is the requirement that the truck driver violated in the days before the crash. Moreover, Tri-State Collision had had its HOS compliance BASIC in alert status since August 2013. It is disconcerting that the FMCSA never conducted a compliance review of Tri-State Collision, despite this longstanding alert in the HOS compliance BASIC and its failed new entrant safety audit.

Following a 2013 crash in Rosedale, Maryland, in which a roll-off truck was struck by a train on a grade crossing, the NTSB issued a recommendation to the FMCSA pertaining to new entrant safety audits (NTSB 2014). The roll-off truck in the Rosedale crash was operated by a new carrier that had a pattern of multiple safety deficiencies. As a result, the NTSB issued the following recommendation to the FMCSA:

> Require a full compliance review of new entrants that fail their safety audits, fail their corrective action plans, or are issued expedited action letters. (H-14-27)

The FMCSA responded that, due to its limited resources, it would continue relying on Safety Measurement System data to prioritize for compliance reviews those motor carriers that demonstrate the highest safety risk, and it planned no further action on this recommendation. As a result, the NTSB classified Safety Recommendation H-14-27 "Open—Unacceptable Response."

The FMCSA's new entrant safety program was ineffective in establishing and maintaining Tri-State Collision as a safe motor carrier. The NTSB concludes that by not conducting a compliance review of the carrier Tri-State Collision after its failed new entrant safety audit or

[84] Following a successful application process, the carrier is granted provisional authority, pending the completion of the new entrant safety audit. After the carrier passes the new entrant safety audit or successfully addresses the deficiencies in a failed audit, the FMCSA grants the carrier permanent operating authority. (See 49 *CFR* 385.307[b].)

during the 3-year-long period during which it had an alert in its BASIC of HOS compliance, the FMCSA missed an opportunity to help the carrier improve its compliance with safety regulations or to remove its operating authority because of safety deficiencies. Therefore, the NTSB reiterates Safety Recommendation H-14-27 to the FMCSA.

2.6 Emergency Egress

The semitrailer intruded 150–200 inches into the bus—more on the right side than on the left side—which, with the displacement of seats and luggage racks, compromised bus occupant space up to row 6. This intrusion zone not only posed increased injury risk to those occupants seated in the first six rows but also limited evacuation space and reduced the points of egress for the passengers. The loading door, the first two emergency exit windows on the driver's side of the bus, and the first three emergency exit windows on the passenger side were within the intrusion zone; due to the damage, they were blocked and could not be used as emergency exits.[85]

Although they were designed as emergency exit windows, the windows outside the intrusion zone kept swinging shut even as the passengers and first responders tried to keep them open. This problem with the emergency windows was not the only one encountered during the evacuation. First responders stated that helping passengers to evacuate via the windows was exceedingly challenging, primarily because it was difficult for passengers to climb out of the windows and down the ladders. For this reason, the evacuation would have been problematic even with windows that did not keep swinging shut. Due to these challenges with evacuation via the windows, first responders began cutting the bus sidewall to create additional means of egress. Once the access points in the sidewall had been created, the evacuation and extrication process proceeded much more quickly. Because of these difficulties, and despite the quick first response by emergency services, the evacuation and extrication of the bus occupants took more than 2.5 hours. Eight bus passengers were not evacuated and transported from the scene for more than 2 hours after the crash. The NTSB concludes that, although emergency services responded quickly to the crash, the loss of the bus's loading door as a means of egress, the limited evacuation space inside the bus, and the difficulties in egressing through the emergency windows resulted in a protracted evacuation process.

The autopsy reports from the fatalities and medical records from the injured bus occupants revealed that more rapid medical intervention might have improved the outcome for some passengers. For one passenger who died, earlier intervention to provide control of bleeding caused by pelvis fractures might have permitted this victim to survive; in addition, care for a passenger with a traumatic brain injury was delayed due to prolonged extrication. The NTSB concludes that the complicated and prolonged process of extricating bus occupants may have contributed to the injury severity of at least one fatally injured and one seriously injured bus passenger.

