Highway–Railroad Grade Crossing Collision
US Highway 95
Miriam, Nevada
June 24, 2011

Accident Report

NTSB/HAR-12/03
PB2013-103891

National Transportation Safety Board

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Notation 8341C
Adopted December 11, 2012

Highway Accident Report

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National
Transportation
Safety Board

490 L'Enfant Plaza, SW
Washington, DC 20594

National Transportation Safety Board. 2012. *Highway–Railroad Grade Crossing Collision, US Highway 95, Miriam, Nevada, June 24, 2011*. Highway Accident Report NTSB/HAR-12/03. Washington, DC.

Abstract: On Friday, June 24, 2011, about 11:19 a.m. Pacific daylight time, a 2008 Peterbilt truck-tractor occupied by a 43-year-old driver was traveling north on US Highway 95 near Miriam, Nevada. The truck-tractor was pulling two empty 2007 side-dump trailers. As it approached an active highway–railroad grade crossing consisting of two cantilever signal masts with flashing lights and two crossing gate arms in the descended position, it failed to stop and struck the left side of Amtrak train no. 5, which was passing through the grade crossing from the northeast. The collision destroyed the truck-tractor and two passenger railcars. The train came to a stop without derailing; however, a fire ensued, engulfing two railcars and damaging a third railcar. The accident killed the truck driver, the train conductor, and four train passengers; 15 train passengers and one crewmember were injured.

Major safety issues identified in this investigation were commercial driver fatigue and distraction, commercial driver license and employment history, commercial vehicle brake maintenance, passenger railcar crashworthiness and fire protection, and grade crossing action plans. The National Transportation Safety Board makes recommendations to the Federal Motor Carrier Safety Administration, the National Highway Traffic Safety Administration, the Federal Highway Administration, the Federal Railroad Administration, the Nevada Highway Patrol, the Commercial Vehicle Safety Alliance, the American Trucking Associations, the Owner-Operator Independent Drivers Association, the Towing and Recovery Association of America Inc., the American Bus Association, the United Motorcoach Association, and John Davis Trucking Company, Inc.

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Contents

Figures

Acronyms and Abbreviations

AAR	Association of American Railroads
AAWS	active advance warning sign
ABS	antilock braking system
Amtrak	National Railroad Passenger Corporation
BASIC	Behavior Analysis and Safety Improvement Category (FMCSA)
BMI	body mass index
CCSO	Churchill County Sheriff's Office
CDL	commercial driver's license
CDLIS	Commercial Driver's License Information System
CFR	*Code of Federal Regulations*
CMV	commercial motor vehicle
CVSA	Commercial Vehicle Safety Alliance
dB	decibel
DMV	Department of Motor Vehicles
DOT	US Department of Transportation
DSRC	dedicated short range communication
DVIR	driver's vehicle inspection report
ECM	engine control module
EDR	event data recorder
EOC	Churchill County Emergency Operations Center
°F	degrees Fahrenheit
FAA	Federal Aviation Administration
FCE	functional capacity evaluation
FCVFD	Fallon/Churchill Volunteer Fire Department
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FMCSRs	*Federal Motor Carrier Safety Regulations*
FR	*Federal Register*
FRA	Federal Railroad Administration

ft/s^2	feet per second^2
g	acceleration due to gravity
GCP-3000	Safetran Microprocessor-Based Grade Crossing Predictor
GPS	global positioning system
HCA	Highway Crossing Analyzer unit
HMR	*Hazardous Materials Regulations*
HSIP	Highway Safety Improvement Program
I-80	Interstate 80
LED	light-emitting diode
MAP-21	Moving Ahead for Progress in the 21st Century Act
MCMIS	Motor Carrier Management Information System
MCSIA	Motor Carrier Safety Improvement Act
MUTCD	*Manual on Uniform Traffic Control Devices*
NDOT	Nevada Department of Transportation
NDR	National Driver Register
NHP	Nevada Highway Patrol
NHTSA	National Highway Traffic Safety Administration
NPRM	Notice of Proposed Rulemaking
NTSB	National Transportation Safety Board
OOS	out-of-service
PDT	Pacific daylight time
P.L.	Public Law
PRIA	Pilot Records Improvement Act of 1996
psi	pounds per square inch
PSP	Pre-employment Screening Program (FMCSA)
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
US 95	US Highway 95
U.S.C.	*United States Code*
USDOT	US Department of Transportation (motor carrier number)
V2I	vehicle to infrastructure communications

Executive Summary

On Friday, June 24, 2011, about 11:19 a.m. Pacific daylight time, a 2008 Peterbilt truck-tractor occupied by a 43-year-old driver was traveling north on US Highway 95 near Miriam, Nevada. The truck-tractor was pulling two empty 2007 side-dump trailers. As it approached an active highway–railroad grade crossing consisting of two cantilever signal masts with flashing lights and two crossing gate arms in the descended position, it failed to stop and struck the left side of Amtrak train no. 5, which was passing through the grade crossing from the northeast. The collision destroyed the truck-tractor and two passenger railcars. The train came to a stop without derailing; however, a fire ensued, engulfing two railcars and damaging a third railcar. The accident killed the truck driver, the train conductor, and four train passengers; 15 train passengers and one crewmember were injured.

The National Transportation Safety Board (NTSB) determines that the probable cause of the Miriam, Nevada, accident was the truck driver's delayed braking and the failure of John Davis Trucking to adequately maintain the brakes on the accident truck. Contributing to the number of fatalities and the severity of injuries was insufficient passenger railcar side impact strength.

The accident investigation focused on the following safety issues:

- **Commercial driver fatigue and distraction:** Despite visual cues provided by the active grade crossing directly in front of him, the truck driver did not begin skidding and depositing tire marks on the roadway until it was too late to avoid a collision with the passing train.

- **Commercial driver license and employment history:** The accident driver's employer was not required to obtain a full history of his motor vehicle-related violations and suspensions; and the driver provided the employer with an incomplete account of his 10-year employment history, which prevented the employer from making an informed hiring decision. This accident is the fourth NTSB investigation in the past 2 years where a commercial driver's employment and license history was at issue.

- **Commercial vehicle brake maintenance:** The brakes of the accident truck were improperly maintained, and their poor condition increased the stopping distance of the truck. This factor—in addition to the driver's delayed braking—led to the collision with the train.

- **Passenger railcar crashworthiness and fire protection:** When the accident truck struck the Amtrak train, it penetrated two railcars and resulted in a loss of occupant survival space for the train crew and passengers. In addition, an estimated 100 gallons of diesel fuel from the truck ignited a fire that spread across three railcars. The NTSB

examined whether the implementation of measures to improve passenger railcar crashworthiness and fire protection could have affected the outcome of this accident.

- **Grade crossing action plans:** The NTSB evaluated the grade crossing warning systems at the accident site to determine whether improvements could be made to alert inattentive drivers to approaching trains. Federal legislation requires states to conduct and systematically maintain a survey of all highways to identify those grade crossings that may require separation, relocation, or protective devices. However, not all states choose to, nor are they required to, create a planning document outlining how they would methodically and systematically reduce grade crossing accidents. The NTSB considered whether a uniform model grade crossing safety action plan is needed to help states systematically improve grade crossing safety.

As a result of this investigation, the NTSB makes recommendations to the Federal Motor Carrier Safety Administration, the National Highway Traffic Safety Administration, the Federal Highway Administration, the Federal Railroad Administration, the Nevada Highway Patrol, the Commercial Vehicle Safety Alliance, the American Trucking Associations, the Owner-Operator Independent Drivers Association, the Towing and Recovery Association of America Inc., the American Bus Association, the United Motorcoach Association, and John Davis Trucking Company, Inc.

1 Factual Information

1.1 Accident Narrative

On Friday, June 24, 2011, about 11:19 a.m. Pacific daylight time (PDT), a 2008 Peterbilt truck-tractor pulling two empty 2007 side-dump trailers (accident truck) was traveling north on US Highway 95 (US 95) near Miriam, Nevada, approaching an active highway–railroad grade crossing near highway milepost 55.9.[1] (See figures 1 and 2.) This grade crossing consisted of two cantilever signal masts with flashing lights and two crossing gate arms. The accident truck driver had begun his shift at 2:30 a.m. and was on his return trip from the Esmeralda mine near Hawthorne, Nevada, to the John Davis Trucking facility in Golconda, Nevada. At this point in his trip, he had driven a total of approximately 372 miles and had been on duty for almost 9 hours.

About the same time, National Railroad Passenger Corporation (Amtrak) train no. 5, a two-locomotive 10-railcar train, approached from the northeast.[2] A video camera mounted to the front of the train revealed that prior to reaching the grade crossing, located 3 miles south of Interstate 80 (I-80), the train was sounding its horn and the crossing gate arms had fully descended to block highway traffic.[3] The locomotive event data recorder (EDR) showed that the train was traveling 77 mph when the collision occurred.[4] Tire marks at the accident scene began 349 feet south of the grade crossing, indicating that the truck driver had initiated a hard braking maneuver prior to striking the train.[5] The accident truck struck the tip of the south crossing gate arm and then the left side of crew sleeper railcar 39013, at a location approximately 222 feet behind the front of the train. The engine compartment of the truck-tractor penetrated and became lodged in the lower level of the crew sleeper railcar. The first side-dump trailer then detached and struck the first coach railcar 34033. Fuel from the accident truck ignited, and a fire ensued in the crew sleeper railcar, which spread to the two trailing coach railcars. (See figure 3.) The train did not derail, and the front of the train came to a stop about 3,117 feet southwest of the grade crossing.

[1] Active grade crossings give advance notice of the approach of a train. They are activated by the passage of a train over a detection circuit in the track, except in those few situations where manual control or manual operation is used.

[2] Amtrak train no. 5 consisted of two locomotives, AMTK 43 and AMTK 177, followed by 10 railcars. The railcars were coupled behind the locomotives in the following order: baggage railcar 1257, crew sleeper railcar 39013, coach railcar 34033, coach railcar 35006, coach railcar 34057, lounge railcar 33022, diner railcar 38032, sleeper railcar 32006, sleeper railcar 32049, and sleeper railcar 32076. Except for the baggage railcar, all railcars had an upper and a lower deck. The total length of the train was 977 feet.

[3] The video camera—triggered by the emergency brake application—stored footage of the forward view beginning 35 seconds before the brake application until 5 seconds after the train had stopped.

[4] The EDR recorded train speed. The maximum allowable speed on this section of track was 79 mph.

[5] It is indeterminate whether the tire marks were initially deposited by tires from the fifth axle or the ninth axle on the accident truck. If the marks were deposited by the ninth axle, the front of the truck was 247 feet from the area of impact when skidding began. If the marks were deposited by the fifth axle, the front of the truck was 299 feet from the area of impact when skidding began.

The train was occupied by 14 Amtrak crewmembers and 195 passengers. The truck driver, the train conductor, and four train passengers were killed; 15 train passengers and one crewmember were injured.

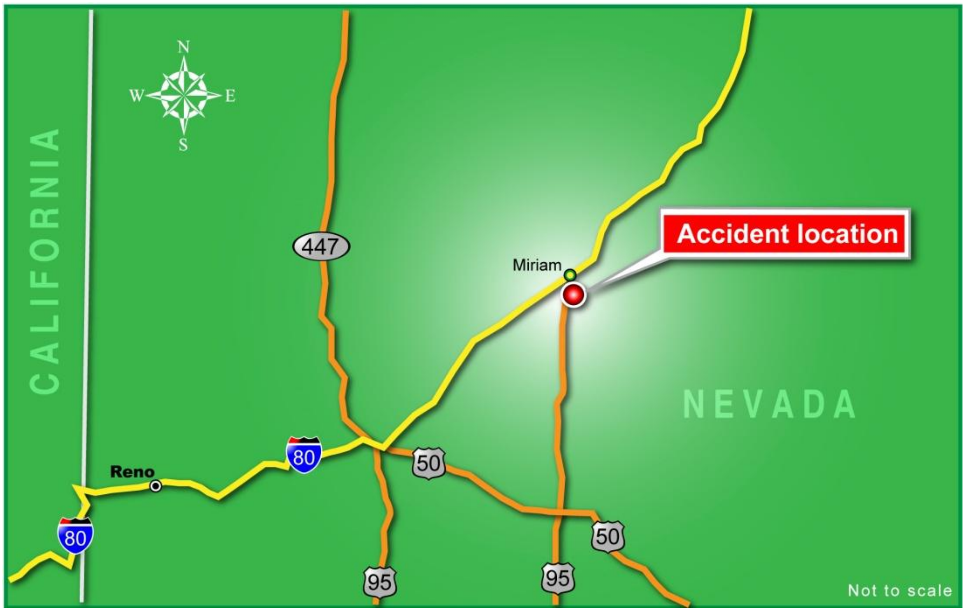

Figure 1. Regional map showing location of Miriam accident, about 75 miles northeast of Reno, Nevada.

Figure 2. Map showing where Union Pacific Railroad track crosses US 95 near Miriam, Nevada, about 3.1 miles south of I-80.

Figure 3. From left to right, photograph showing two locomotives, baggage railcar, burning crew sleeper railcar, first coach railcar with large opening where penetrated by first side-dump trailer, and front of second coach railcar. (Courtesy of rail passenger)

At the time of the accident, the skies were clear, the wind was light, the visibility was 10 miles, and the temperature was 82 degrees Fahrenheit (°F). There was no report of precipitation during the previous 24 hours.[6] The sun was 63.7 degrees above the horizon.[7]

1.2 Witness Statement

A truck driver who had been traveling behind the accident truck for approximately 45 miles stated that it had exhibited no unusual movements such as swerving or speeding prior to the accident. The witness stated that he saw the approaching train 0.25–0.5 mile before the grade crossing and started to slow his truck. He noticed that the accident truck was not slowing, and he looked to see if the signal was working. He saw the grade crossing lights flashing and saw the crossing gate arms down. The witness stated that he was about 300 yards behind the accident truck at the time of the crash. Prior to the crash, he saw the accident truck's brakes lock up and saw "black smoke coming from the brakes." He did not see any other signs that the driver had tried to slow the truck or steer away. Upon impact, the witness saw what he described as an explosion and fire. He saw "little spires of fire" all the way down the tracks to where the train stopped. By the time he arrived at the intersection, the tractor was "missing."

[6] These conditions are based on observations made at 10:53 a.m. from Derby Field Airport, Lovelock, Nevada, located approximately 13 miles northeast of the accident site at an elevation of 3,904 feet.

[7] As reported by the US Naval Observatory for Lovelock, Pershing County, Nevada.

1.3 Injuries

The truck driver, the train conductor in the crew sleeper railcar, and four passengers in the first coach railcar were killed. (See table 1.) According to the Washoe County medical examiner, all six deaths were caused by blunt force trauma. Five train occupants (four passengers and one crewmember) suffered serious injuries, such as fractures, lacerations, and burns. Eleven passengers received minor injuries, such as abrasions, contusions, and smoke and carbon monoxide inhalation.

Table 1. Injuries and fatalities.

Injury[a]	Truck Driver	Train Crew	Train Passengers	Total
Fatal	1	1	4	6
Serious	0	1	4	5
Minor	0	0	11	11
None	0	12	176	188
Total	1	14	195	210

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

1.4 Emergency Response

The accident occurred near Miriam, an unincorporated locale of Churchill County, Nevada. The nearest populated municipal jurisdictions are the city of Lovelock, located 25 miles to the northeast, and the city of Fallon, located 31 miles to the south.

Based on the train's data communication system,[8] the accident occurred at 11:19:28 a.m. PDT.[9] Postaccident interviews indicate that once the train had stopped, the Amtrak train crew, who were trained in emergency preparedness and response, quickly began to evacuate passengers.[10] The train crew, assisted by some passengers, also attempted to suppress the fire in

[8] The lead locomotive was fitted with an automatic data communications system, referred to as a Wi-Tracker. This system is connected to the locomotive EDR and the onboard digital video recorder, and it captures and transmits data to a central Amtrak location in real time. Automatic data transmission was triggered by emergency brake applications at speeds above 10 mph. Transmitted data include train speed, airbrake system pressure, direction of travel, throttle setting, global positioning system (GPS) coordinates, and video images.

[9] Communication system time was verified against US Naval Observatory standard time.

[10] New employees are required to take a 40-hour course, and 16 hours of refresher training is required on a biannual basis. The course focuses on rail equipment, situational awareness, passenger evacuation, coordination of functions and operations, and emergency care.

the burning passenger railcars. The locomotives were later disconnected from the train to prevent further damage.

The Churchill County Sheriff's Office (CCSO) dispatch received a 911 call at 11:21 a.m. and notified the Nevada Highway Patrol (NHP) and the Fallon/Churchill Volunteer Fire Department (FCVFD) at 11:22 a.m. The Fallon-based FCVFD fire and patrol units were dispatched at 11:24 a.m.; the nearest dispatched NHP trooper arrived at 11:43 a.m. and set up a command post. The FCVFD chief arrived at 11:47 a.m. and requested two helicopters. At 11:53 a.m., a CCSO captain arrived and assumed the role of incident commander, and the Churchill County Emergency Operations Center (EOC) was activated. The EOC assumed various coordination and logistical duties, including contact with the Red Cross, the Amtrak Operations Center, the National Transportation Safety Board (NTSB), and the Washoe County Emergency Management/Medical Examiner's Office.

The incident commander noted that the railcars were on fire about 0.25 mile from the roadway[11] and that most passengers had evacuated the train by 11:50 a.m. The first ambulance arrived at 11:47 a.m., and the first of two Care-flight helicopters arrived at 12:20 p.m. Of the 209 occupants of the train, 10 were transported to hospitals by ambulance or helicopter, and 52 were transported by bus to an offsite triage and aid center located at a local school.

The first fire engine arrived at 11:53 a.m., but efforts to fight the fire were hindered by the off-road location of the engulfed railcars. The need for off-road-capable fire equipment was quickly recognized, and a formal request was made of Naval Air Station Fallon at 11:52 a.m. The all-wheel-drive foam pumper trucks began arriving at 12:46 p.m. to extinguish the railcar fires. (See figure 4.) Photographic evidence from occupants of the train indicated that the fire was substantially suppressed by 1:26 p.m. The fire chief cancelled additional fire equipment at 1:41 p.m. The highway was reopened for traffic at 2:40 p.m.

Figure 4. Aerial photograph showing all-wheel-drive foam pumper truck extinguishing fire on Amtrak train. (Courtesy of Nevada Highway Patrol)

[11] This distance was later measured by investigators to be about 0.5 mile.

1.5 Survival Factors

1.5.1 Amtrak Railcar Wreckage

1.5.1.1 Crew Sleeper Railcar 39013. During the accident sequence, the left front of the truck-tractor struck the bilevel crew sleeper railcar near the midpoint of its forward wheel assembly. (See figure 5.) Postrecovery examination showed that the railcar roof had a wavy appearance consistent with distortion due to high temperatures. All the railcar windows had melted. The outer surfaces of the stainless-steel side panels had pronounced thermal discoloration, as evidenced by blue- and straw-colored hues. On the forward end of the railcar, the rubber diaphragm that surrounded the car-to-car door opening was intact. On the aft end of the railcar, the fire had consumed the rubber diaphragm on the car-to-car door leading to the trailing coach railcar. The interior compartment of the lower level was destroyed, rendering it substantially a continuous open space. The fire consumed all combustible materials in the lower level and destroyed the upper level of the railcar.

Figure 5. Photograph of crew sleeper railcar 39013, with front of railcar at left, showing where accident truck-tractor penetrated lower level and ensuing fire engulfed railcar.

1.5.1.2 First Coach Railcar 34033. The coach railcar behind the crew sleeper railcar also sustained impact and subsequent fire damage, as shown in figures 6 and 7. This bilevel railcar had passenger seating on the upper level, and lavatories and a smaller passenger compartment on the lower level. During the accident sequence, the first trailer of the accident truck penetrated the upper level sidewall panel of the railcar, and the impact damage continued longitudinally toward the aft end. This damage resulted in an opening in the left sidewall panel, extending horizontally from the forward corner-post of the upper level passenger compartment and progressing aft about 33 feet (which is about 40 percent of the length of the railcar). The seating area at the forward end of the upper level passenger compartment also showed signs of impact damage.

Figure 6. Photograph of first coach railcar 34033 at impound lot, with front of railcar at left, showing extent of damage caused by collision with first side-dump trailer and fire damage throughout railcar.

Figure 7. Photograph of interior of lower level of first coach railcar 34033, showing extensive structural and fire damage.

The fire consumed the passenger compartment on the lower level of the first coach railcar, leaving only small scraps of charred materials. The fire also consumed the passenger compartment on the upper level. All the windows of this coach railcar had melted or were missing, with the exception of two on the lower right-hand side, which were charred but remained in position. The fire had destroyed the rubber diaphragm surrounding the car-to-car door at the forward end of the railcar. The outer door mode control switch was found to be in the normal position; the inner door mode control switch was destroyed by the fire. The fire consumed the upper portion of the rubber diaphragm surrounding the car-to-car door at the aft end of the railcar. Both the inner and outer mode control switches of this door were found to be in the normal position. The roof of the railcar exhibited waviness consistent with thermally induced deformation. The exterior surface of the stainless-steel side panels had thermal discoloration and charred paint in the areas where logos and striping were affixed—mostly on the sidewalls of the upper level and surrounding windows of the lower level.

1.5.1.3 Second Coach Railcar 35006. The second coach railcar had an upper level passenger compartment, and a lower level consisting of a snack bar and lavatories. This railcar sustained only fire damage. Soot covered the exterior of the railcar. (See figure 8.) The lower level windows on the left-hand side were opaque due to degradation from thermal exposure. On the right-hand side, the lower level windows were covered with soot but had not become opaque. Thermal buckling of the roof structure was observed from the forward portion of the railcar to its middle. The fire consumed the rubber diaphragm of the forward car-to-car door, with more extensive damage on the right side than on the left. The window of the car-to-car door had melted and fallen out of position. Apart from soot, the lower level of the railcar did not sustain fire damage. The passenger compartment on the upper level was coated with soot throughout. (See figure 9.) At the forward end of the passenger compartment, the ceiling and luggage rack materials were charred. This charring extended to approximately the seventh row of seats from the front.

Figure 8. Photograph of second coach railcar 35006 at impound lot, with front of railcar at left.

Figure 9. Photograph of interior of second coach railcar 35006, showing damage from heat and soot throughout.

1.5.1.4 Railcar Crashworthiness and Fire Resistance. The crew sleeper railcar and the eight passenger railcars were Superliner passenger railcars.[12] The railcars were bilevel, consisting of upper and lower level passenger compartments, and had environmental controls, service lighting, running water, lavatories (except in dining cars), and safety features for emergency use (for example, window exits, signage, lighting, and emergency tools). The railcars were designed with structural components to deter car body sidewall intrusion under impact loading, including side posts,[13] side sill members,[14] and sheathing.[15] The Superliner railcars were constructed in compliance with Association of American Railroads (AAR) standard S-034-69.[16]

Review of Amtrak documentation, dating to 1990, indicated that none of the three damaged railcars involved in this accident had sustained prior serious accident damage or had undergone structural modification that might potentially affect their crashworthiness performance.

[12] Superliner I series railcars were manufactured and delivered to Amtrak in 1979–1980. Superliner II series railcars were manufactured and delivered to Amtrak in 1994–1995.

[13] Side posts are the main vertical structural elements in the sides of a rail vehicle.

[14] Side sill members are the portion of the underframe or side at the bottom of the rail vehicle sidewall.

[15] Sheathing refers to the sheet metal panels that make up the outer layer of the car body sidewall structure.

[16] *Specifications for the Construction of New Passenger Equipment Cars*, AAR standard S-034-69 (Washington, DC: Association of American Railroads, 1984).

1.5.2 Accident Truck Wreckage

The accident truck consisted of a 2008 Peterbilt truck-tractor in combination with two 2007 SmithCo side-dump trailers, as shown in figures 10 and 11. The accident resulted in two debris fields of truck components—the first at the grade crossing site and the other on the railroad track where the damaged railcars came to rest. The frame rails, engine, transmission, and front axle of the accident truck were found embedded in the crew sleeper railcar. (See figure 12.) Truck cab parts—including the driver's seat, both the driver and passenger side doors, and pieces of the interior and dash—were found spread over the debris fields along the south side of the railroad tracks near the grade crossing. The three rear axles of the truck were also located, individually, near the grade crossing. Truck components located closer to the crossing, and farther from where the train came to rest, sustained mainly impact damage, whereas components located in the railcar and closer to where the train came to rest showed damage from both the impact and the fire.

Figure 10. Photograph of exemplar Peterbilt truck-tractor in combination with two SmithCo side-dump trailers.

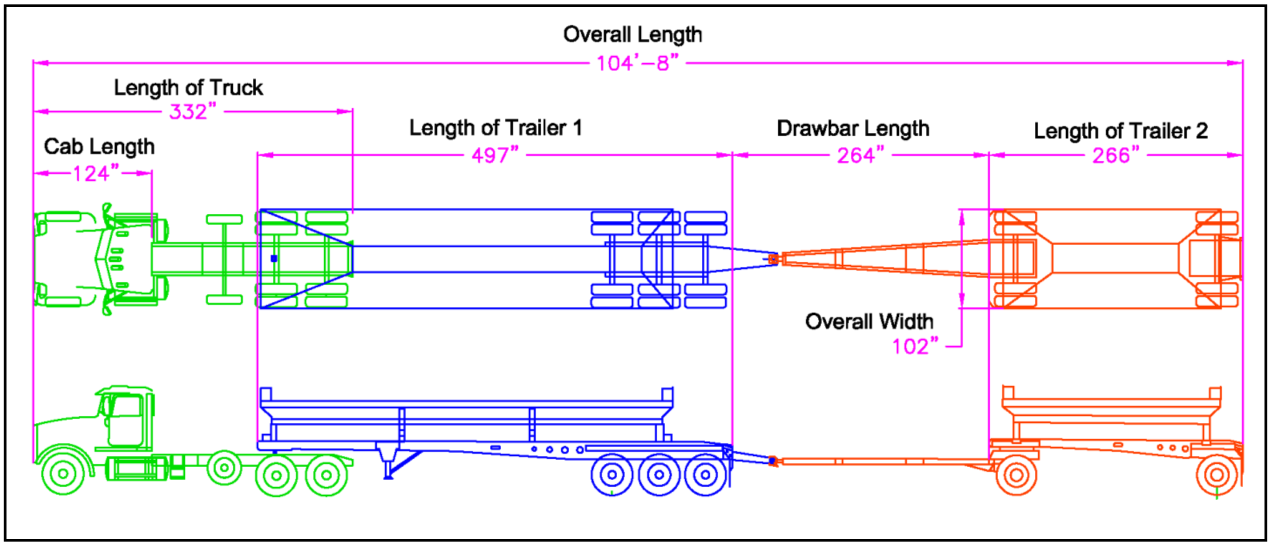

Figure 11. Diagram of accident truck and two side-dump trailers in combination.

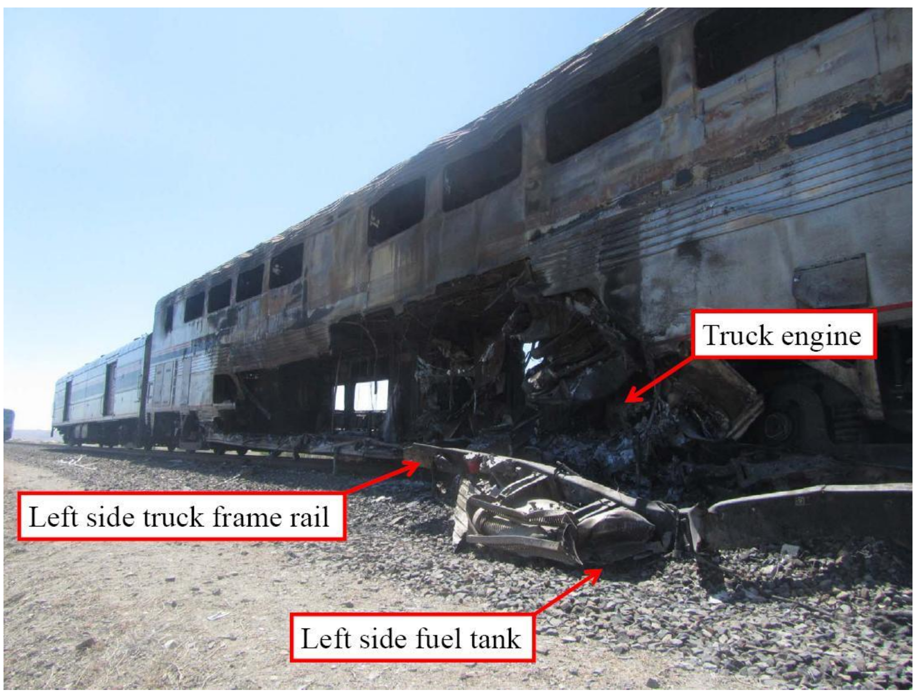

Figure 12. Photograph of portion of damaged train, showing frame-rail elements and engine of accident truck embedded within and extending from side of crew sleeper railcar.

The first trailer in the combination unit came to rest near the southwest corner of the grade crossing. The second trailer came to rest south of the grade crossing, across both lanes of US 95. (See figure 13.) The first trailer sustained impact damage at its left front corner in the area of its hydraulic side-dump motor and fittings, and at its front underside in the area of its fifth wheel attachment.[17] The fifth wheel from the truck remained attached to the underside of the first trailer but torn away from the truck frame rails. Material from the left top corner of the accident truck (interior and exterior roof) was found embedded along the left front corner of the first trailer. Fire damage and black soot were present along the left side of the first trailer. The front side of the second trailer was also damaged, with its drawbar attachment rails to the first trailer torn off. The second trailer showed no fire damage. All trailer axles remained attached to the trailers.

Figure 13. Photograph showing grade crossing, at-rest location of side-dump trailers (located at center and right), and fourth axle of accident truck (left foreground). (Courtesy of Nevada Highway Patrol)

1.6 Driver Factors

1.6.1 Background

The accident driver was 43 years old and held a current Nevada class A commercial driver's license (CDL) with endorsements for tank vehicles and double/triple trailers. His CDL was valid until October 2013. His medical certificate was valid for 2 years and would have expired on August 8, 2011.

The driver was hired by John Davis Trucking Company, Inc., on February 14, 2011. He typically worked Monday through Friday, making the 472-mile round trip daily from the John Davis facility in Golconda to the Esmeralda mine near Hawthorne. His shift was 11–12 hours

[17] The fifth wheel is the coupling between a truck-tractor and a trailer.

long and began about 2:30 a.m. During his regular runs between Golconda and Hawthorne, the driver typically spent 10–11 hours driving, with short intervals of on-duty/not-driving periods at the beginning and end of his shift, and when at the mine.

During the week, the driver lived in a recreational vehicle across the street from his reporting location; and on the weekends, he drove or took the train to Reno, where his girlfriend lived. According to the driver's girlfriend, his normal sleep pattern on work nights was to go to bed by 5:00 p.m. and awaken at 2:00 a.m. She stated that she would phone to wake him every morning at 2:00 a.m. Records from the driver's cell phones indicated that he did not use the phones from approximately 6:30 p.m. to 2:00 a.m. during the 3 days before the accident. The driver's girlfriend stated that on Saturdays, he would generally go to bed around 9:00 p.m. and awaken at 10:00 a.m. On Sunday nights, he would try to be in bed no later than 5:00 or 6:00 p.m. so he would be rested for his workweek.

In the 2 weeks preceding the accident, the driver had worked 6 days (June 13–18) followed by 2 days off. The day of the accident—Friday June 24—was his fourth day on duty. On June 21, 22, and 23, the driver had begun his duty day at 2:30 a.m. and ended between 1:45 and 2:45 p.m. On the day of the accident, according to a coworker, the driver arrived at work at 2:30 a.m.

The driver's recent work/activity history was reconstructed using information from his logbooks for the days preceding the accident, from mine logs, from his cell phone records, and from interviews with his supervisor and his girlfriend. Figure 14 summarizes the driver's activities on the day of the accident and for the 3 preceding days.

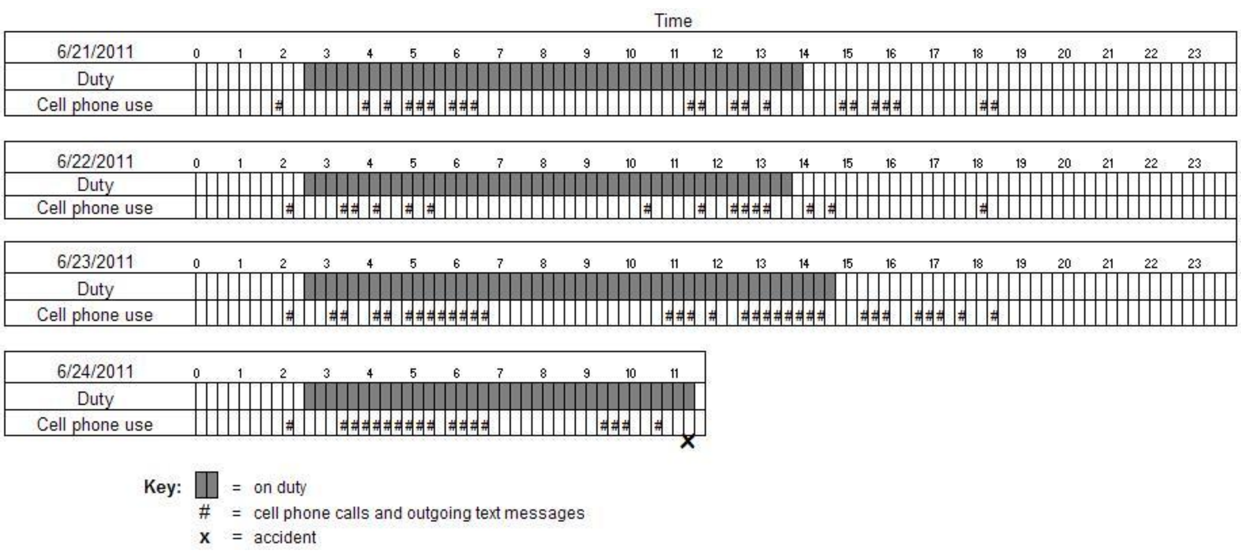

Figure 14. Summary of accident driver's duty schedule leading up to accident.

1.6.2 Driver Activities Prior to Accident

The driver had two cell phones.[18] A review of cell phone records from June 21 to 24 revealed that the driver routinely used his phones during periods when his logbook states he was driving. In addition to making and receiving voice calls during driving periods, the driver also used his phones to send text messages and to access the Internet. On the morning of the accident, cell phone records indicate that the driver's last known use of his phones was an outgoing call made at 10:32 a.m. At 11:17:28 a.m., 2 minutes prior to the accident, an incoming call placed to the driver's phone was routed to voicemail.[19] Investigators contacted the individual who placed this call and learned that it was another John Davis Trucking driver—who had the shift that started at 2:15 a.m., immediately preceding the accident driver's shift—and he was ahead on the route when he placed the call. According to that driver, he was traveling eastbound on I-80, approximately 5 miles east of the I-80–US 95 intersection, when he noticed the westbound Amtrak train and decided to notify his coworker of its approach. He said that the phone rang four or five times before going to voicemail and that it was unusual for the accident driver not to answer the phone.

1.6.3 Driver Toxicology

Postmortem blood, brain, kidney, liver, lung, muscle, and vitreous specimens from the accident driver were sent to the Federal Aviation Administration (FAA) Civil Aerospace Medical Institute forensic toxicology laboratory for analysis, where they were received on June 29, 2011. The vitreous sample was tested for alcohol, and the liver was tested for nine classes of drugs.[20] The results of all tests were negative.

1.6.4 Driver Fitness

The accident driver underwent a commercial driver fitness exam with a physician on August 6, 2009. At the time of the exam, he was 68 inches tall and weighed 216 pounds, with a body mass index (BMI) of 32.8.[21] In the health history section of the driver's 2009 medical exam report, "no" was checked for all listed conditions with the exception of "Any illness or injury in the last 5 years," for which both the "yes" and "no" boxes were checked. In the comment line was written, "Recent fracture left hand—good recovery." The section on medication usage was left blank. The driver was listed as having corrected visual acuity of 20/25 in the right eye, the

[18] Because of the extent of destruction of the truck cab, the NTSB could not determine from the wreckage whether the driver had been in possession of any other potentially distracting electronic devices, such as a computer, tablet, or portable music player.

[19] According to the cellular service provider, it uses a GPS developed by the US Department of Defense that references a master clock at the US Naval Observatory for mobile synchronization of phones. The GPS receivers at cell sites ensure that the time on customer phones is accurate to 10 microseconds.

[20] The tested drugs included amphetamines, opiates, marihuana, cocaine, phencyclidine, benzodiazepines, barbiturates, antidepressants, and antihistamines.