The bus was equipped with two roof hatches, one in the front, within the intrusion zone, and another in the rear of the bus. Although the rear roof hatch was outside the intrusion zone, it was never used. Considering that first responders had great difficulty in evacuating the passengers

[85] The semitrailer intruded partially into the third emergency window on the right side of the bus; the third window was partially within the intrusion zone.

through the windows, due in part to the height of the windows, using the roof hatch for evacuation would most likely have been even more challenging and slower.[86] According to the *Federal Motor Vehicle Safety Standards* (*FMVSS*s), the presence of the rear roof hatch met the requirement for a mandatory emergency egress point. FMVSS 217 requires buses with GVWRs greater than 10,000 pounds to provide side emergency exit windows and at least one rear emergency exit door in the mid-portion or rear of the bus.[87] However, the standard also permits buses with a rear engine to have at least one emergency roof exit hatch instead of a rear exit door.

Following a 2014 crash in Orland, California, in which difficulties in bus passengers' egress contributed to the severity of their injuries (NTSB 2015a), the NTSB issued the following recommendation to the National Highway Traffic Safety Administration (NHTSA):

> Require new motorcoach and bus designs to include a secondary door for use as an additional emergency exit. (H-15-13)

NHTSA responded that the agency is evaluating the feasibility of the secondary exit door requirement. The NTSB classified Safety Recommendation H-15-13 "Open—Initial Response Received." Secondary service doors or wheelchair lift doors are permitted under the *FMVSS*s and are used on some buses. Such secondary doors could significantly speed the evacuation process for certain crashes, and they should be standard components of any emergency egress regulation for high-occupancy commercial vehicles.

Under European Union regulations, for example, a bus of the type involved in this crash would be required to have at least two service doors, or one service door and one emergency exit door, and a minimum of six exits.[88] The NTSB concludes that having a secondary door for use as an emergency exit on the bus would have considerably expedited the evacuation process and potentially improved the medical outcome for at least two passengers. Therefore, the NTSB reiterates Safety Recommendation H-15-13 to NHTSA.

2.7 Collision Avoidance Systems

The NTSB has been advocating for various collision avoidance systems (CAS) since 1995, when the Board recommended in Safety Recommendation H-95-44 that the DOT examine the efficacy of collision warning systems (CWS) in commercial vehicles (NTSB 1995). In 2001, as part of a special investigation report, the Board issued 10 recommendations pertaining to the development and adoption of collision avoidance technologies (NTSB 2001). Although technologies have advanced considerably since 2001, the level of deployment of CAS in highway vehicles has remained minimal. More importantly, the rate of rear-end crashes, which forward CAS are designed to prevent, remains unaffected. In 2015, the NTSB published an updated special investigation report on forward CAS, including CWS and autonomous emergency braking systems, which contained six recommendations to vehicle manufacturers and NHTSA

[86] Roof hatches can be beneficial as means of egress in crashes involving a rollover in which a bus comes to rest on its side.

[87] The crash bus met the criteria for a commercial vehicle, per 49 *CFR* 390.5, and of a bus, with a designed seating capacity greater than 10 persons, per 49 *CFR* 571.3.

[88] Section 7.6 of Economic Commission for Europe Regulation 107 defines various configurations of acceptable exits according to vehicle type and passenger capacity.

(NTSB 2015b). Specifically, the NTSB recommended that both passenger and commercial vehicle manufacturers take the following actions:[89]

> Install forward collision avoidance systems that include, at a minimum, a forward collision warning component, as standard equipment on all new vehicles. (H-15-8)
>
> Once the National Highway Traffic Safety Administration publishes performance standards for autonomous emergency braking, install systems meeting those standards on all new vehicles. (H-15-9)

Safety Recommendations H-15-8 and -9 are classified "Open—Await Response" for the commercial vehicle manufacturers Daimler Trucks North America LLC, Fuji Heavy Industries USA Inc., and MCI; they are classified "Open—Acceptable Response" for the commercial vehicle manufacturers Hino Motors Manufacturing USA Inc., Navistar Inc., PACCAR Inc., Van Hool NV, and Volvo Group North America LLC.

With the understanding that commercial vehicles may require different performance parameters than those for passenger vehicles, the NTSB also issued the following recommendation to NHTSA:

> Complete, as soon as possible, the development and application of performance standards and protocols for the assessment of forward collision avoidance systems in commercial vehicles. (H-15-5)

Based on NHTSA's response, which did not address CAS in commercial vehicles, the NTSB classified Safety Recommendation H-15-5 "Open—Unacceptable Response."