[21] The US Centers for Disease Control and Prevention classifies a BMI of 30 or greater as obese. See http://www.cdc.gov/healthyweight/assessing/bmi/adult_bmi/index.html, accessed October 17, 2012.

left eye, and both eyes combined.[22] The driver's horizontal field of vision was recorded as 90 degrees in both the right eye and the left eye. The form indicated that the driver could distinguish between red, green, and amber colors; that he did not have monocular vision; and that he met the visual acuity requirement only when wearing corrective lenses.

The medical certificate signed by the medical examiner indicated that the driver was qualified to drive a commercial motor vehicle (CMV) provided that he wore corrective lenses. The medical examiner recorded no abnormalities except for the driver's eyes, for which he noted "amblyopia"—a condition that the examiner appeared to discount due to the uniform visual acuity and visual field in both eyes.[23,24] The driver received a 2-year certificate, which was set to expire in August 2011. According to the driver's girlfriend, he routinely wore glasses while driving. The driver's glasses were not found at the scene; however, a coworker reported seeing the driver wearing his glasses on the morning of the accident.

The driver's medical records indicated that approximately 2 months after he received his 2009 medical certificate, he was seen at a clinic for a workplace back injury that occurred during his employment with Western Express.[25] From October 2009 to January 2011, the driver made at least 16 additional visits to doctors for treatment relating to his back injury. He had two back surgeries (in April and November 2010) and two selective nerve root block procedures (in August and September 2010). During this 17-month period, with the exception of a brief time of restricted duty that did not involve driving, he did not work due to his injury.

In February 2011, the driver was deemed by the Tennessee Workers' Compensation Program to have achieved "maximum medical improvement."[26] He underwent a "functional capacity evaluation" (FCE), which is a set of physical tests designed to assess his ability to return to work as a truck driver. The FCE results stated that due to restrictions in his lifting ability and his posture, he was "not able to perform the essential job functions in a full duty capacity." He was terminated from his job at Western Express on February 11, 2011, because of his inability to meet the company's physical standards for a truck driver. As of February 2011, his medical records document him as experiencing pain when moving or lifting.

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[22] The driver's vision was screened by the Nevada Department of Motor Vehicles (DMV) in 2009 when he renewed his license. According to Nevada DMV records, his uncorrected vision was 20/40 in his left eye, his right eye, and both eyes, which is Nevada's threshold for full driving privileges.

[23] According to the National Institutes of Health (http://www.nei.nih.gov/health/amblyopia/factsaboutamblyopia.pdf), amblyopia is "a condition resulting in poor vision in an otherwise healthy eye due to unequal or abnormal visual input while the brain is developing in infancy and childhood."

[24] A 1991 Federal Highway Administration (FHWA) report, *Visual Disorders and Commercial Drivers* (FHWA-MC-92-003), states that if visual acuity and visual field standards are met, conditions such as amblyopia probably need not be reported and do not necessarily disqualify a driver from operating a CMV. The accident driver's 2009 fitness examination results indicate that he met all visual standards when wearing corrective lenses.

[25] The company is headquartered in Nashville, Tennessee, with service centers throughout the country.

[26] According to the Tennessee Workers' Compensation Program (which managed the driver's workers' compensation claim), maximum medical improvement is defined as: "The highest degree of recovery that the treating physician believes will ever be reached from the compensable injury. In some instances, maximum medical improvement will be reached because the injury has fully healed; in other cases, maximum medical improvement will be reached because the physician has determined that no further improvement can be expected." See http://treasury.tn.gov/wc/Glossary.html, accessed August 15, 2012.

According to the director of safety and the vice president of Western Express, though the driver was terminated in February 2011 due to his "medical disqualification," he continued to be on the payroll through April 2011.[27] Western Express said that it had no record of a request for "verification of employment" of the accident driver.[28] When asked what they would have told a company seeking verification of employment, they stated that they would not have shared information about his medical issues or indicated his "medical disqualification" termination. If a potential employer had called in February 2011, the vice president stated that they likely would have reported the driver as being "still employed but not actively working."

Hospital records from the Humboldt General Hospital in Winnemucca, Nevada, indicate that in May 2011, the driver visited the emergency department with a complaint of ankle pain. He was diagnosed as having Achilles tendonitis and was prescribed a "Bledsoe type" boot,[29] was referred to an orthopedic specialist, and was instructed to stop work for 1 week. A cousin of the driver reported that he had complained to him about the ankle pain. The cousin remarked that the driver was concerned that he would be fired if he took time off to care for his ankle. The driver's sister also indicated that he was having problems with his Achilles tendon. He had told her that he had a brace but could not wear it while driving. She said that she saw ankle braces in his camper when she cleaned it out after the accident. An individual who spoke with the driver's girlfriend the day after the accident reported to the NHP that she told him the driver had been experiencing severe pain in his right Achilles tendon and she [the girlfriend] wondered if that had been the cause of the accident.

Cell phone records indicate that the accident driver called four orthopedic clinics in the 3 hours prior to the accident. NTSB staff followed up with each of the clinics, and staff from one of the clinics reported receiving a call from the driver on the morning of the accident. The clinic employee reported that the driver had requested an appointment for Monday, July 5, but was told he could not be seen until July 14, and he accepted that appointment.

1.6.5 Driver Employment History

According to his employment application for John Davis Trucking, the accident driver had 8 years of experience driving "van semis"[30] and 1 year driving "flatbed semis." In addition to working for Western Express, the driver listed nine other jobs in the past 10 years, with seven of those jobs as a CMV driver. Interviews with former employers and coworkers—as well as examination of job applications from previous employers, documentation from work injury reports, and third-party background checks—indicate that the driver had as many as 30 different jobs from 2002 to 2011, most of which were not listed on his application to John Davis Trucking. During this 10-year period, the NTSB found that the driver had driven CMVs for at least 13 employers and might have driven for nine additional employers as well. Evidence

[27] The driver was paid for several weeks following his termination while his workers' compensation payout was determined.

[28] The company tracks such requests and stated that any inquiry about the driver would have been documented in his file.

[29] A "Bledsoe type" boot is a foot-to-knee length rigid brace that fits around the leg.

[30] "Semis" refers to semitrailers.

indicated that the accident driver mischaracterized his departure from two jobs on his application, stating that he had been laid off rather than fired for his involvement in traffic accidents.

1.6.6 Violation and Accident History

John Davis Trucking employed a contractor to conduct a background check on the accident driver in February 2011. The contractor's report listed three speeding convictions and two seat-belt nonuse convictions from 2008 to 2009. Nevada DMV records provided by the NHP indicated that since 1992, the driver had 10 speeding citations, two seat-belt nonuse violations, four failure to maintain liability insurance violations, two inattentive driving violations, one driving with suspended license violation, and one improper lane/location violation. Additionally, since 1995, the driver's license had been suspended or revoked 14 times.

According to a Motor Carrier Management Information System (MCMIS) report,[31] the driver was involved in a collision on July 20, 2007, while driving a tractor/semitrailer. The collision resulted in three injuries and was reported to the NHP. Additionally, DMV records provided by the NHP indicated that the driver had an accident on July 25, 2006. On a job application for a previous employer, the driver self-reported involvement in a traffic accident in February 2006. Also, a former employer stated during a background check that in April 2005, the driver had backed into a stationary object while driving a truck.

1.6.7 Commercial Driver Licensing and Oversight

A driver-applicant must include specific information when submitting an application to a prospective motor carrier, as required by 49 CFR 391.21, including:

- All employers for the previous 3 years
- Motor carrier employment for the past 10 years, per 49 CFR 383.35
- A signed waiver that allows the prospective employer access to the applicant's driving and employment history.

The driver-applicant must sign the application, indicating that the information is true and complete. The motor carrier may require additional information and is required to make certain inquires of the driver-applicant's previous records, including driving history for the most recent 3 years, as specified in 49 CFR 391.23. Driver disqualification criteria found in 49 CFR 383.51 include disqualification for traffic violations that occur either in the CDL holder's private vehicle or when operating a CMV.

There are three national sources of driver records—two for drivers who hold a CDL and one for drivers who hold noncommercial licenses. The Commercial Driver's License Information

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

System (CDLIS) is the Federal Motor Carrier Safety Administration (FMCSA) system for drivers who hold a CDL. It is a central site that holds basic identification information about each commercial driver, such as date of birth, Social Security number, state driver license number, alias information, and current state of record. CDLIS is a records retrieval system—not a complete database of historical records—in that, when an inquiry is made, it "points" to the state of record and obtains the driver history, which is then relayed to the person making the inquiry. Access is limited to authorized federal and state entities. With the driver's written permission, carriers may also access this information via the state of licensure.

In April 2010, the FMCSA launched the Pre-employment Screening Program (PSP) to give motor carriers access to MCMIS data to assess an individual driver's crash and serious safety violation inspection history; however, use of the program is voluntary and only for preemployment assessment of driver applicants.[32] The available data (after a carrier registers with the FMCSA and has the applicant's written consent) consist of driver-applicant records for the most recent 5 years of crash data and the most recent 3 years of roadside inspection data (traffic violation records are excluded). The PSP contains only MCMIS roadside inspection and crash information collected by FMCSA staff and state partners; it does not provide a driver's record from a state DMV or state suspensions not related to safety.

The National Highway Traffic Safety Administration (NHTSA) National Driver Register (NDR) is a nationwide records retrieval system containing information provided by state DMVs on noncommercial drivers who have had their licenses revoked or suspended or who have been convicted of serious traffic violations, such as driving while impaired by drugs or alcohol. With any application for a noncommercial driver's license, the state checks to see whether that person has been reported to the NDR as a problem driver via the Problem Driver Pointer System.[33] If that is the case, the individual's license may be denied. A request for an NDR record by a motor carrier or other prospective employer must be initiated through the local DMV. The form must be submitted to the state in which the employee or driver applicant is licensed. The NDR discloses any information reported by the states during the past 3 years, subject to individual state release of information rules.

1.6.8 Retention of Commercial Driver License-Holder Records

State DMVs are the primary repository for a driver's records. Traffic violations, convictions, suspensions, revocations, and accidents are all reported to the state of license issuance. The Driver's Privacy Protection Act (18 *United States Code* [U.S.C.] 2721–2725) and each state control the amount of time that DMVs retain this information and to whom it may be released. Although state DMVs may have records for the past 15–20 years, released driver histories are usually limited to a much narrower time frame.

The length of time states retain commercial driver records varies. The Motor Carrier Safety Improvement Act of 2005 (MCSIA) states that the minimum time a conviction or withdrawal must be retained from the date of CDL or CDL-related convictions is as follows:

[32] For more information, see http://www.psp.fmcsa.dot.gov/Pages/FAQ.aspx, accessed August 27, 2012.

[33] For more information, see http://www.nationaldriverregister.com, accessed August 27, 2012.

55 years for a major conviction, 4 years for a serious violation, 4 years for a grade crossing conviction, 15 years for an out-of-service (OOS) conviction, and 3 years for all other convictions.[34]

1.7 Motor Carrier Factors

John Davis Trucking Company, Inc., is an intrastate commercial carrier that provides hauling services to mines and processing plants located in northern and central Nevada. John Davis Trucking was formerly an interstate operation and still retains its interstate operating authority and US Department of Transportation (USDOT) number. However, as an intrastate carrier, it is subject to Nevada regulations, not federal regulations.[35] The company's main office is located in Battle Mountain, Nevada, and it has satellite terminals in Golconda and Carlin. According to John Davis officials, the company employs 140 full-time drivers, 30 mechanics, and 30 support personnel. The company has 75 truck-tractors and 175 trailers. It operates 24 hours per day, 7 days per week.

Vehicles used for mining operations consist of a truck-tractor and two trailers. This configuration results in vehicles that are about 105 feet long. When loaded with product, vehicle weight is typically about 129,000 pounds, according to company officials. Because the length and gross weight of the vehicles when fully loaded exceed the state maximum limits of 70 feet and 80,000 pounds, each vehicle requires a special permit. Permits are issued by the Motor Carrier Unit of the Nevada DMV. The company acquired 53 such permits, which are interchangeable from vehicle to vehicle.[36] Vehicles are not equipped with GPS devices, electronic messaging systems, or onboard recording devices for monitoring driver hours of service.

John Davis Trucking operations are divided between the transport of gold ore and barite. About 45 vehicles are used for the "gold ore division" and 25 vehicles for the "barite division." The accident driver had been assigned to the Golconda terminal, which transported only gold ore.

1.7.1 Cell Phone Policy

John Davis Trucking provides each driver with its *Employee Policies and Procedures* (explaining company policy) and *Safety Program Manual* (detailing safety requirements). The cell phone policy for John Davis Trucking states:

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[34] Section 384.225, MCSIA, Public Law (P.L.) 106-159. Also see 49 CFR 383.51 for retention of CDL holder records documenting disqualifying offenses.

[35] Nevada has adopted the FMCSRs in the *Nevada Administrative Code*, sections 706.247, 706.297, and 459.977, for consistency and uniformity of enforcement between interstate and intrastate carriers. Nevada adopted the following FMCSRs that apply to the accident carrier: part 383, CDL requirements; part 387, Insurance requirements; parts 390–397, Operational requirements (company and vehicle); and Appendix G to part 396, Vehicle inspection criteria.

[36] Not all vehicles in the fleet exceed state limits. Some vehicles may consist only of tractor and semitrailer when in operation. Some combination vehicles that do exceed state limits are held in reserve in case another vehicle develops mechanical problems.

> When you are on duty, you may find it necessary to use different communication systems. Most common will be the CB or cellular phones. You are being asked to use these devices only when necessary and for JDT/3D business only, unless there is an emergency. In regard to cellular phones, it is best that you stop the vehicle to talk, but that is not always possible, therefore keep conversations short and discuss only those items that pertain to your duties at JDT/3D. The above applies to JDT/3D phones or your own private phone. When you are driving a 100-foot-long vehicle, your full attention is to be on the road—not on the phone.

The driver's supervisor reported that the accident driver regularly carried his cell phones with him and showed investigators that he had both of the driver's cell phone numbers stored in his own cell phone. The supervisor stated that he used cell phones and the CB radio as a means of communicating with drivers.

In January 2012, the FMCSA published new regulations prohibiting interstate commercial drivers from unsafely reaching for, holding, or pressing multiple buttons on a cell phone while driving.[37] In addition, as of January 1, 2012, it is illegal for any driver in Nevada to text, access the Internet, or use a hand-held cell phone while driving. It is still legal to use a hands-free headset to make calls or to touch a cell phone to "activate, deactivate or initiate a feature or function on the device."[38]

1.7.2 Inspection and Maintenance Program

According to documents obtained from John Davis Trucking, the company has a general maintenance schedule, where vehicles are serviced every 15,000 miles. In addition, a preventative maintenance service—consisting of an inspection of all operating systems, including lights, steering, tires, air pressure, and brakes—is completed every 7–14 days.

The NTSB requested the annual and recurring inspection and maintenance records for the accident truck-tractor and attached trailers. Annual inspections were done at the Kenworth sales facility in Elko, Nevada.[39] Records indicated that the accident truck and both trailers were last inspected, and passed inspection, on June 9, 2010, just over 1 year prior to the accident. No items were checked in the "needs repair" column on the forms, which also indicated that the inspection met the qualification requirements of the FMCSRs, section 396.19. These inspections were valid at the time of the accident and were due to expire on June 30, 2011.[40]

Because John Davis Trucking retained its USDOT number despite its status as an intrastate operator, the carrier's roadside inspection and safety review information was recorded in the MCMIS database. These data are evaluated with the FMCSA Safety Measurement

[37] *Federal Register* (FR), vol. 76, no. 232 (December 2, 2011), p. 75470.

[38] See *Nevada Revised Statutes*, chapter 484B, section 165.

[39] According to John Davis Trucking, it conducts its own vehicle annual inspection in conformance with state and federal regulations.

[40] In accordance with 49 CFR 396.17, annual inspections are valid for 12 months commencing from the last day of the month in which the inspection was performed.

System,[41] and scores are recorded in the appropriate Behavior Analysis and Safety Improvement Category (BASIC). BASIC describes seven on-road safety performance categories (unsafe driving, fatigued driving, driver fitness, controlled substance, vehicle maintenance, cargo related, and crash indicators) used to determine the rank of a motor carrier relative to other carriers. Percentiles from 0 to 100 are determined by comparing the BASIC measurements of the carrier to the measurements of other carriers in the peer group. A percentile of 100 indicates the worst performance. The FMCSA has created "intervention" percentile thresholds for each BASIC category. The BASIC percentile scores allow the FMCSA to prioritize which carriers require a safety intervention and the type of intervention necessary. John Davis Trucking's BASIC scores were below the threshold for intervention in all seven on-road safety performance categories.

1.8 Vehicle Factors

The accident truck consisted of a 2008 Peterbilt truck-tractor in combination with two empty 2007 SmithCo side-dump trailers.[42] The truck-tractor was equipped with a Cummins ISX diesel engine and a Fuller manual transmission. Because of the extent of damage from the collision, the weight of the accident truck could not be established. According to the manufacturer's records, when built, the truck-tractor weighed 19,822 pounds, and the first and second trailers weighed 15,828 and 11,868 pounds, respectively. These values indicate that the combination unit weighed 47,518 pounds when new. An exemplar truck with nearly identical trailers weighed 49,550 pounds and was 104 feet 8 inches long.[43]

The Cummins ISX engine had the capability of capturing and storing within its engine control module (ECM) vehicle speed, engine rpm, brake circuit status, throttle percentage, and other associated data in the event of a sudden deceleration or hard brake event. The ECM was noticeably burned, crushed inward, and cracked open along one edge. It provided no data.

1.8.1 Vehicle Components

According to maintenance records, the air conditioning system in the accident truck was reported as not working in the days prior to the accident, and service was pending. A panel for the heating and air conditioning controls was found with the air flow volume and direction dials broken off. The third dial was for selecting air temperature, and it was found turned to the left, for cold air. Very little window glass was left in the driver side door to determine the position of the window. The passenger side door appeared to have a section of glass located in the rearward edge window seal, toward the bottom of the door.

The accident truck was equipped with two side-mounted diesel fuel tanks with a capacity of 110 gallons each. The left side fuel tank was found torn open and crushed, but still attached to

[41] The Safety Measurement System has replaced SafeStat in the new Compliance, Safety, Accountability program. It quantifies the on-road safety performance of carriers and drivers to determine their specific safety problems, to monitor whether safety issues are improving or worsening, and to identify candidates for interventions.

[42] The same combination of vehicles and trailers remains in place unless repairs are necessary.