The large dimensions of the truck, coupled with the sparse surrounding traffic, would have made the truck a detectable obstacle for a forward CAS. The NTSB concludes that the installation of CAS technology in all highway vehicles could prevent the occurrence of rear-end crashes similar to this crash. Therefore, the NTSB reiterates Safety Recommendations H-15-8 and -9 to Daimler Trucks North America LLC, Fuji Heavy Industries USA Inc., Hino Motors Manufacturing USA Inc., MCI, Navistar Inc., PACCAR Inc., Van Hool NV, and Volvo Group North America LLC. Further, to ensure that the CAS components for commercial vehicles, particularly autonomous emergency braking systems, are manufactured to optimal performance standards, the NTSB also reiterates Safety Recommendation H-15-5 to NHTSA.

[89] Safety Recommendations H-15-8 and -9 were issued to 23 passenger vehicle manufacturers and 8 commercial motor vehicle manufacturers.

3 Conclusions

3.1 Findings

1. None of the following were primary or contributory factors in the crash: (1) driver licensing or experience, (2) driver cell phone distraction or substance impairment, (3) mechanical condition of the truck or the bus, or (4) weather.

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

3. Based on the evidence that the truck driver did not move his vehicle for more than 2 minutes after the traffic break ended and his reported belief that the break had lasted about four times its actual length, he was most likely asleep at the time of the crash, due to fatigue that, given his extremely high level of obesity, probably resulted from undiagnosed and untreated moderate-to-severe obstructive sleep apnea.

4. Although the bus driver did not have an expectation of a traffic stoppage and looming was his only perceptual cue of vehicle movement, the truck was conspicuous, and the bus driver had sufficient time to observe it, determine that it was stopped, and take appropriate action to avoid the crash.

5. The minimal action the bus driver took to avoid the collision and the 4 hours or less of sleep he obtained in the day and a half before the crash indicate that he was fatigued at the time of the crash, most likely as a result of acute sleep loss.

6. Additional traffic management countermeasures, such as advance warning devices and an additional law enforcement vehicle with activated emergency lights at the end of the traffic queue, could have alerted the bus driver about the traffic break, possibly increasing his vigilance sufficiently to enable him to detect the stopped truck in time to prevent the crash.

7. An expanded transportation management policy, such as one including the use of an additional law enforcement vehicle to conduct the rolling roadblock, could have provided greater opportunity for law enforcement to recognize that the truck had remained stopped in its lane after traffic was released, and to respond accordingly.

8. Even though traffic breaks and rolling roadblocks are commonly used across the country, many states that use these methods of traffic control lack standard policies specifying how they should be implemented safely.

9. States that use rolling roadblocks would benefit from transportation management policies that include procedures for alerting drivers to upcoming roadblocks and for monitoring the formation and dispersal of traffic queues; procedures such as the use of advance warning devices and additional law enforcement vehicles can reduce the risks associated with sudden traffic breaks.

10. Although it has authoritative and useful guidance available on screening commercial drivers for obstructive sleep apnea (OSA), the Federal Motor Carrier Safety Administration has not publicized, distributed, or recommended this guidance to medical examiners; as a result, identification and effective treatment of drivers at high risk for OSA is unlikely to improve.

11. Given the high risk for obstructive sleep apnea (OSA) among commercial drivers, the currently mandated screening method is inadequate, and its continued use increases the possibility that commercial drivers with undiagnosed OSA will obtain commercial driver's license medical certification.

12. Postcrash test results indicate that the bus driver had undiagnosed diabetes with significantly elevated average blood sugar in the several weeks before the crash.

13. The medical examiner's failure to effectively pursue the bus driver's positive urine glucose result during his last commercial driver's license exam was a missed opportunity to diagnose and treat the driver's diabetes.

14. The available information is insufficient to determine whether the bus driver had blurred vision due to his undiagnosed and poorly controlled diabetes or the extent to which it might have contributed to the crash.

15. Because certified medical examiners without experience in diagnosing or treating diabetes cannot rely on their clinical expertise to interpret urine dip test results, they would benefit from readily accessible and appropriate guidance from the Federal Motor Carrier Safety Administration.

16. By not using the available data from its driver-monitoring systems, Tri-State Collision LLC did not adequately oversee its drivers' compliance with hours-of-service regulations.

17. By not conducting a compliance review of the carrier Tri-State Collision LLC after its failed new entrant safety audit or during the 3-year-long period during which it had an alert in its Behavior Analysis and Safety Improvement Category of hours-of-service compliance, the Federal Motor Carrier Safety Administration missed an opportunity to help the carrier improve its compliance with safety regulations or to remove its operating authority because of safety deficiencies.