[43] The fluids and equipment placed on the exemplar vehicle by John Davis Trucking account for the differences in weight—47,518 pounds new and 49,550 pounds for the exemplar vehicle.

the frame rail, which was hanging out of the crew sleeper railcar. Melted remains of the right side fuel tank were found inside the railcar, along the frame rail, and against the far wall from where the accident truck entered. Portions of the fuel tanks were also found among the debris fields.

The accident truck refueled prior to departing Golconda, Nevada, on the morning of the accident. The truck was driven approximately 240 miles to the Esmeralda mine and another 132 miles from the mine to the accident location. Having traveled 372 miles at a fuel consumption rate of approximately 3.17 miles per gallon,[44] the accident truck would have consumed about 117 gallons of diesel fuel during the precrash trip. The remaining fuel at the time of the accident, about 100 gallons, would have been just under one-half of the truck's overall fuel capacity.

The steering wheel was located in the wreckage, severely deformed but still attached to the top of the steering column through a universal joint. The TRW-built steering gear and attached pitman arm were shipped to TRW for internal examination. According to the report prepared by TRW, damage to the steering gear indicated that the front wheels were positioned very nearly straight ahead when the collision occurred, and that the direction of impact was from the right front, forcing the front wheels to the left.

All tires and wheels were located. Tires not consumed by the fire had tread depths within the minimum tread depth regulation for commercial vehicle tires.[45] Additionally, all tires that remained inflated had a satisfactory level of inflation, based on Commercial Vehicle Safety Alliance (CVSA) OOS criteria.[46]

1.8.2 Vehicle Brakes

The accident truck and both trailers were equipped with air brakes. All nine axles were equipped with 16.5-inch drum brakes and 5.5-inch automatic slack adjusters. The second axle on the truck-tractor was a lift axle, which was up and not in use at the time of the accident.[47] Air brake system tanks and hoses from the accident truck were located throughout the debris, with

[44] According to Peterbilt, simulated fuel consumption rates for this model of truck and engine ranged from 4.7 to 7.2 mpg. According to calculations run by John Davis Trucking that are required for fuel tax accounting, the average fuel consumption rate of its trucks is 3.17 mpg. The difference in estimated and actual mpg is likely the result of heavy loads and mountainous terrain.

[45] According to 49 CFR 393.75, the minimum tread depth requirement for commercial vehicle tires is 4/32 inch for the steer axle and 2/32 inch for all other axles, measured in two adjacent tread grooves at any location on the tire.

[46] The CVSA North American OOS Criteria are a set of driver and vehicle requirements that have been determined by the CVSA—in conjunction with federal, state, and industry representatives—to constitute an imminent hazard and are applicable at both the federal (interstate) and state (intrastate) levels. Although the set of criteria has its origin in the FMCSRs, it also differs from them in some areas—in which case, it recognizes state regulations for citation purposes. Nevada has adopted the FMCSRs and in citing OOS violations, reference is made to the appropriate FMCSRs via the Nevada code. A finding of an OOS condition by a qualified inspector precludes further operation by the driver or of the vehicle, as appropriate, until the condition is corrected.

[47] A lift axle, or pusher axle, can be lowered to help distribute weight, and it can also be steered to increase maneuverability.

some components consumed by the postcrash fire. This circumstance prohibited complete testing of the air brake system for low air warnings or valve operations.

Commercial vehicle safety inspectors from the NHP attempted to obtain pushrod stroke measurements for the available brakes using approximately 120 pounds per square inch (psi) of compressed air from a tow truck. The first and second axle brakes were damaged and could not be measured. When the NHP inspectors attempted to supply air and actuate the brakes on the eighth axle, located on the second trailer, no pushrod movement was observed. No damage was noted in the area of this axle that would have caused the brakes to seize. This axle was not equipped with parking spring brakes, so air did not have to be supplied to first release the parking brakes; nevertheless, several attempts were made, including plumbing directly into the service brake chambers, and no pushrod stroke was observed. The NHP classified the brakes on this axle as inoperative.

Of the 12 remaining brakes where measurements could be taken, seven were found to be 0.25 inch or more out of adjustment. It is important to note that the pushrod stroke measurements were taken using compressed air at approximately 120 psi, whereas CVSA inspection guidelines specify that measurements be taken between 90 and 100 psi. It is the practice of NTSB investigators to perform their own measurements with strict observance of current guidelines; however, this action was not possible because a tow truck company at the scene "backed off" the slack adjusters on all axles after the NHP took its measurements.[48] As a result, the position of the slack adjusters was altered, precluding further measurement of pushrod stroke lengths.

Due to the absence of braking action on the eighth axle, in total, nine brakes would have been counted as defective according to CVSA OOS criteria—accounting for 56 percent of the 16 brakes in service on the combination unit at the time of the accident, well in excess of the allowable 20 percent needed to place the vehicle out of service for defective brakes.

Mismatched and incorrectly sized brake chambers were found on the first trailer, where the fifth through seventh axles of the combination vehicle were located. According to manufacturer specifications, this trailer should have been equipped with all type 24 brake chambers. However, the left brake chamber on the fifth axle and the right brake chamber on the seventh axle were found to be type 30. According to the FMCSRs, at 49 CFR 393.47(b), brake chambers on each end of an axle must be the same size. The mismatched brake chamber sizes would not, however, be considered out of service because the CVSA OOS criteria specify this condition as an OOS item only for front axle brakes.

As part of the postcrash inspection, all brake drums and brake shoes were located, identified, and examined. All brake pads were found to be within the minimum thickness established in federal regulations.[49] The inside diameter of all brake drums was measured, and 11 of the 16 brake drums in service were found to be worn beyond the limits established by the

[48] The term "backed off" refers to de-adjusting the slack adjusters by rotating their ratcheting mechanism, the adjustment hex, counterclockwise, causing the brake shoes to back off and away from the brake drums.

[49] Title 49 CFR 393.47(d), Lining and pads, specifies 1/4 inch for air-braked nonsteering axles or 3/16 inch for air-braked front steering axles.

brake drum manufacturer per 49 CFR 393.47(g). CVSA OOS criteria do not include brake drum wear.[50]

Title 49 CFR 393.55(c) requires that all air braked truck-tractors manufactured after March 1997, and all other commercial vehicles (such as trailers) manufactured after March 1998, be equipped with an antilock braking system (ABS). Because of the extent of damage and separation of the accident truck, the factory-equipped ABS units were not recovered in the wreckage and debris, and no testing or assessment was possible. When the trailer ABS was examined, NTSB investigators noticed that the wheel speed sensors were missing on the left side of the eighth axle and on both sides of the ninth axle.[51] The wires to the missing sensors were found to be cut and zip-tied around their respective axles. Additionally, the wires going into the required amber ABS malfunction lights located at the left rear corner of both trailers were found to be disconnected.[52] Missing or disconnected ABS components are violations but are not included in CVSA OOS criteria. Numerous ABS defects were also discovered among other John Davis Trucking vehicles during a postaccident sample fleet inspection. Because the dashboard in the truck-tractor was destroyed, investigators could not determine whether the ABS malfunction indicator had been operational.

In summary, the NHP identified nine of the 16 brakes on the accident truck as out of adjustment or inoperative. The NTSB found two axles with mismatched and incorrectly sized brake chambers, 11 brake drums worn beyond the specified limits, missing or disconnected ABS sensors on the eighth and ninth axles, and disconnected ABS malfunction indicator lights at the left rear of both trailers. Figure 15 illustrates the specific brake issues identified on the accident truck.

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[50] Brake drum wear is not a roadside inspection item because the wheel and brake drum must be removed to measure the inside diameter of the brake drum.

[51] A wheel speed sensor, attached to the inside of the wheel, reads rotational speed by counting the teeth of a ring that rotates with the wheel. Wheel speed sensor information is used by the ABS to sense when wheels are about to lock up, so that it can accurately modulate braking at each wheel.

[52] Title 49 CFR 393.55(d) requires ABS malfunction indicators to be installed on the left rear corner of all trailers after March 1998.

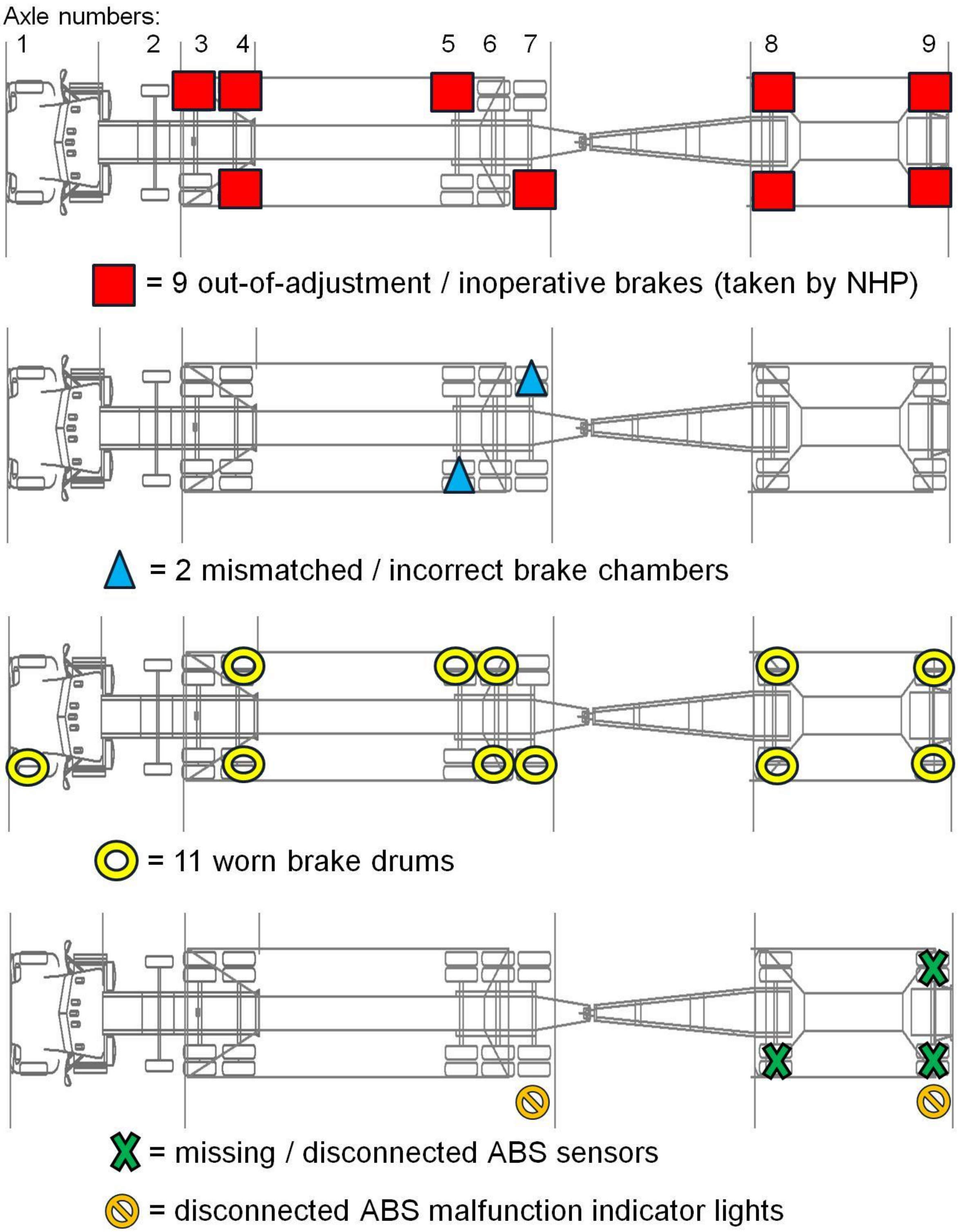

Figure 15. Depiction of brake issues identified on accident truck**.**

1.8.3 Vehicle Maintenance

According to 49 CFR 396.11 and 396.13, drivers are required to perform a pretrip and a posttrip inspection of their vehicles and complete a driver's vehicle inspection report (DVIR), noting when defects are found or repaired. When a defect is found, a driver notifies the mechanic at the terminal. John Davis Trucking indicated that minor repairs are completed immediately; a vehicle determined to be unsafe is not used, and a substitute vehicle is provided.

The company provided 6 months of maintenance records for the accident truck and both trailers. The DVIRs for the accident truck and trailers were also obtained for the 2 months prior to the accident.

These records indicated a variety of mechanical problems noted by drivers of the accident truck, such as a broken driver seat; lack of air conditioning; engine fan, radiator, and startup problems; high engine oil temperature; and nonfunctional lighting. The broken driver seat was first noted in the DVIRs on May 31, 2011. A work order dated June 9, 2011, indicated that the seat was replaced. Mention of the air conditioning system not working was first noted in the DVIRs on June 12, 2011. No corresponding maintenance records or repair work orders indicated that the air conditioning system was repaired.

According to maintenance records, the brakes on the accident truck had last been adjusted on June 18, 2011. Notes suggesting that the brakes had been adjusted appeared 22 times in the 6 months of records. The accident truck was equipped with automatic slack adjusters, which normally do not require manual adjustment unless a problem exists elsewhere in the foundation brakes. Manual adjustment may bring the brake back into compliance and improve the way it operates—but only temporarily. The records indicated routine manual adjustment of the brakes on the accident trailers. In 2006, the NTSB issued several recommendations on the manual adjustment of automatic slack adjusters as a result of a dump truck accident in Glen Rock, Pennsylvania, where two people were killed and three were injured.[53]

1.8.4 Vehicle Testing

Air brake timing and deceleration tests were conducted using the exemplar truck and trailers. The purpose of the air brake tests was to measure the time it took for compressed air from the braking system to travel to each axle of the combination unit and reach 60 psi in the brake chambers once the brake pedal was depressed. This time is also referred to as "brake response time." Six tests conducted with varying brake adjustment conditions yielded average brake response times of 0.462–0.564 second.

Deceleration tests of the exemplar combination unit were conducted at the accident location to measure the deceleration rate during an emergency brake application. Prior to the first deceleration test, the brakes were checked on the truck and trailers, and all were found to be within adjustment. The ABSs on the exemplar tractor and trailers were operational. The

[53] *Collision Between a Ford Dump Truck and Four Passenger Cars, Glen Rock, Pennsylvania, April 11, 2003,* Highway Accident Report NTSB/HAR-06/01 (Washington, DC: National Transportation Safety Board, 2006).

exemplar combination unit was then tested three times at speeds of 29.7 mph, 41.5 mph, and 43.0 mph. The tests yielded an average deceleration rate of 0.456 g.[54,55]

1.9 Train Operations

The accident train was a westbound intercity passenger train, assigned the operational designation "train no. 5" and the marketing designation "The California Zephyr." The train had departed Chicago, Illinois, on June 22, 2011, and was scheduled to reach Emeryville, California (near San Francisco), on June 24. The train crew had begun their shift at 7:10 a.m., relieving the previous crew at Winnemucca, Nevada, about 100 miles northeast of the accident site.

According to Union Pacific Railroad, the typical number of trains operating over the crossing in a 24-hour period was 18, including one eastbound and one westbound Amtrak train. The railroad consisted of one track at the grade crossing. Trains were operated in both directions on the track and were governed and authorized by signal indication. A dispatcher in Omaha, Nebraska, directed the train traffic by controlling the signals and switches that routed trains in and out of sidings. The accident train was operating on a green signal aspect, which meant that it was authorized to proceed to the next block signal at track speed. At the accident location, highway milepost 55.9, track speed was 79 mph for passenger trains and 70 mph for freight trains. The EDR showed that the train was traveling 77 mph when the collision occurred.

The 51-year-old locomotive engineer was the only Amtrak crewmember to witness the approach of the accident truck. He reported that he sounded the standard train horn sequence as he neared the grade crossing at US 95.[56] He saw a Union Pacific employee on the north side of the crossing and waved. The engineer stated that about halfway through the horn sequence, he noticed the truck approaching on the south side of the crossing. He estimated that he first noticed the truck when it was 225–300 feet from the crossing, "moving at a high rate of speed and the tires were smoking." The engineer stated that once he realized the train would be struck by the truck, he initiated a full service brake application in an effort to keep the train "stretched" and lessen the chance of a derailment from the side impact. He further stated that after the truck hit the train, he applied the emergency brakes to bring the train to a stop.

1.10 Signal Operations

The grade crossing signal system has two gates with aluminum/fiberglass arms, each about 18.5 feet long, as shown in figure 16. Each gate arm has 13 alternating red and white stripes, with each stripe measuring 16 inches wide per the *Manual on Uniform Traffic Control*

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[54] A unit of "g" describes acceleration and deceleration in relation to the gravitational constant of 32.2 feet per second^2 (ft/s^2). For example, when a vehicle is decelerating at a rate of 0.5 g, its speed is decreasing at a rate of 16.1 ft/s^2.

[55] Deceleration was measured simultaneously using two sources for each test, a Vericom VC2000 and a STALKER radar. The sources closely matched each other, within about 0.01 g. The 0.456 g value is the average of the three deceleration tests collected by the Vericom VC2000.

[56] The horn sequence for a crossing has four blasts. The first two blasts are long, the third is short, and the fourth is long and occurs while the locomotives are entering and occupying the crossing. The sequence starts 0.25 mile from the crossing.

Devices (MUTCD).[57] Each gate arm has three lights mounted along the top. The third light, or tip light, is constantly lit; when the grade crossing signal system is activated, the first two lights flash alternately.

Figure 16. Photograph of Miriam grade crossing, viewed from northbound side, with crossing gate arms in the descended position.

Each crossing gate arm is mounted on a mast, and each mast has a bell. There are also two cantilever signal masts with four 12-inch light-emitting diode (LED) flashers on each mast and four 12-inch LED flashers mounted above the highway—such that drivers approaching the grade crossing would see a total of eight 12-inch LED flashers. The inclusion of cantilever-mounted flashing lights exceeds the minimum MUTCD requirements. The crossing gate arms are attached to horizontal springs so that vehicles coming into contact with a lowered gate arm would cause it to rotate horizontally, thus minimizing damage to the gate. After contact, the gate arm returns to its original position and locks into place.

The train detection system consisted of a Safetran Microprocessor-Based Grade Crossing Predictor (GCP-3000)[58] with a Highway Crossing Analyzer (HCA) unit[59] housed in a bungalow about 108 feet southwest of the centerline of the roadway, where it intersects the grade crossing. The GCP-3000 termination shunts were located 4,636 feet in each direction from the grade

[57] The MUTCD contains national standards governing the installation and maintenance of traffic control devices on public streets, highways, bikeways, and private roads open to the public.