18. Although emergency services responded quickly to the crash, the loss of the bus's loading door as a means of egress, the limited evacuation space inside the bus, and the difficulties in egressing through the emergency windows resulted in a protracted evacuation process.

19. The complicated and prolonged process of extricating bus occupants may have contributed to the injury severity of at least one fatally injured and one seriously injured bus passenger.

20. Having a secondary door for use as an emergency exit on the bus would have considerably expedited the evacuation process and potentially improved the medical outcome for at least two passengers.

21. The installation of collision avoidance system technology in all highway vehicles could prevent the occurrence of rear-end crashes similar to this crash.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of the Palm Springs, California, crash was (1) the California Department of Transportation's inadequate transportation management plan for the traffic break, which resulted in a hazardous traffic situation in which law enforcement did not detect the combination vehicle's lack of movement after the traffic break ended and the bus driver did not receive any advance warning of potential traffic stoppage ahead; (2) the truck driver's not moving his combination vehicle after the traffic break ended, most likely due to his falling asleep as a result of his undiagnosed moderate-to-severe obstructive sleep apnea; and (3) the bus driver's lack of action to avoid the crash due to his not perceiving the combination vehicle as stopped, as a result of his fatigue and the fact that he did not expect to encounter stopped traffic.

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:

> Advise state department of transportation officials about the circumstances of this crash; distribute to them exemplar state and American Traffic Safety Services Association guidance on the safe implementation of traffic breaks; and urge each state to adopt a policy for conducting traffic breaks that includes procedures similar to those used in other temporary traffic control operations, such as (1) providing drivers with advance notice of slowed or stopped traffic, and (2) monitoring the formation and dispersal of traffic queues. In addition, the implementation of the policy should be documented in every encroachment permit involving a traffic break in the state. (H-17-46)

> During your next regular process review with each state department of transportation, ask about the state's policy for conducting traffic breaks and, if necessary, urge the state to adopt a policy that includes procedures similar to those used in other temporary traffic control operations, such as (1) providing drivers with advance notice of slowed or stopped traffic, and (2) monitoring the formation and dispersal of traffic queues. In addition, the implementation of the policy should be documented in every encroachment permit involving a traffic break in the state. (H-17-47)

> Develop recommended guidance for traffic break operations based on exemplar state and American Traffic Safety Services Association guidance on the safe implementation of traffic breaks, and include your recommended guidance in the next edition of the *Manual on Uniform Traffic Control Devices for Streets and Highways*. (H-17-48)

To the Federal Motor Carrier Safety Administration:

> Make the 2016 Medical Review Board/Motor Carrier Safety Advisory Committee recommendations on screening for obstructive sleep apnea (OSA) easily accessible to certified medical examiners, and instruct the examiners to use the recommendations as guidance when evaluating commercial drivers for OSA risk. (H-17-49)

> Provide clear and readily searchable guidance for certified medical examiners to use when evaluating commercial drivers who are not known to have diabetes but who have glucose in their urine. (H-17-50)

To Tri-State Collision LLC:

> Use data from all available driver-monitoring systems to improve your oversight of your drivers' compliance with safety regulations. (H-17-51)

To the American Trucking Associations, Owner-Operator Independent Drivers Association, and Commercial Vehicle Safety Alliance:

> Advise your members of the circumstances of the Palm Springs, California, crash, and encourage them to use data from all available driver-monitoring systems to provide the best possible oversight of drivers' compliance with safety regulations. (H-17-52)

To the International Association of Chiefs of Police and the National Sheriffs' Association:

> Inform your members of the circumstances of the Palm Springs, California, crash and about countermeasures that can be used to improve the safety of temporary road closures. (H-17-53)

4.2 Recommendations Reiterated in this Report

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

To the Federal Motor Carrier Safety Administration:

> Develop and disseminate guidance for commercial drivers, employers, and physicians regarding the identification and treatment of individuals at high risk of obstructive sleep apnea (OSA), emphasizing that drivers who have OSA that is effectively treated are routinely approved for continued medical certification. (H-09-16)

> Require a full compliance review of new entrants that fail their safety audits, fail their corrective action plans, or are issued expedited action letters. (H-14-27)

To the National Highway Traffic Safety Administration:

> Complete, as soon as possible, the development and application of performance standards and protocols for the assessment of forward collision avoidance systems in commercial vehicles. (H-15-5)

> Require new motorcoach and bus designs to include a secondary door for use as an additional emergency exit. (H-15-13)

To Daimler Trucks North America LLC, Fuji Heavy Industries USA Inc., Hino Motors Manufacturing USA Inc., Motor Coach Industries International Inc., Navistar Inc., PACCAR Inc., Van Hool NV, and Volvo Group North America LLC:

> Install forward collision avoidance systems that include, at a minimum, a forward collision warning component, as standard equipment on all new vehicles. (H-15-8)

> Once the National Highway Traffic Safety Administration publishes performance standards for autonomous emergency braking, install systems meeting those standards on all new vehicles. (H-15-9)

4.3 Recommendation Reiterated and Reclassified in this Report

The National Transportation Safety Board also reiterates and reclassifies the following safety recommendation:

To the Federal Motor Carrier Safety Administration:

> Implement a program to identify commercial drivers at high risk for obstructive sleep apnea and require that those drivers provide evidence through the medical certification process of having been appropriately evaluated and, if treatment is needed, effectively treated for that disorder before being granted unrestricted medical certification. (H-09-15)

This recommendation is reclassified "Open—Unacceptable Response" in section 2.4.1 of this report.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

ROBERT L. SUMWALT, III
Chairman

EARL F. WEENER
Member

CHRISTOPHER A. HART
Member

T. BELLA DINH-ZARR
Member

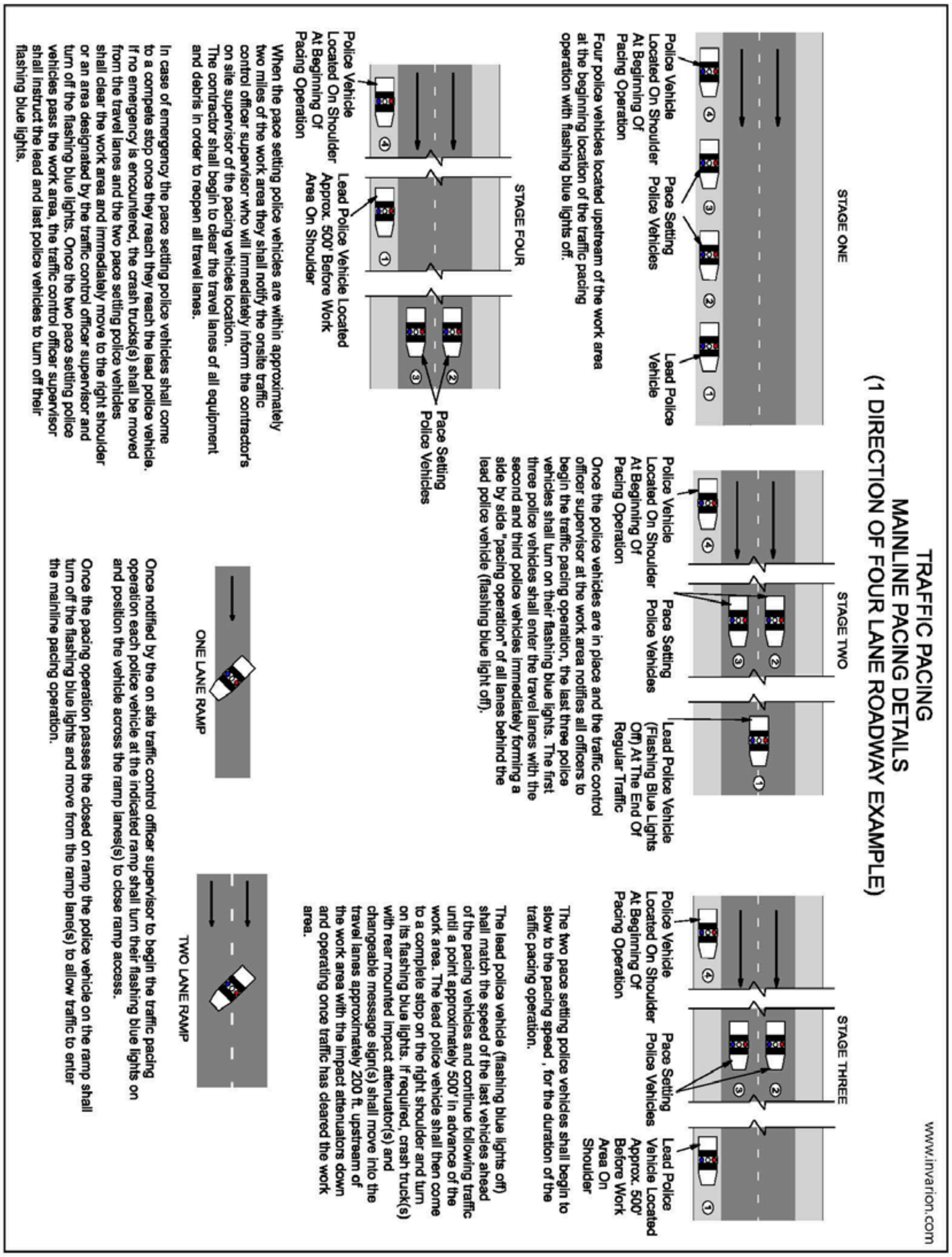
Adopted: October 31, 2017

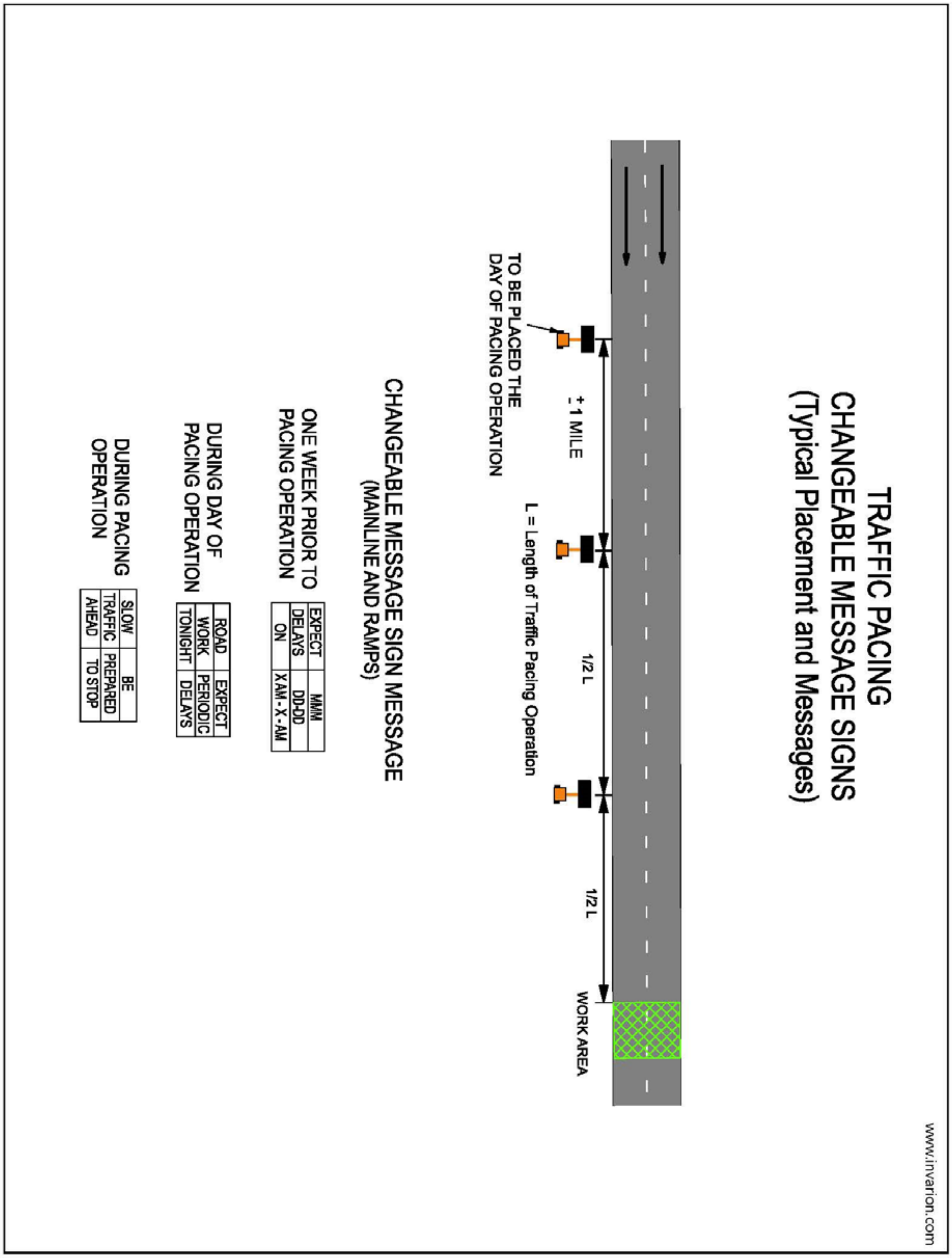