[58] The GCP-3000 is a microprocessor-controlled system that continually monitors the approaches to grade crossings. In operation, it may function either in the predictor or motion sensor modes. It detects approaching trains, computes train speed and distance, predicts train arrival time, and activates crossing-protection equipment at a set (programmed) time prior to the predicted arrival of the train.

[59] The HCA is a nonvital, general-purpose operational event recorder and analytic diagnostic tool. It features analog inputs, digital inputs/outputs, monitoring, timing, and reporting and communication capabilities.

crossing. The GCP-3000 monitored railroad traffic and controlled activation of the warning devices. The system was configured to provide a constant minimum warning time of 30 seconds for approaching trains before they occupy the crossing at any speed up to the maximum allowable speed.[60]

In general, when a train approaches the grade crossing, the following sequence of events occurs:

- The system detects the approach of the train once it enters the termination shunts.
- After factoring in speed, the GCP-3000 determines when to activate the grade crossing signal system to achieve 30 seconds of warning time.
- Within 1–2 seconds, the lights and bell begin to activate.
- After 3–4 seconds, the gate arms begin descending to the horizontal position; another 4–6 seconds is required for the gate arms to fully descend.
- No less than 30 seconds after system activation, the train enters the grade crossing.
- Once the entire train passes through the grade crossing, the gates begin to move to the vertical position (approximately 5–8 seconds).
- Once the gates are back in the full vertical position, the lights and bell deactivate.

The signal system bungalow was destroyed during the accident; however, a monthly signal test had been conducted at the grade crossing approximately 2 hours before the accident, with the Union Pacific signal maintainer reporting no issues with the system. The NTSB examined maintenance records for the grade crossing and found that in the 6 months prior to the accident (January 1–June 24, 2011), two "trouble tickets" had been submitted. The first one was submitted on January 12, 2011, reporting an unsecured light hanging from the gate arm. The light was resecured to the gate. The second ticket was submitted on February 24, 2011, reporting a power failure that kept the strobe light activated. Both problems were rectified within a day of being reported.

Postaccident inspection of the grade crossing signal system equipment and junction boxes showed no indications of tampering or vandalism that would have interfered with operation of the system. Because the signal bungalow was extensively damaged, investigators were unable to retrieve any signal data from the GCP-3000 unit or the HCA unit. NTSB investigators observed damage on the tip of the crossing gate arm in the northbound lane of US 95; the horizontal rest position of the gate arm was found to be rotated approximately 8 degrees clockwise from its normal position. (See figure 17.) In addition, the middle of the three lights mounted on top of the gate arm was found to be detached and hanging by its power cord, as shown in figure 18.

[60] The actual warning time may vary by plus or minus 3 seconds.

Figure 17. Photograph showing damage to tip of crossing gate arm in northbound lane of US 95. (Courtesy of Nevada Highway Patrol)

Figure 18. Photograph showing detached center light of crossing gate arm hanging from its power cord and fourth axle from accident truck at bottom left. (Courtesy of Nevada Highway Patrol)

NTSB investigators extracted a still image from the video captured by the lead locomotive's front-mounted camera. Figure 19 shows the image taken at 11:19:24 a.m. with the crossing gate arms in the descended position in the northbound and southbound lanes of US 95 about 1 second prior to arrival of the lead locomotive. Witness statements also indicate that the grade crossing flashing lights on the northbound side of US 95 were operational.

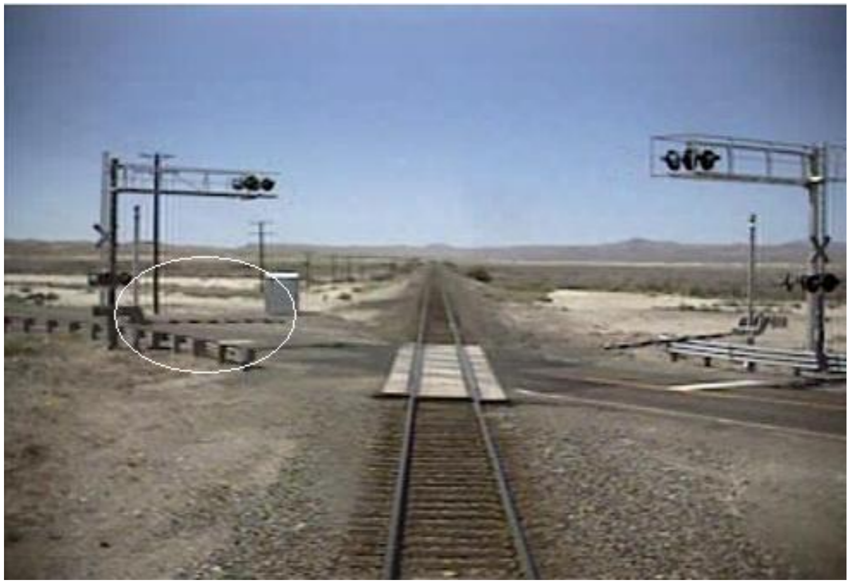

Figure 19. Video frame capture from Amtrak train no. 5 at 11:19:24 a.m., about 4 seconds prior to accident truck collision, showing crossing gate arms in descended position on northbound (circled) and southbound sides of US 95. At point of image capture, accident truck is approaching grade crossing but outside video camera field of view.

1.11 Highway Factors

1.11.1 Roadway Characteristics

The accident occurred on US 95 at the Union Pacific grade crossing (US Department of Transportation [DOT] crossing number 740765S) at highway milepost 55.9. Figure 19 illustrates the general horizontal alignment of US 95 and the railroad track in the vicinity of the accident. The posted speed limit for northbound US 95 in this area was 70 mph.

US 95 is a two-lane undivided state highway. The travel lanes are 12 feet wide and bounded by 2-foot-wide paved shoulders. The travel lane pavement markings consist of centerline markings separating the northbound and southbound lanes and 6-inch-wide edge lines separating the travel lanes from the shoulder. Grooved rumble strips are in place along the centerline of US 95 immediately north and south of the grade crossing. The rumble strips are approximately 7 inches wide and 12 inches long, with 12-inch gaps.

The horizontal curvature on the northbound approach of US 95 prior to the grade crossing advance warning sign has a radius of 3,000 feet and turns to the left in the direction of travel. Figure 20 depicts the horizontal curve and the final rest of the Amtrak passenger train, approximately 2,140 feet west of the impact area. The grade crossing and US 95 form a skew angle of approximately 139 degrees. The vertical grade on the northbound approach of US 95 prior to the grade crossing consists of a +0.35 (percent) slope. The vertical grade on the crossing is level.

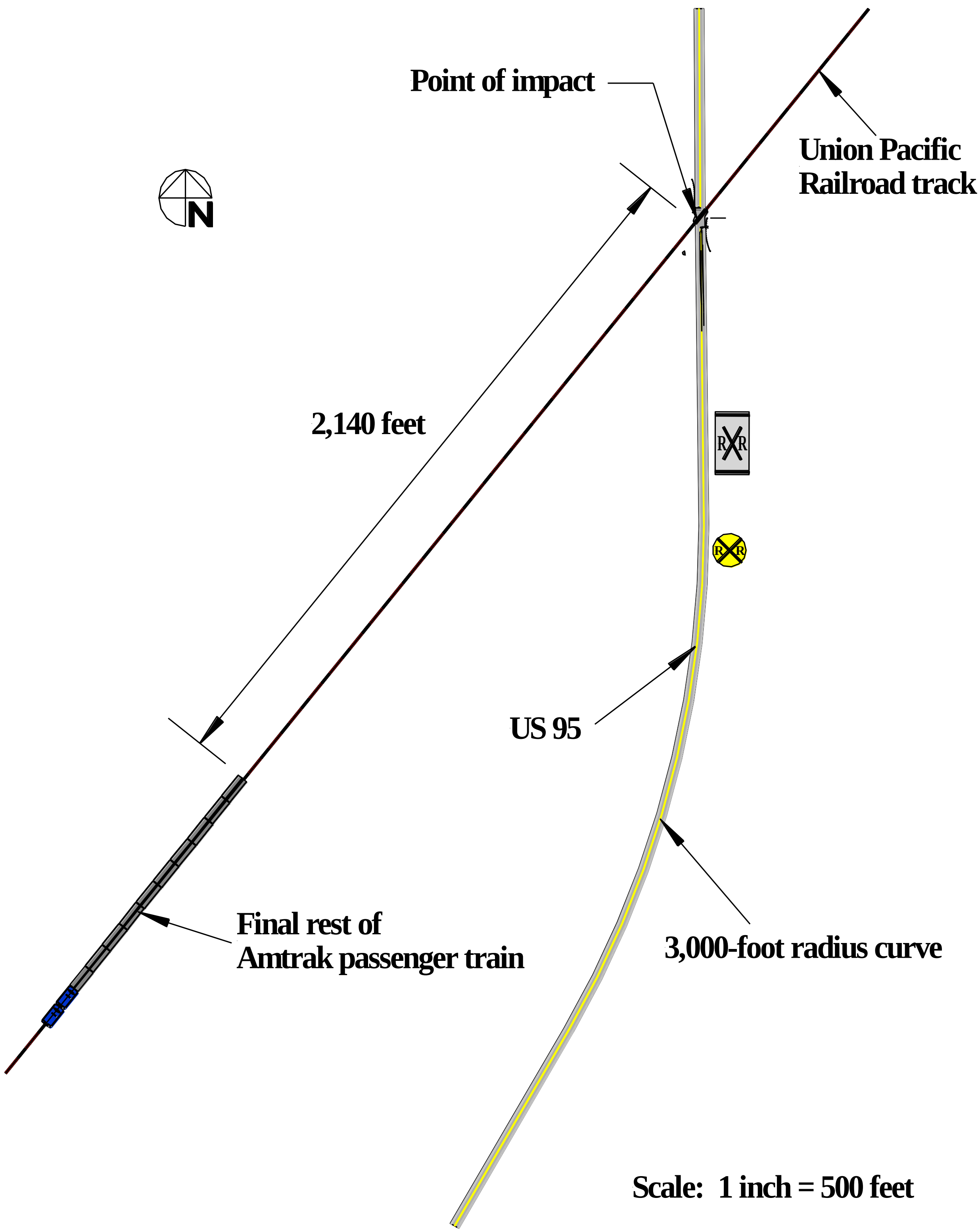

Figure 20. Diagram showing alignment of US 95 and Union Pacific Railroad track at accident location.

1.11.2 Rail-Related Traffic Control Devices

An advance warning sign was located approximately 900 feet from the grade crossing in the northbound lane of US 95.[61] (See figure 21.) A pavement marking was located about 760 feet in advance of the grade crossing in the northbound and southbound lanes. The 140-foot offset between the warning sign and pavement marking deviated from federal guidance for signal and marking placement.[62]

Figure 21. Photograph showing advance warning sign on right side of roadway, with pavement marking painted on northbound lane of US 95 about 140 feet beyond sign. (Tire marks in advance of pavement marking were determined not to have originated from accident truck.)

White stop lines were located approximately 11 feet from the crossing gate arm on the south side of the grade crossing and 8 feet from the gate arm on the north side of the crossing. The white stop lines were approximately 2 feet wide and 12 feet long. Apart from the offset deviation mentioned above, all other signals and markings were found to conform to applicable federal standards.

1.11.3 Physical Evidence

Figure 22 illustrates the tire marks originating in the northbound lane, with the longest marks attributed to the left wheels of the accident truck. The overall distance from the onset of left side tire marks to the point of impact was 349 feet. It was not possible to determine if the onset of the tire marks was deposited by the ninth axle tires or the fifth axle tires. The forward

[61] The point of measure for the grade crossing is where the highway centerline would intersect the closest rail of the railroad tracks.

[62] According to the 2009 MUTCD, the pavement marking should have been placed 900 feet ahead of the grade crossing, along with the advance warning sign.

end of the accident truck covered a preimpact braking distance of 247 feet if the tire marks were deposited by the ninth axle tires and 299 feet if deposited by the fifth axle tires. The onset of the right side tire marks appeared approximately 32 feet north of the onset of the left side tire marks. The onset of additional overlapping tire marks began 95–114 feet north on the left side and 110 feet farther north on the right side. Approximately 140 feet north of onset for the left side tire marks, marks consistent with a dual tire configuration were offset to the left and crossed the highway centerline into the opposing lane of travel. These marks continued northbound about 1 foot west of the highway centerline to a point several feet south of the railroad tracks. The right side tire marks terminated with a series of leftward “hooked” marks atop the stop line preceding the crossing gate arm.

1.11.4 Line-of-Sight Test of Flashing Signals

On June 28, 2011, NTSB investigators conducted line-of-sight tests of the flashing lights located on the post-mount and cantilevered overhead structure from the northbound travel lane of US 95 to determine whether the design or configuration of rail-related traffic control devices factored into the accident. To best simulate conditions at the time of the accident, the tests were conducted using an exemplar truck at approximately the same time of day.

To determine the initial point at which the accident driver would have been able to detect the flashing lights, the exemplar truck was moved approximately 9,000 feet south of the grade crossing and then incrementally forward toward the crossing. At each increment, a determination was made as to whether the flashing lights could be detected, and a photograph was taken in the direction of the flashing lights. Investigators could see the flashing light signals at approximately 2,430 feet from the grade crossing, well in advance of the advance warning sign and pavement markings. At this point, the grade crossing would be 21 degrees left of the driver’s forward view. Figure 23 illustrates the first point at which the flashing lights could have been visible to an approaching driver. As described in the analysis, given the approach speed of the accident truck, it was probably about 2,400 feet from the grade crossing when the flashing lights activated.

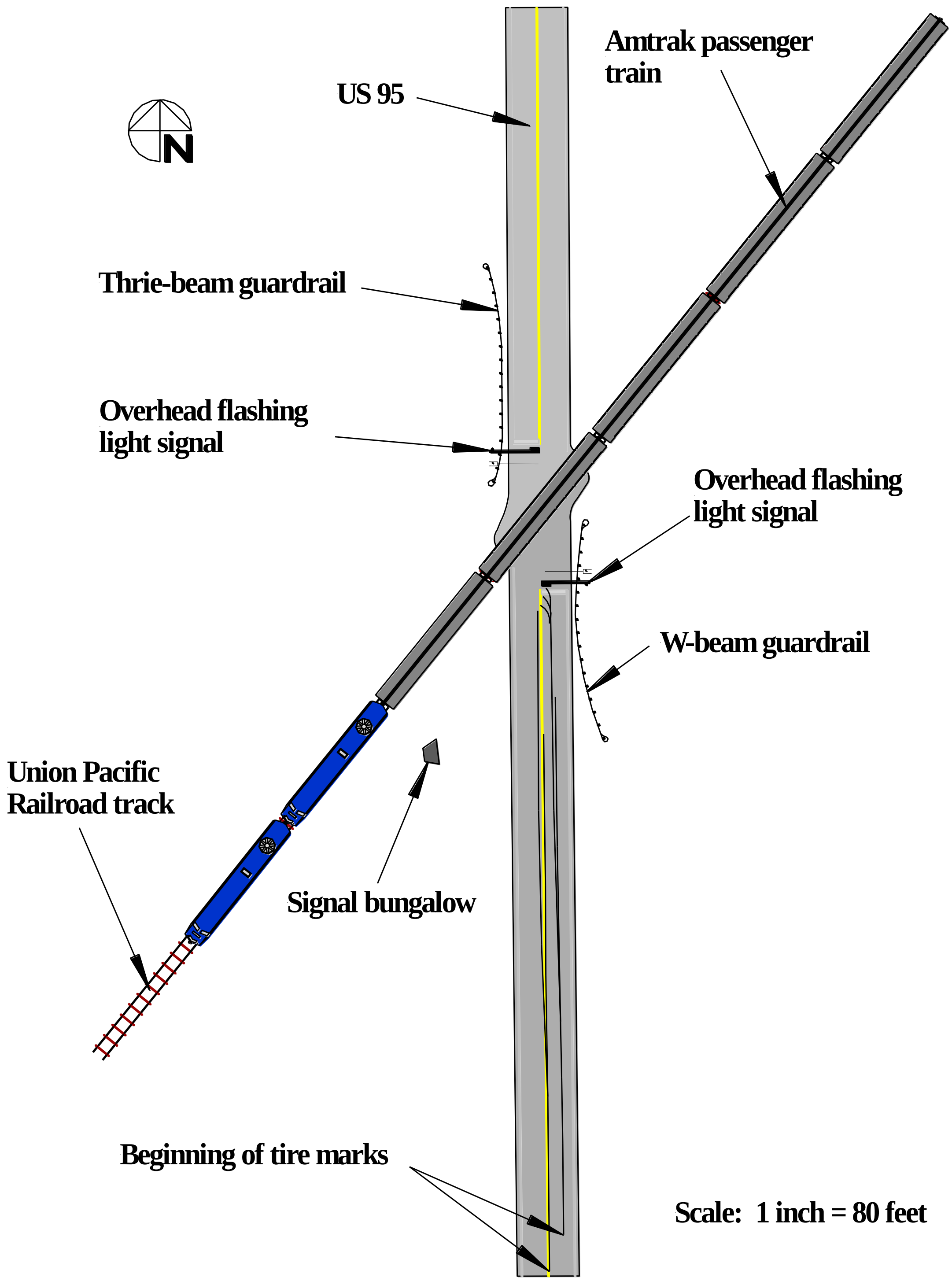

Figure 22. Diagram depicting tire marks left by accident truck in northbound lane of US 95.

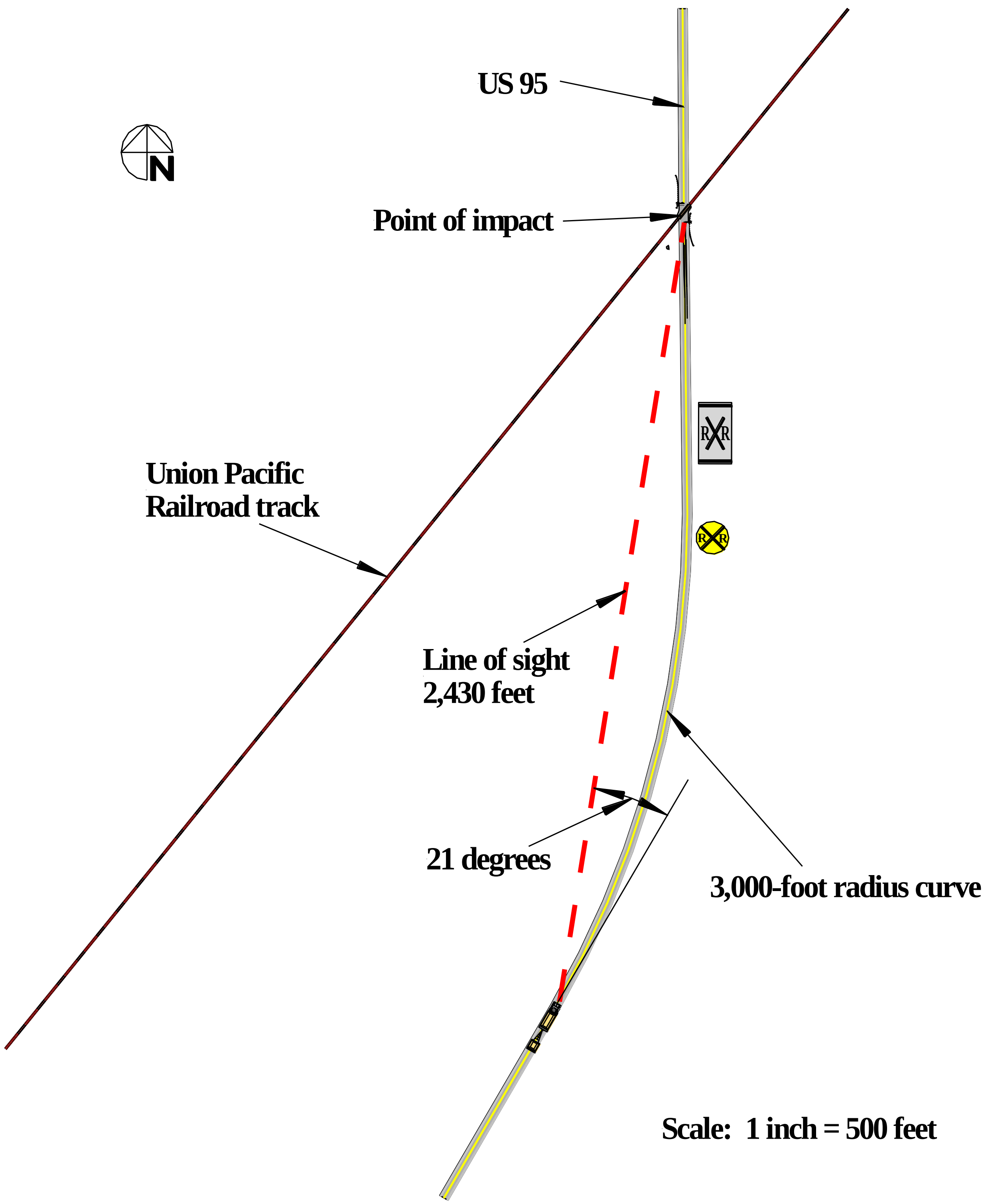

Figure 23. Diagram depicting initial point at which flashing warning lights located on post-mount and cantilevered overhead structure were visible from exemplar truck.

1.11.5 Nevada Grade Crossing Accidents

In 2010, the average annual daily traffic on US 95 was 940 vehicles. Trucks and buses accounted for 22 percent of northbound traffic and 28 percent of southbound traffic. The Nevada Department of Transportation (NDOT) conducted an 85th percentile speed study on US 95 in the vicinity of the accident location from September 13 to 20, 2011. Approximately 3,309 vehicles were recorded in the northbound lane and 2,884 vehicles in the southbound lane. The 85th percentile speed was 74 mph in the northbound lane and 76 mph in the southbound lane.

According to Nevada records, in the 5 years prior to this accident, there had been one other reported accident at this grade crossing, which occurred on September 14, 2010, and involved a 2005 Kenworth tractor pulling a flatbed trailer. The vehicle had been approaching the grade crossing on southbound US 95. The post-mounts supporting the overhead flashing light signal system and crossing gate arm were illuminated and activated at the time of the accident. The driver applied the brakes and steered to the right, penetrating a section of strong post blocked-out W-beam guardrail and striking one of the post-mounts. The vehicle came to a stop and did not strike the passing westbound train. No one was injured in the accident. Amtrak personnel have since related to the NTSB two other incidents—occurring on April 6, 2012, and June 27, 2012—involving commercial vehicles engaged in emergency braking on approach to this grade crossing.

In response to the September 2010 accident noted above, representatives from NDOT, Union Pacific Railroad, and the Federal Railroad Administration (FRA) conducted a diagnostic review of the grade crossing in November 2010. Among the improvements discussed were the placement of active advance warning signs (AAWS)[63] and grooved centerline rumble strips on the roadway. According to NDOT records, AAWSs had previously been installed at rural active crossings with characteristics similar to the Miriam crossing. However, NDOT indicated that AAWSs were dismissed for the Miriam location because it was determined that sight distance was not an issue. The centerline rumble strips were installed in March 2011 and were thus in place at the time of this accident (June 24, 2011).

NDOT conducted a second diagnostic review of the Miriam grade crossing in November 2011 and considered the following solutions:

- Installation of two AAWSs on both approaches to the crossing, possibly over the travel lane.
- Installation of an advisory sign showing the speed of vehicles when approaching the crossing.
- Addition of an oversized advance warning sign.
- Courses for local trucking companies to educate drivers on grade crossing safety.

[63] AAWSs typically consist of one or two 12-inch amber hazard identification beacons mounted above a grade crossing warning sign. The beacons are connected to the railroad track circuitry and activated on the approach of a train. An AAWS stays activated until the crossing signals are deactivated.

- Higher level of speed enforcement from the NHP.

- Installation of transverse rumble strips to determine if they are appropriate on high speed roadways.

Following the diagnostic review in November 2011, NDOT decided to install AAWSs cantilevered over the US 95 travel lanes in both directions prior to the grade crossing, as depicted in figure 24. Construction is scheduled to begin in early 2013. The AAWSs will consist of two 12-inch-diameter amber beacons, two grade crossing advance warning signs, and a sign centered over the travel lanes indicating "PREPARE TO STOP WHEN FLASHING."[64] The AAWS will be mounted to a mast arm cantilevered over the travel lanes. Each AAWS will be located in the vicinity of the pavement markings, approximately 760 feet in advance of the grade crossing in the northbound and southbound lanes. The project will also entail installing AAWSs that are cantilevered over the travel lanes at two other locations in Nevada—the US 93–South of Wells grade crossing (DOT 833523F) and the Montello Road grade crossing (DOT 740889K).

Figure 24. Depiction of proposed active advance warning sign to be constructed on approach to Miriam, Nevada, grade crossing.

In addition to upgrading the advance warning system at the Miriam grade crossing, NDOT is taking other postcrash actions related to grade crossing safety. NDOT is working to create a traffic control device standard for rural grade crossings with speed limits greater than 65 mph. The standard would include flashing lights and gates, cantilevered lights (all of which were in place at the US 95 grade crossing before the June 24, 2011, accident), and AAWSs cantilevered over the travel lanes in advance of the grade crossing.

[64] This sign will be located no lower than 18 feet 6 inches vertical distance from the roadway surface. The vertical distance is measured from the bottom edge of the sign to the actual travel lane surface.

NDOT is currently evaluating two hazard index formulas for prioritizing grade crossing improvements[65]—the crash frequency method and the crash severity method. Table 2 shows the ranking of the US 95 Miriam grade crossing using these two methods before and after the June 24, 2011, accident.

Table 2. Ranking of US 95 Miriam grade crossing using crash frequency and severity methods before and after June 24, 2011, accident.

Hazard Index Formula	Before June 24, 2011	After June 24, 2011
Crash frequency method	Ranks 39th of 277 grade crossings	Ranks 25th of 277 grade crossings
Crash severity method	Ranks 62nd of 277 grade crossings	Ranks 40th of 277 grade crossings

1.11.6 Grade Crossing Improvements

Aside from AAWSs and centerline rumble strips, a number of other technologies are being developed to reduce grade crossing-related incidents. Among these are radio signal-based technologies that transmit information between vehicles and the roadway infrastructure, and provide drivers with alerts via in-vehicle displays. Demonstration projects have shown the benefits of having real-time in-vehicle alerts to warn drivers of approaching trains.[66] Consistent with the vision of deploying a minimum level of infrastructure to provide a maximum level of safety and mobility benefits for highway safety and operational efficiency, concept-of-operations studies are underway to explore low-cost solutions using dedicated short-range communication (DSRC) to exchange status data between vehicles and grade crossings to provide drivers with real-time alerts for approaching trains.[67,68] For example, a vehicle to infrastructure (V2I) communications demonstration project sponsored by the New York State Department of Transportation would not only alert commercial vehicle drivers via an in-vehicle device, but also provide increasingly more urgent warnings if the driver does not appear to be slowing down soon enough to stop before the grade crossing.[69] Because the alert comes from an in-vehicle system, it is less likely that the signal will be masked by ambient noise or competing visual stimuli. If an

[65] A hazard index formula is any safety or crash prediction formula used to determine the relative likelihood of hazardous conditions at grade crossings, taking into consideration weighted factors and severity of crashes. See 23 CFR 924.3.

[66] *In-Vehicle Signing for School Buses at Railroad–Highway Grade Crossings: System Design Summary Report* (St. Paul, Minnesota: Minnesota Department of Transportation, August 1998).

[67] See http://www.its.dot.gov/research/v2i.htm, accessed October 23, 2012, for a summary of DOT research on connected vehicle applications.

[68] X. Zeng, K. Balke, and P. Songchitruksa, *Potential Connected Vehicle Applications to Enhance Mobility, Safety, and Environmental Security*, Report No. SWUTC/12/161103-1 (College Station, Texas: Texas Transportation Institute, February 2012).

[69] *Concept of Operations, C030588 CVII Task 10*, Document No. 6980-02941-01-21 (Albany, New York: New York State Department of Transportation, December 2011).

incident does occur, such as an accident or a vehicle breakdown on a grade crossing, V2I technology could also be used to transmit the location directly to emergency responders.[70]

1.11.7 Grade Crossing Action Plan

The DOT has developed two grade crossing action plans since 1994.[71] The goal of the 1994 plan was to reduce accidents and fatalities at grade crossings by 50 percent. This plan described 55 initiatives,[72] among which are increased enforcement; evaluation of new vehicle- and infrastructure-based technologies; continued use of educational media; evaluation and implementation of engineering-based improvements, grade separation, and closings; and continuous data collection and evaluation. From 1994 to 2002, the number of grade crossing fatalities decreased by 42 percent. In 2004, the DOT issued an action plan that specifically focused on building upon the success of the 1994 plan. The goal of the 2004 plan was to realize a steady decrease in the number of vehicle/train collisions. Data obtained from the FRA Office of Data Analysis website indicate that accidents involving motor vehicles and trains at public grade crossings have decreased from 2,537 in 2004 to 1,579 in 2011.

As part of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU),[73] the Highway Safety Improvement Program (HSIP) requires states to submit an annual report describing progress on highway safety improvement projects, including projects related to safety at public grade crossings. The report is to include data on the cost and effectiveness of these projects in reducing roadway-related fatalities, injuries, and crashes. In fiscal year 2011, SAFETEA-LU apportioned a total of $220 million to the states for the elimination of hazards at grade crossings. The Moving Ahead for Progress in the 21st Century Act (MAP-21),[74] continues the same annual funding apportionments and reporting requirements.

The overall purpose of the public grade crossing program within HSIP is to eliminate hazards at grade crossings (23 U.S.C. 130[a]) through an ordered process wherein needed improvements are identified, prioritized, funded, and evaluated. The program does not provide detailed examples of policies and procedures that could be used to evaluate and systematically improve the safety of grade crossings. It is the responsibility of the states to determine which public crossings are in need of improvement and how to implement such. To facilitate the reporting of public grade crossing improvements, the FHWA developed a website that describes the type of information to include in the annual report, such as the scope and cost of improvements, types of improvements (such as equipment installation, visibility, and crossing

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[70] D. Taranto, K. Young, and D. Logan, *Evaluation of the Potential Safety Benefits of Collision Avoidance Technologies Through Vehicle-to-Vehicle Dedicated Short-Range Communications (DSRC) in Australia*, Publication No. AP–R375/11 (Sydney, Australia: Austroads Ltd, March 2011).

[71] *Secretary's Action Plan for Highway–Rail Crossing Safety and Trespass Prevention* (Washington, DC: US Department of Transportation, May 2004).

[72] The initiatives are grouped into six broad categories: (1) enhance the enforcement of traffic laws at crossings, (2) enhance rail corridor crossing reviews and improvements, (3) expand public education and Operation Lifesaver activities, (4) increase safety at private crossings, (5) improve data and research efforts, and (6) prevent rail trespasser tragedies.

[73] P.L. 109-59, August 10, 2005.

[74] P.L. 112-141, July 6, 2012.

elimination), location of improvements, and effectiveness of prior upgrades (based on crash data). This website was developed in May 2006 and has not been updated since.

In June 2010, as required by the Rail Safety Improvement Act of 2008,[75] the FRA published a final rule, at 75 FR 36551, to require the 10 states with the most grade crossing collisions, from 2006 to 2008, to develop 5-year grade crossing action plans.[76] Each plan was to be submitted for approval to the FRA by August 2011. The final rule directs the states to identify specific solutions for improving safety at crossings, including grade separations and closings, and to focus on crossings that have experienced multiple collisions or are at high risk for such incidents. The states do not have to conduct engineering evaluations when identifying safety solutions, nor does the FRA have to create a model action plan to promote uniformity among states.[77] The rule does, however, state that FRA regional grade crossing managers and experts from the grade crossing and trespasser prevention division are available to provide assistance to the 10 states in developing and carrying out the action plans. The final rule states that it is beyond its scope to require other states to create such action plans, though they may do so if desired.

1.12 Additional Information

NTSB investigators conducted field auditory testing of the ambient vehicle noise of an exemplar truck and train in October 2011 at the accident site. The tests were designed to measure (1) ambient vehicle sound levels of a Peterbilt truck-tractor in combination with two SmithCo side-dump trailers, (2) train horn sounds as heard in the exemplar vehicle at the location where the accident driver would have had the best opportunity to hear and react to the horn, and (3) sound attenuation of the truck cab with windows open and closed.

The train horn was mounted on the roof of the locomotive, approximately one-third of the length from the front. The most recent horn test had been conducted on September 20, 2010, at which time the horn was measured to have an average sound level reading of 104.4 decibels (dB) at 100 feet, which is within federal regulatory requirements.[78]

Because it is not known whether the truck cab windows were rolled up or down at the time of the accident, the ambient noise level in the truck was measured under various conditions.[79] At a speed of about 57 mph—which the train video indicated was the likely approach speed of the accident truck—the ambient noise was measured to be 76.8 dB with both

[75] P.L. 110-432, October 16, 2008.

[76] The 10 states are Alabama, California, Florida, Georgia, Illinois, Indiana, Iowa, Louisiana, Ohio, and Texas.

[77] *Railroad–Highway Grade Crossing Handbook*, FHWA-SA-07-010 (Washington, DC: Federal Highway Administration, August 2007). Although not a model action plan, the handbook provides information and guidelines for implementing improvements at grade crossings.

[78] Federal regulations require the train horn to be at least 96 dB but no more than 110 dB at 100 feet in front of the train in its direction of travel (49 CFR 229.129).

[79] According to maintenance records, the air conditioning was not functioning on the day of the accident. The driver's girlfriend said that he would drive with the windows down when the air conditioning was not working and would roll the windows up to use his cell phone.

cab windows closed, 80.5 dB with the driver's side window open, and 82.9 dB with both cab windows open.

To determine the sound level of the horn from an approaching westbound Amtrak train from the perspective of the accident truck, the exemplar truck with open windows was positioned approximately 550 feet from the crossing, which represented the estimated midpoint of the third horn blast of the accident train. From this distance, the fourth horn blast was measured as 70.3 dB, which was approximately 10–13 dB below the estimated ambient vehicle noise for the exemplar truck traveling at 57 mph with one or both windows open.

2 Analysis

2.1 Introduction

The line-of-sight tests conducted by the NTSB indicated that the grade crossing signals could be seen from as far as 2,430 feet away and that the visual cues from the grade crossing were directly in front of the driver as he approached an advance warning sign 900 feet from the crossing. A witness traveling behind the driver reported seeing both the active grade crossing signals and the approaching train from about 0.25–0.5 mile. The train video indicated that the crossing gate arm had fully descended prior to the train's arrival at the grade crossing. The flashing lights and lowered gate arms should have elicited a timely braking response from the accident driver; however, he did not start braking until more than 6 seconds after passing the advance warning sign. Investigators evaluated numerous factors that could account for the driver's delayed braking response to the visual cues ahead of him. Section 2.4 discusses several of those factors, including fatigue, distraction due to cell phone use, and distraction due to medical issues.

The NTSB discovered that the driver had a long record of violations and suspensions that indicate a history of unsafe driving behavior, much of which was unknown to his employer. NTSB investigators also determined that the driver regularly submitted job applications with incomplete employment histories, omitting jobs that ended in termination and employment action. Section 2.4 also discusses the driver's employment record and driving violation history.

Through examination of the accident truck, tire marks, maintenance records, and pushrod stroke measurements taken by the NHP, NTSB investigators determined that there were several problems with the installation and maintenance of the brakes on the truck. Among these issues were nonfunctional ABSs on both trailers, mismatched brake chambers on two axles, nonfunctioning brakes on one axle, and evidence that John Davis Trucking mechanics were manually adjusting the automatic slack adjusters. Section 2.3 discusses the poorly maintained brakes, and section 2.5 reviews the brake maintenance issues.

The truck-tractor penetrated the crew sleeper railcar, and the first trailer penetrated the first coach railcar. The intrusion into these two railcars resulted in fatal blunt force and crushing injuries to one crewmember and four passengers. Passenger railcars are typically not designed to withstand side impact by large highway vehicles such as the accident truck. Additionally, the ensuing fire and smoke in the crew sleeper railcar spread into the first and second passenger railcars, possibly through the doors between the cars. Section 2.6 discusses these issues.

The investigation determined that the active grade crossing warning system performed as designed; however, the methods currently used by the states to identify and address hazardous grade crossings could be improved. The NTSB examined whether current initiatives aimed at reducing grade crossing accidents in targeted states would also yield benefits in other states, which is discussed in section 2.7.

The accident driver was licensed and held a current medical certificate. He was familiar with the roadway and the grade crossing, having driven the same route for about 4 months. Postaccident toxicological tests were negative for alcohol and drugs.

At the time of the accident, the weather was clear and dry, the sun was overhead at 63.7 degrees above the horizon, and the visibility was 10 miles.