Appendix A: Investigation

The National Transportation Safety Board (NTSB) received notification of this crash on October 23, 2016, and launched investigators to address highway, vehicle, and survival factors; motor carrier operations; human performance; and onboard recorders. The NTSB team included staff from the Office of Research and Engineering. Board Member Earl F. Weener was the NTSB spokesperson on scene.

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

Appendix B: Missouri Department of Transportation Procedure for Conducting a Rolling Roadblock




TRAFFIC PACING
CHANGEABLE MESSAGE SIGNS
(Typical Placement and Messages)
TO BE PLACED THE
DAY OF PACING OPERATION
± 1 MILE
L = Length of Traffic Pacing Operation
1/2 L
1/2 L
WORK AREA
CHANGEABLE MESSAGE SIGN MESSAGE
(MAINLINE AND RAMPS)
ONE WEEK PRIOR TO
PACING OPERATION
EXPECT
DELAYS
ON
MMM
DD-DD
XAM - X AM
DURING DAY OF
PACING OPERATION
ROAD
WORK
TONIGHT
EXPECT
PERIODIC
DELAYS
DURING PACING
OPERATION
SLOW
TRAFFIC
AHEAD
BE
PREPARED
TO STOP
www.invarion.com

References

AAA (American Automobile Association) Foundation for Traffic Safety. 2016. *Acute Sleep Deprivation and Risk of Motor Vehicle Crash Involvement*. Washington, DC: AAA.

Basoglu, O.K., and M.S. Tasbakan. 2014. "Elevated Risk of Sleepiness-Related Motor Vehicle Accidents in Patients With Obstructive Sleep Apnea Syndrome: A Case-Control Study." *Traffic Injury Prevention* 15(5): 470−476.

Caltrans (California Department of Transportation). 2015. *Caltrans Transportation Management Plan Guidelines*. Division of Traffic Operations, Office of Traffic Management, November 2015.