On the basis of this evidence, the NTSB concludes that the following were not factors in this accident: (1) malfunctioning or lack of grade crossing warning devices, (2) alcohol or drug use, and (3) weather.

The 911 calls by witnesses provided an accurate location for the accident. The emergency dispatcher initially handled the incoming calls, and then an emergency operations center was set up. Neither resource encountered problems while handling the emergency calls, and the emergency response was quickly and efficiently dispatched and managed. The emergency response teams also appropriately adapted to conditions at the accident scene. Therefore, the NTSB concludes that the emergency response was sufficient, given the rural location of the accident.

The remainder of the analysis discusses the factors that caused or contributed to the accident and the major issue areas identified in the course of the investigation, as follows:

- Commercial driver fatigue and distraction
- Commercial driver license and employment history
- Commercial vehicle brake maintenance
- Passenger railcar crashworthiness and fire protection
- Grade crossing action plans.

As a prelude to the detailed discussion of these issues, the method used to determine the speed of the accident truck as it approached the grade crossing is described based on analysis of the Amtrak surveillance video and accident reconstruction.

2.2 Video Analysis

A video camera was installed in the front left window of the lead locomotive of the Amtrak train. The accident truck was visible in the video until about 9 seconds prior to impact. The truck left the field of view of the camera when it was 653 feet from the point of impact and the train was 772 feet from the point of impact. The NTSB was able to use 5 seconds of video prior to the accident truck exiting the camera view to determine the speed of the truck as it approached the grade crossing. This analysis determined that the truck was moving at a constant speed of 57.8 mph during the 5-second period, up to a point 9 seconds before impact. The analysis also estimated that the speed of the train was 78 mph 9 seconds before impact, which is in close agreement with the train's 77-mph speed at impact as recorded on the EDR.

2.3 Accident Reconstruction

Using data from the train video and EDR, tire marks found on scene, and typical signal activation sequences from similar gate crossing systems, the NTSB reconstructed the sequence of events leading to the Miriam accident.

The signal system installed at the Miriam grade crossing was configured to provide a warning time of at least 30 seconds before an approaching train occupied the crossing. The lights and bell at the crossing activated about 2 seconds after the termination shunts sensed a train approaching. With the accident truck traveling at a constant speed of 57.8 mph, it was about 2,400 feet from the point of impact when the grade crossing signals activated. Line-of-sight tests conducted by the NTSB determined that the flashing lights could have been visible from this distance if the truck driver was looking in the direction of the grade crossing.

About 3–4 seconds after the termination shunts sensed the approaching train, the crossing gate arms began to descend to the horizontal position. It took another 4–6 seconds before the gate arms had fully descended, at which time the accident truck was over 1,500 feet from the point of impact. An advance warning sign was positioned 900 feet from the grade crossing, at the location where US 95 straightened, such that the descended gate and flashing signals were directly in the truck driver's forward view.

There was no evidence to indicate that the truck driver began to slow his vehicle until it had traveled 556–607 feet past the advance warning sign—an elapsed time of 6.6–7.2 seconds. Tire marks from wheels of either the fifth or ninth axle first appeared about 349 feet from the point of impact, which indicated that the front of the accident truck was 247–299 feet from the point of impact when hard braking was initiated.[80] It is estimated that the truck had slowed at least 1.5 mph, to a speed of 56.3 mph, at the onset of tire marks. The tire marks indicated that as the truck braked, it began to leave its lane and straddle the centerline as it continued toward the point of impact. A little over 4 seconds after the initiation of hard braking, the truck struck the end of the south crossing gate arm and then collided with the train at a speed of 26–30 mph.

Analysis of this sequence of events indicates that the truck driver should have begun gradual braking around the time he passed the advance warning sign. Instead, he conducted an emergency braking maneuver when the truck had traveled over 550 feet past the warning sign. If he had started emergency braking 119 feet sooner (corresponding to 1.4 seconds sooner), he would have been able to stop before hitting the train, despite the condition of the brakes on the truck.

During deceleration tests, an exemplar combination unit with brakes in adjustment decelerated at a rate of 0.456 g. The video analysis and accident reconstruction determined that the accident truck decelerated at a rate of 0.26–0.34 g, indicating a 57–75 percent braking efficiency. Had the accident truck been able to decelerate as efficiently as the exemplar vehicle,

[80] This assertion is dependent on which axle initiated the tire marks farthest from the crossing. If the ninth axle initiated the tire marks, subtracting 102 feet between the front of the truck back to the ninth axle results in 247 feet of precrash tire marks. If the fifth axle initiated the tire marks, subtracting 50 feet between the front of the truck back to the fifth axle results in 299 feet of precrash tire marks.

it could have come to a complete stop in approximately 232 feet from an initial speed of 56.3 mph. Therefore, the accident truck could have stopped 15–67 feet short of the grade crossing, and it would not have hit the train if the brakes had been properly maintained. Therefore, the NTSB concludes that the accident could have been avoided had the truck driver been more attentive and responsive to the visual cues available to him or had the brakes on the truck been in adjustment and operational.

2.4 Truck Driver

The NTSB examined factors that might have caused the driver to delay braking, including his ability to see or hear the train and his possible fatigue, distraction from using a cell phone, or distraction from pain associated with a medical ailment.

2.4.1 Driver's Ability to See or Hear Train

The physician who conducted a commercial driver fitness exam for the driver in 2009 had qualified him to drive, provided that he wore corrective lenses. According to the driver's girlfriend, he routinely wore glasses while driving. Although the driver's glasses were not found at the scene, a coworker reported seeing him wearing his glasses on the morning of the crash. However, even if the driver had not been wearing his glasses, his visual impairment would not have precluded him from detecting the visual warnings well in advance of the grade crossing. The NTSB concludes that the driver was capable of seeing the flashing lights and the descending gate at the grade crossing.

Auditory testing conducted by the NTSB at the accident scene determined that the sound of the train horn was approximately 10–13 dB lower than the ambient vehicle noise. Research has shown that under ideal listening conditions, train horn sounds may be detected at thresholds as low as 10 dB below the levels of vehicle interior noise.[81] A 1999 FRA report indicated that horn detection thresholds could range from –1 to +9 dB depending on whether a motorist anticipated encountering a train at a crossing.[82] According to the International Organization for Standardization, standard 7731:1986(E), to ensure audibility under adverse conditions, it is recommended that an auditory signal level exceed masked threshold levels by 13 dB.[83] Therefore, the NTSB concludes that the ambient noise in the truck cab likely masked the sound of the train horn.

[81] T. Dolan and J. Rainey, "Audibility of Train Horns in Passenger Vehicles," *Human Factors*, vol. 47, no. 3 (2005), pp. 613–629.

[82] A. Rapoza, T. Raslear, and E. Rickley, *Railroad Horn Systems Research*, Final Report, DOT/FRA/ORD-99/10 (Washington, DC: Federal Railroad Administration, January 1999).

[83] *Danger Signals for Work Places–Auditory Danger Signals*, Standard No. ISO 7731:1986 (Geneva, Switzerland: International Organization for Standardization, 1986).

2.4.2 Driver Distraction and Fatigue

There was no evidence from the train video, from witness statements, or from an investigator review of the accident scene to suggest that any factors external to the vehicle would have distracted the driver.

Fatigue is one factor that could account for the driver's delayed braking response. When determining the role of fatigue, the NTSB examined sleep duration, sleep disturbances, circadian disruption, time awake, medical issues, and task factors. NTSB investigators also considered whether the driver's performance, behavior, and appearance at the time of the accident were consistent with the effects of fatigue. This accident appeared to involve a delayed response to clear signals of an impending collision. Such delayed responses, or lapses, are characteristic of driver fatigue.[84]

The driver generally worked 11–12 hours per day. During the 2-month period for which driver logs were available, his shifts started about 2:30 a.m. The week before the accident, he worked 6 days (Monday, June 13–Saturday, June 18) and had 2 days off. The day of the accident, Friday, June 24, was his fourth day on duty. The driver lived in a camper across the street from his work reporting location. According to the driver's girlfriend, he typically went to bed by 5:00 p.m., and she called to awaken him at 2:00 a.m.

Cell phone records indicate that the driver did not use his cell phones from approximately 6:30 p.m. to 2:00 a.m. during the 3 days before the accident. Had the driver been in bed during these periods, he would have had the opportunity to sleep approximately 7.5 hours each day, which is within the range of what is considered "normal" human sleep. The driver had no risk factors for sleep disorders;[85] however, several key factors could have affected the quantity and quality of his sleep:

- Difficulty in falling asleep or staying asleep in the early evening hours,[86] which is consistent with a peak evening period in the circadian cycle.
- Pain due to Achilles tendonitis.
- Changes in his sleep/wake pattern on days off.

On his days off, the driver typically went to bed at 9:00 p.m. and awoke at 10:00 a.m. This change, though not extreme, may have led to a condition known as circadian dysrhythmia, in which the driver's circadian rhythm would need to constantly readjust to the new sleep/wake schedules. The effect of such a change would likely be most pronounced at the beginning rather

[84] N. Goel and others, "Neurocognitive Consequences of Sleep Deprivation," *Seminars in Neurology,* vol. 29, no. 4 (2009), pp. 320–339.

[85] N. Hartenbaum and others, "Sleep Apnea and Commercial Motor Vehicle Operators: Statement From the Joint Task Force of the American College of Chest Physicians, American College of Occupational and Environmental Medicine, and the National Sleep Foundation," *Journal of Occupational and Environmental Medicine*, vol. 48, no. 9 (Supplemental) (2006), pp. 34–37.

[86] P. Lavie, "Ultrashort Sleep-Waking Schedule, III, 'Gates' and 'Forbidden Zones' for Sleep," *Electroencephalography and Clinical Neurophysiology*, vol. 63, issue 5 (May 1986), pp. 414–425.

than at the end of a workweek; however, it is possible that the driver's cyclical rotation from the 5:00 p.m. to 2:00 a.m. and the 9:00 p.m. to 10:00 a.m. sleep periods further hindered the quality of his sleep.

The fact that the driver reportedly slept 13 hours per night on his days off while sleeping less than 7.5 hours per night during the workweek provides additional evidence that he may have regularly accumulated a "sleep debt" and used his off days to recover by obtaining extra sleep. Sleep debt is a term used to signify the additive effects of sleep loss over multiple days. Research has shown that even minor reductions in sleep time can result in a negative effect on sleepiness, vigilance, and performance over the course of several days.[87]

The accident driver traveled for long periods of time on the same route almost every day through a desert environment. Driving conditions such as these have been associated with reductions in vigilance and alertness.[88] The air conditioning in his truck was apparently broken, and the weather was hot, which may have created a condition that could exacerbate any preexisting fatigue.

With respect to distractions inside the vehicle, there is evidence to suggest that the accident driver routinely used his hand-held cell phone for talking, texting, and Internet usage while driving. On the day of the accident, during his approximately 8 hours of driving, he made 30 outgoing voice calls, took one incoming voice call, sent one text message, checked voicemail four times, and used the Internet three times.[89] The driver would sometimes allow incoming calls to go to voicemail, and he often checked voicemail within minutes of receiving the call. The last outgoing call placed by the driver was a 16-second call initiated at 10:32 a.m., about 47 minutes before the accident. The driver received an incoming call at 11:17:28 a.m., 2 minutes prior to the accident, which was unanswered and went to voicemail. Cell phone records would not have documented an attempt to retrieve the voicemail or to place another call.

The accident driver may have been experiencing pain at the time of the accident, which could have been a source of distraction. As late as February 2011, his medical records document him experiencing pain when moving or lifting due to back problems. About a month before the accident, the driver was diagnosed with Achilles tendonitis. He was instructed not to work for 1 week, but his driver logs indicate that he continued to work. Cell phone records indicate that the driver called four orthopedic clinics in the 3 hours preceding the accident. One of the clinics reported receiving a call from him on the morning of the accident.

[87] G. Belenky and others, "Patterns of Performance Degradation and Restoration During Sleep Restriction and Subsequent Recovery: A Sleep Dose-Response Study," *Journal of Sleep Research*, vol. 12 (2003), pp. 1–12.

[88] G. Larue, A. Rakontonirainy, and A. Pettitt, "Driving Performance Impairments Due to Hypovigilance on Monotonous Roads," *Accident Analysis and Prevention*, vol. 43, no. 6 (2011), pp. 2037–2046.

[89] Additionally, two incoming calls were routed to voicemail.

Some laboratory research has linked chronic pain and decrements in certain cognitive abilities—such as attentional capacity,[90] processing speed, and psychomotor speed[91]—though other laboratory studies have found no support for such relationships.[92] A study comparing patients with chronic pain to healthy participants using an on-the-road driving test in highway driving conditions found that those experiencing pain demonstrated significantly higher variability in lane deviations than the other drivers.[93]

In summary, though the driver may have slept as much as 7.5 hours per day in the 3 days leading to the accident, it is likely that his sleep quantity and quality were diminished by the timing of his sleep opportunities, the weekday/weekend shift of his sleep schedule, and pain associated with his medical problems. The NTSB concludes that possible reasons for the driver's delayed braking include fatigue, distraction from using his hand-held cell phone, and distraction from pain associated with his medical ailment.

2.4.3 Driving History

When hiring commercial drivers, a motor carrier is required to verify the applicant's qualifications and complete a background investigation. The applicant must supply the motor carrier with the names and addresses of employers during the previous 3 years, the dates of employment, and the reason for leaving each position, as specified in 49 CFR 391.21(10)(i)–(iii). In addition, if the driver has driven a CMV for any employers in the previous 10 years, those employers must be listed as well. However, 49 CFR 391.23(d) requires the hiring motor carrier to inquire of CMV employers only for the previous 3 years. Drivers with histories suggesting a high risk for accident involvement should optimally be screened out during the hiring process, but driver applicants may be reluctant to provide information that could jeopardize an employment opportunity or lead to termination. In each of three recent NTSB accident investigations, the commercial driver's employment and license history was at issue.[94]

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[90] B. Dick and S. Rashiq, "Disruption of Attention and Working Memory Traces in Individuals With Chronic Pain," *Anesthesia and Analgesia*, vol. 104, no. 5 (May 2007), pp. 1223–1229.

[91] (a) J. Grisart and L. Plaghki, "Impaired Selective Attention in Chronic Pain Patients," *European Journal of Pain*, vol. 3 (1999), pp. 325–333. (b) R. Hart, M. Martelli, and N. Zasler, "Chronic Pain and Neuropsychological Functioning," *Neuropsychology Review*, vol. 10 (2000), pp. 131–149. (c) S. Taimela and others, "Long Psychomotor Reaction Time in Patients With Chronic Low-Back Pain, Preliminary Report," *Archives of Physical Medicine and Rehabilitation*, vol. 74, no. 11 (1993), pp. 1161–1164.

[92] D. Seminowicz and K. Davis, "Interactions of Pain Intensity and Cognitive Load: The Brain Stays on Task," *Cerebral Cortex*, vol. 17 (2001), pp. 1412–1422.

[93] D. Veldhuijzen and others, "Effect of Chronic Nonmalignant Pain on Highway Driving Performance," *Pain*, vol. 122 (2006), pp. 28–35.

[94] For further information, see (a) *Truck-Tractor Semitrailer Median Crossover Collision With 15-Passenger Van Near Munfordville, Kentucky, March 26, 2010*, Highway Accident Report NTSB/HAR-11/02 (Washington, DC: National Transportation Safety Board, 2011). (b) *Motorcoach Run-Off-the-Road and Collision With Vertical Highway Signpost, Interstate 95 Southbound, New York City, New York, March 12, 2011*, Highway Accident Report NTSB/HAR-12/01 (Washington, DC: National Transportation Safety Board, 2012). (c) *Motorcoach Run-Off-the-Road and Overturn on Interstate 95 Near Doswell, Virginia, May 31, 2011*, Highway Accident Report NTSB/HAR-12/02 (Washington, DC: National Transportation Safety Board, 2012).

In the Miriam accident, the NTSB found many discrepancies on the driver's job application to John Davis Trucking in which he omitted certain information. In some cases, his employment had recently been terminated, and he chose not to include that employer. The NTSB concludes that by not disclosing all previous employers on his job application, the accident driver failed to provide John Davis Trucking with a complete record by which it could make an informed hiring decision, and there is currently no means by which a company can verify the completeness of information provided by a driver applicant.

The NTSB has addressed deficiencies in the regulations for various transportation modes regarding evaluation of a commercial operator's experience, skills, abilities, and physical qualifications. For example, in its investigation of the December 1994 accident involving American Eagle Flight 3379,[95] the NTSB found deficiencies in the regulations for evaluating a pilot's experience, skills, and abilities during the preemployment process, and issued four recommendations to the FAA. (See appendix B.)

The recommendations called on the FAA to create a clearinghouse storage and retrieval system of standardized information on an airline pilot's performance,[96] as well as the names of all previous employers. The recommendations stated that airlines should obtain information from this system to evaluate applicants for pilot positions and should also provide data about their pilots to the FAA. In part due to the American Eagle investigation, Congress enacted the Pilot Records Improvement Act of 1996 (PRIA), 49 U.S.C. 44703. The pilot records system adopted by the FAA, pursuant to the law, establishes a system of maintaining records; provides a limitation of liability to carriers; and provides a mechanism to evaluate all information pertaining to a pilot's qualification, training, and safety employment records.

Although the NTSB acknowledges that there are significant differences between the regulatory and operating environments found in commercial aviation and commercial trucking and busing, PRIA can still serve as a model for improved commercial driver evaluation and hiring practices. Table 3 summarizes the rules that govern the hiring process under the FMCSRs and PRIA.

[95] *Uncontrolled Collision With Terrain, Flagship Airlines, Inc., dba American Eagle Flight 3379, BAe Jetstream 3201, Morrisville, North Carolina, December 13, 1994,* Aircraft Accident Report NTSB/AAR-95/07 (Washington, DC: National Transportation Safety Board, 1995).

[96] These performance items included activities that assess skills, abilities, knowledge, and judgment during training, check flights, initial operating experience, and line checks.

Table 3. Hiring requirements of FMCSRs compared with PRIA.

Hiring Company Task	FMCSR Requirement[a]	PRIA Requirement[b]
Inquiry to each state where applicant holds vehicle license	3-year history	5-year history
Investigation of applicant's safety performance history	Within 30 days of date of employment	Obtained before pilot begins employment or training
Evaluation of training, qualifications, proficiency, competence	Typically not required[c]	Obtained before pilot begins employment or training
Inquiry into disciplinary action	Not required	Obtained before pilot begins employment or training
Evaluation of any release from employment, resignation, termination, or disqualification with respect to employment	Not required	Obtained before pilot begins employment or training
Maintenance of records	3-year retention after termination	5-year retention
Work storage retrieval system	Not available (FMCSA has PSP, which maintains roadside data on drivers only)[d]	Available

[a] See www.fmcsa.dot.gov.