CVSA (Commercial Vehicle Safety Alliance). 2016. *North American Standard Out-Of-Service Criteria Handbook and Pictorial*. CVSA: April 2016.

Czeisler, C.A., E.M. Wickwire, L.K. Barger, W.C. Dement, K. Gamble, N. Hartenbaum, M.M. Oyhon, R. Pelayo, B. Phillips, K. Strohl, B. Tefft, S.M.W. Rajaratnam, R. Malhotra, K. Whiton, and M. Hirshkowitz. 2016. "Sleep-Deprived Motor Vehicle Operators are Unfit to Drive: A Multidisciplinary Expert Consensus Statement on Drowsy Driving." *Sleep Health* 2(2): 94–99.

Davoodi, S., H. Hamid, M. Pazhouhanfar, and J. Muttart. 2012. "Motorcyclist Perception Response Time in Stopping Sight Distance Situations." *Safety Science* 50: 371–377.

DeLucia, P., and A. Tharanathan. 2009. "Responses to Deceleration During Car Following: Roles of Optic Flow, Warnings, Expectations, and Interruptions." *Journal of Experimental Psychology: Applied* 15: 334–350.

Duarte, R.L., and F.J. Magalhães-da-Silveira. 2015. "Factors Predictive of Obstructive Sleep Apnea in Patients Undergoing Pre-Operative Evaluation for Bariatric Surgery and Referred to a Sleep Laboratory for Polysomnography." *Journal Brasileiro de Pneumologia* 41(5): 440–448.

FHWA (Federal Highway Administration). 2013. *Guidelines on Rolling Roadblocks for Work Zone Applications*. Developed by the FHWA in collaboration with the American Traffic Safety Services Association. https://www.workzonesafety.org/training-resources/fhwa_wz_grant/atssa_rolling_roadblocks/, accessed July 25, 2017.

FMCSA (Federal Motor Carrier Safety Administration). 2013. *Medical Examiner Handbook* (online document, since removed from FMCSA website). For a section of the document, see the FMCSA *Medical Examiner Handbook* in the docket for this investigation.

Fritschi, C., and L. Quinn. 2010. "Fatigue in Patients With Diabetes: A Review." *Journal of Psychosomatic Research* 69: 33–41.

Furushima, M., M. Imaizumi, and K. Nakatsuka. 1999. "Changes in Refraction Caused by Induction of Acute Hyperglycemia in Healthy Volunteers." *Japanese Journal of Ophthalmology*, 1999 Sept./Oct. 43(5): 398–403.

Green, M. 2000. "How Long Does It Take To Stop? Methodological Analysis of Driver Perception-Brake Times." *Transportation Human Factors* 2: 195–216.

Kennedy, R., F. Jentsch, and J. Smither. 2001. "Looming Detection Among Drivers of Different Ages." *Human Factors and Ergonomic Society Annual Meeting Proceedings* 45: 240–244.

Laffel, L., and B. Svoren. 2017. "Epidemiology, Presentation, and Diagnosis of Type 2 Diabetes Mellitus in Children and Adolescents." In: *UpToDate*, editor T.W. Post. Waltham, MA. https://www.uptodate.com/contents/epidemiology-presentation-and-diagnosis-of-type-2-diabetes-mellitus-in-children-and-adolescents, accessed August 7, 2017.

Mulgrew, A.T., G. Nasvadi, A. Butt, R. Cheema, N. Fox, J.A. Fleetham, C.F. Ryan, and others. 2008. "Risk and Severity of Motor Vehicle Crashes in Patients With Obstructive Sleep Apnoea/Hypopnea." *Thorax* 63(6): 536–541.

Ogden, C.L., M.D. Carroll, C.D. Fryar, and K.M. Flegal. 2015. *Prevalence of Obesity Among Adults and Youth: United States, 2011–2014*. National Center for Health Statistics Data Brief No. 219, November 2015 (219): 1–8.

NTSB (National Transportation Safety Board). 1995. *Multiple Vehicle Collision With Fire During Fog Near Milepost 118 on Interstate 40, Menifee, Arkansas, January 9, 1995*. Highway Accident Report NTSB/HAR-95/03. Washington, DC: NTSB.

——. 2001. *Vehicle- and Infrastructure-Based Technology for the Prevention of Rear-End Collisions*. Special Investigation Report NTSB/SIR-01/01. Washington, DC: NTSB.

——. 2014. *Highway–Railroad Grade Crossing Collision, Rosedale, Maryland, May 28, 2013*. Highway Accident Report NTSB/HAR-14/02. Washington, DC: NTSB.

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

——. 2015b. *The Use of Forward Collision Avoidance Systems to Prevent and Mitigate Rear-End Crashes.* Special Investigation Report NTSB/SIR-15/01. Washington, DC: NTSB.

Regan, D., and A. Vincent. 1995. "Visual Processing of Looming and Time to Contact Throughout the Visual Field." *Vision Research* 35(13): 1845–1857.

Schwartz, A., S. Patil, A. Laffan, V. Polotsky, H. Schneider, and P. Smith. 2008. "Obesity and Obstructive Sleep Apnea: Pathogenic Mechanisms and Therapeutic Approaches." *Proceedings of the American Thoracic Society* 5: 185–192.

Slater, G., and J. Steier. 2012. "Excessive Daytime Sleepiness in Sleep Disorders." *Journal of Thoracic Disease* 4: 608–616.

Sommerfield, A., I. Deary, and B. Frier. 2004. "Acute Hyperglycemia Alters Mood State and Impairs Cognitive Performance in People With Type 2 Diabetes." *Diabetes Care* 27: 2335–2340.

Talmage, J.B., T.B. Hudson, K.T. Hegmann, and M.S. Thiese. 2008. "Consensus Criteria for Screening Commercial Drivers for Obstructive Sleep Apnea: Evidence of Efficacy." *Journal of Occupational and Environmental Medicine* 50: 324–329.

Terry, H., S. Charlton, and J. Perrone. 2008. "The Role of Looming and Attention Capture in Drivers' Braking Responses." *Accident Analysis & Prevention* 40: 1375–1382.

Thiese, M.S., G. Moffitt, R.J. Hanowski, S.N. Kales, R.J. Porter, and K.T. Hegmann. 2015. "Commercial Driver Medical Examinations: Prevalence of Obesity, Comorbidities, and Certification Outcomes." *Journal of Occupational and Environmental Medicine* 57: 659–665.