[b] See www.faa.dot.gov.

[c] New drivers must undergo a road test, and additional testing is also required for drivers to obtain certain types of endorsements, such as for driving longer combination vehicles or for hauling hazardous material.

[d] The PSP offers access to up to 5 years of driver roadside and crash data and 3 years of inspection data regardless of the state or jurisdiction.

Federal statutes, at 49 U.S.C 508, limit the liability of motor carriers that request or provide safety performance information about a prospective commercial driver. Access to commercial driver professional information, similar to what is required in the airline industry, would provide carriers with a source of complete and objective data on which to base hiring decisions. Therefore, the NTSB recommends that the FMCSA create a mechanism to gather and record commercial driving-related employment history information about all drivers who have a CDL, and make this information available to all prospective motor carrier employers. Further, the NTSB recommends that the FMCSA, using the mechanism developed above, require motor carriers to conduct and document investigations into the employment records of prospective drivers for the 10 years that precede the application date.

Currently, a motor carrier is required to obtain an applicant's driving history for the most recent 3 years from any state in which the driver held a CDL.[97] In this case, John Davis Trucking reviewed the past 3 years of the accident driver's DMV record, which listed five violations in

[97] In accordance with 49 CFR 391.23(a), ". . . each motor carrier with respect to each driver it employs . . . (1) an inquiry to each State where the driver held or holds a motor vehicle operator's license or permit during the preceding 3 years to obtain that driver's motor vehicle record."

Nevada—three for speeding and two for not wearing a seat belt.[98] If John Davis Trucking had access to the driver's full driving history, including information identified through CDLIS, it would have discovered the following records, amassed across four states since 1992: seven additional speeding violations, two inattentive driving violations, one driving while suspended violation, four violations for failing to maintain insurance, one improper lane location violation, and 14 license suspensions.[99] John Davis Trucking would have also discovered that the driver had been involved in accidents in 2006 and 2007. Federal regulations specify four entities that have access to information from CDLIS: the Secretary of Transportation, the states, an employer or prospective employer of a person who operates a CMV, and a person who operates a CMV for an employer that owns or leases a CMV or assigns employees to operate a CMV. Carriers must have the written permission of a driver or driver applicant to access CDLIS information.

Another source of driver history records is the NDR,[100] which provides access to information on noncommercial drivers who have had their licenses revoked or suspended, or who have been convicted of serious traffic violations. The NDR can be especially useful for evaluating commercial driver applicants who have not held a CDL for more than 3 years.

Although carriers are allowed to access an applicant's CDLIS and NDR records, which are typically more detailed and comprehensive than the driver history supplied by the state, the NTSB is concerned that many carriers do not take advantage of this opportunity or are not aware of their right to do so. The NTSB is convinced that if all carriers accessed CDLIS and NDR information for all driver applicants, more informed hiring decisions would be made, which could result in additional training for most drivers and the rejection of those whose driving history reflects a disregard for safely operating a CMV. The NTSB concludes that requiring motor carriers to access the comprehensive driving history contained in CDLIS and the NDR would help them better evaluate driver applicants. The NTSB recommends that the FMCSA require motor carriers to retrieve records from CDLIS and the NDR for all driver applicants so that they can obtain a complete driving and license history of prospective drivers. By specifying additional sources of information (CDLIS and NDR) that carriers must query when evaluating the safety performance history of prospective drivers, this recommendation complements Safety Recommendation H-12-15 to the FMCSA, calling for revision of 49 CFR 391.23 to require that motor carriers obtain a 10-year driving history for all prospective commercial vehicle drivers.[101]

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[98] October 2009, speeding (while driving a CMV); January 2009, speeding (while driving a CMV); December 2008, speeding (while driving a CMV); October 2008, seat belt not used properly; and June 2008, seat belt not used properly.

[99] CDLIS contains pointers to driver history information housed by state driver licensing agencies. Information available through CDLIS includes a CDL holder's physical description, commercial and noncommercial driving status, medical certification status, convictions, disqualifications, and accidents. CDLIS links only to driver violations that occur at the point of CDL issuance. It does not carry forward violations that occurred previous to the driver obtaining a CDL.

[100] PRIA requires query of the NDR.

[101] NTSB/HAR-12/01.

2.5 Accident Truck

2.5.1 Truck Brakes

Several brake maintenance issues were identified for the accident truck and trailers during the course of the investigation. The NHP found nine of the 16 brakes to be defective according to CVSA OOS criteria, with two brakes inoperative and seven out of adjustment. Various approaches were taken to actuate the eighth axle brakes, and none were successful. It is unknown why the brakes would not function; however, according to maintenance records, recent brake work had been completed on the eighth axle.

Before the arrival of NTSB investigators, the NHP took pushrod stroke measurements by using compressed air at approximately 120 psi. However, the CVSA OOS criteria specify that these measurements be taken at an air pressure of 90–100 psi.

The relationship between application pressure and pushrod stroke illustrates the importance of taking these measurements within the recommended air pressure range. Pushrod stroke increases with application pressure. Some research suggests that there is a 0.1-inch increase in pushrod stroke for every 10-psi pressure increase;[102] however, further research is needed to verify this finding and describe how certain brake design characteristics could affect this relationship. It would have been beneficial to repeat the measurements at the guidance pressures; however, after the NHP took the pushrod stroke measurements, a tow truck company on scene "backed off" the slack adjusters, thereby altering the evidence and preventing the NTSB from taking measurements in accordance with CVSA protocol.[103] Consequently, it was not possible to determine the actual number of brakes that were out of adjustment. The NTSB concludes that because the NHP did not follow the pushrod stroke measurement procedure described in the CVSA OOS criteria, it is not possible to make a definitive statement regarding the number of brakes that were out of adjustment on the accident truck. The NTSB further concludes that a tow truck company that responded to the accident scene "backed-off" the brakes during vehicle recovery operations, thereby destroying evidence and precluding further brake measurements.

The NTSB recommends that the FMCSA, the NHP, and the CVSA inform commercial vehicle inspectors of (1) the importance of taking pushrod stroke measurements within the specified pressure range, (2) the relationship between pushrod stroke and specific air pressure, and (3) the consequence of taking measurements outside of this range. The NTSB also recommends that the CVSA and the Towing and Recovery Association of America Inc. inform their members to avoid backing off air brake slack adjusters after a vehicle has been involved in an accident.

[102] P. Fancher, C. Winkler, and M. Campbell, *The Influence of Braking Strategy on Brake Temperatures in Mountain Descents*, UMTRI-92-11/FHWA/MC-93/002 (Ann Arbor, Michigan: University of Michigan Transportation Research Institute, 1992). See the chamber stroke versus control pressure charts contained in the appendix to this joint report.

[103] The correct procedure would have been to mechanically compress ("cage") the spring brakes using a caging bolt, so as not to alter the position of the slack adjusters prior to inspection.

A second vehicle braking issue surfaced during examination of the trailer ABS. Wheel speed sensors were missing on the second trailer on the left side of the eighth axle and on both sides of the ninth axle. The wires to the missing sensors were found cut and zip-tied around the axles. The missing sensors and cut wires would have caused the ABS on the second trailer to be nonfunctional. Additionally, on both trailers, the wires going into the amber ABS malfunction lights located at the left rear corners were found to be disconnected. Had the ABS on the first trailer been in proper working order, there would have been no reason to disconnect its malfunction indicator light.

Aside from the out-of-adjustment and inoperative brakes, and the nonfunctioning ABS on both trailers, the accident truck was also found to have two axles equipped with mismatched and incorrectly sized brake chambers. Federal regulations require that brake chambers on each end of an axle be of the same size; however, the CVSA considers this an OOS item only when the mismatched chambers occur on the front axle brakes.

Eleven of the 16 brake drums in service on the accident truck were worn beyond manufacturer specifications. Brake drum wear is not included in the CVSA OOS criteria due to the difficulty of measuring such wear during a roadside inspection or while the wheels are still mounted to the vehicle. According to John Davis Trucking representatives, the deterioration was likely due to the rough terrain and operating environment at the mines, which can cause brake components to wear quickly.

Although the rough mine terrain might have caused some of the brake component wear documented during the investigation, the number of brake system issues found reflects the poor quality of maintenance of the accident truck and trailers. Review of maintenance records and discussion with John Davis Trucking revealed that—though brake maintenance was frequent—some of the work was being done incorrectly. Such was the case with the mismatched and incorrectly sized brake chambers, as well as with the cutting of required ABS wiring—both of which can be detrimental to the braking performance of a vehicle. Cutting the wiring, tying it up out of the way, and disconnecting the ABS malfunction indicator lights at the rear of both trailers were deliberate actions.

In addition to the ABS defects found in the accident combination unit, numerous ABS defects were discovered among other John Davis Trucking vehicles during a postaccident compliance review of the company by the NHP. This inspection uncovered 14 separate wheel locations where the ABS wiring was cut, broken, damaged, or missing. Additionally, two trailers were found to have inoperative ABS malfunction indicator lights, as was the case with the two accident trailers.

Maintenance records documented the routine and frequent manual adjustment of automatic slack adjusters for the accident truck and trailers. The NTSB has previously issued recommendations advising against the manual adjustment of automatic slack adjusters.[104] Although manual adjustment may temporarily bring the brake into compliance, it will quickly come back out of adjustment, resulting in reduced braking ability until the root of the problem is addressed. The NTSB concludes that John Davis Trucking used improper brake maintenance

[104] NTSB/HAR-06/01.

procedures by manually adjusting the automatic slack adjusters, disabling the ABS on the trailers, failing to maintain brakes in adjustment, equipping two axles with mismatched and incorrectly sized brake chambers, and operating with 11 of the 16 brake drums in service worn beyond specified limits. Therefore, the NTSB recommends that John Davis Trucking revise its vehicle maintenance to follow recommended practices, particularly with regard to automatic slack adjusters and ABSs.

2.5.2 Onboard Brake Stroke Monitoring Systems

Although the accident truck would have been considered out of service due to brake adjustment problems, it is possible that the truck driver was completely unaware of the condition of the brakes. Drivers do not typically get under their vehicles to check brake adjustment during routine pretrip inspections. Doing so would require another person to assist in the application and release of the brakes while the driver measured the pushrod strokes—which might explain why brake-related violations are a leading cause of vehicles being placed out of service. In a 2011 unannounced CVSA "operation air brake" event, more than half of the vehicles placed out of service for brake violations—and 10 percent of all vehicles inspected—were so designated because of out-of-adjustment brakes.[105]

Onboard brake stroke monitoring systems incorporate sensors into the brake chambers and pushrods of commercial vehicles with air brakes to instantly identify wheel-specific out-of-adjustment, nonfunctioning, or dragging brakes. Sensors located at each brake actuator monitor pushrod travel. These monitoring systems include driver interfaces that display brake problems to be addressed by the driver or a mechanic.

The display units, which can be mounted anywhere on the vehicle, use different colors of indicator lights to specify types of brake faults and wheel locations. Some systems also illuminate a separate warning light on the vehicle's dashboard once designated brake fault thresholds are met.

The FMCSA has developed a product guide for onboard brake stroke monitoring systems to assist carriers, drivers, fleet managers, and other interested individuals in learning more about these safety systems.[106] However, there are currently no standards or requirements for brake stroke monitoring systems on air-braked commercial vehicles.

According to the FMCSA, brake stroke monitoring systems can provide valuable information to the driver to help maintain the vehicle's safe operation, and they can also aid motor carriers in identifying air brake adjustment and maintenance problems. In addition, the systems allow information to be readily available to enforcement personnel during roadside inspections, possibly resulting in fewer brake inspections and reduced associated downtime. Although these systems can be a valuable aid in monitoring and maintaining proper brake adjustment, they are not intended to replace comprehensive brake inspections.

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[105] "CVSA Operation Air Brake/Brake Safety Week Program Launches 2nd Generation Demonstration Models," *CVSA Guardian*, vol. 19, issue 2 (2012), pp. 20–22.

[106] See http://www.fmcsa.dot.gov/facts-research/systems-technology/product-guides/brake-stroke.htm, accessed September 27, 2012.

The FMCSA estimates a $1,200–$2,500 cost for an onboard brake stroke monitoring system, depending on the type of system, type of vehicle (number of axles), and method of purchase.[107] Discounts are typically applied to multiple systems installed within a fleet. Costs can increase if the existing brake chambers need to be replaced with new sensor-equipped chambers. Onboard brake stroke monitoring systems can be included on a vehicle as original equipment or as an aftermarket installation.

The NTSB concludes that had the accident truck been equipped with an onboard brake stroke monitoring system, the truck driver would have had information about the out-of-adjustment and inoperative brakes. The NTSB recommends that NHTSA develop minimum performance standards for onboard brake stroke monitoring systems for all air-braked commercial vehicles. Once these performance standards have been developed, the NTSB further recommends that NHTSA require that all newly manufactured air-braked commercial vehicles be equipped with onboard brake stroke monitoring systems. The NTSB also recommends that the American Trucking Associations and the Owner-Operator Independent Drivers Association inform their members of the circumstances of this accident and encourage them to conduct proper maintenance on brake systems with automatic slack adjusters and to install onboard brake stroke monitoring systems on their CMVs. Additionally, the NTSB recommends that the American Bus Association and the United Motorcoach Association inform their members of the circumstances of this accident and encourage them to install onboard brake stroke monitoring systems on their CMVs.

2.6 Passenger Railcar Safety

2.6.1 Accident Damage

The locomotive EDR indicated that the train did not undergo a discernible loss of speed after being struck by the accident truck. Correspondingly, the train did not derail during the lateral impact of the truck, but it slowed over a span of 44 seconds and a distance (from the last railcar) of 2,140 feet. The accident truck caused substantial damage to two of the passenger railcars. Part of the truck-tractor penetrated and became lodged in the crew sleeper railcar (39013), causing catastrophic damage to the interior elements. The remainder of the truck cab came to rest on the ground near the point of impact. The first trailer contacted the truck cab as it moved forward, ramped over it, and collided with first coach railcar (34033) as the train continued westerly along the track. This movement also caused catastrophic damage to the interior elements of the railcar.

Prior NTSB railcar accident investigations have shown that in severe collisions involving structural intrusion, occupants located in or near the intrusion zone are less likely to survive.[108]

[107] See http://www.fmcsa.dot.gov/facts-research/systems-technology/product-guides/brake-stroke.htm, accessed October 24, 2012.

[108] (a) *Collision of Two Washington Metropolitan Area Transit Authority Metrorail Trains Near Fort Totten Station, Washington, DC, June 22, 2009*, Railroad Accident Report NTSB/RAR-10/02 (Washington, DC: National Transportation Safety Board, 2010). (b) *Collision of Metrolink Train 111 With Union Pacific Train LOF65-12, Chatsworth, California, September 12, 2001*, Railroad Accident Report NTSB/RAR-10/01 (Washington, DC: National Transportation Safety Board, 2010).

In this accident, the intrusion by the truck-tractor and first trailer caused fatal blunt force injuries to crew and passengers in these locations, and the subsequent immediate rearward movement of the truck-tractor through the railcar (as the train continued west) resulted in loss of occupant survival space in adjacent areas and additional fatal and severe blunt force injuries. Passengers outside of these locations sustained minor to no injury.

2.6.2 Passenger Railcar Crashworthiness

A historical review of the federal passenger railcar side impact strength regulations contained in 49 CFR 238.217 indicates that they are based on passenger railcar design standards published by the AAR in 1984.[109,110] According to a 1997 NPRM, the FRA was aware that simply incorporating AAR standards into federal regulations might not be sufficient, and the FRA left open the possibility of additional rulemaking in areas that included increased side impact strength requirements for passenger railcar bodies.[111] The NPRM specifically mentions bilevel passenger railcars:

> In designing a side impact strength requirement for a passenger car . . . FRA believes that current design practice may not be adequate to meet this goal. FRA also believes that cars with low floors, such as bi-level equipment, are particularly vulnerable to penetration when struck in the side. A more meaningful side impact strength requirement is necessary and will be a priority in the second phase of the rulemaking, as research determines what may be feasible in terms of cost and weight. The proposed requirement is therefore an interim measure to prevent the introduction or use of equipment not meeting this basic strength requirement. [112]

The NTSB compared the current federal regulations found in 49 CFR 238.217 with the crashworthiness design specifications for the Amtrak Superliner I and Superliner II railcars, and found them to be technically identical—which is not surprising, given that both were based on the 1984 AAR standard.[113] However, a review of the side impact strength requirements in the AAR standard revealed that they do not reflect contemporary concepts or principles of crash energy management (such as crush zone, vehicle dynamics, or occupant biomechanics) for the design of passenger railcars.[114]

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[109] (a) "Passenger Equipment Safety Standards, June 17, 1996," Advance Notice of Proposed Rulemaking, Federal Railroad Administration, http://www.gpo.gov/fdsys/pkg/FR-1997-09-23/pdf/97-24713.pdf, accessed August 10, 2012. (b) "Passenger Equipment Safety Standards, September 23, 1997," Notice of Proposed Rulemaking (NPRM), Federal Railroad Administration, http://www.gpo.gov/fdsys/pkg/FR-1997-09-23/pdf/97-24713.pdf, accessed August 10, 2012.

[110] *Specifications for the Construction of New Passenger Equipment Cars*, AAR standard S-034-69.

[111] "Passenger Equipment Safety Standards, September 23, 1997," NPRM, p. 49751.

[112] "Passenger Equipment Safety Standards, September 23, 1997," NPRM, p. 49767.

[113] *Specifications for the Construction of New Passenger Equipment Cars*, AAR standard S-034-69.

[114] Concepts of crash energy management are discussed in such documents as D. Tyrell, K. Severson, and B. Marquis, *Crashworthiness of Passenger Trains*, *Safety of High-Speed Ground Transportation Systems*, Report No. DOT/FRA/ORD-97/10 (Washington, DC: US Department of Transportation, Research and Special Programs Administration, February 1998).

For the most part, the interior components of the passenger railcars in this accident (for example, seats and tables) were ripped from their fitted positions, either through direct impact or by debris sweeping through the car, which resulted in a complete loss of occupant survival space in the area of intrusion and fatal injuries to four passengers and one crewmember. Those passengers and crew located in areas peripheral to the intrusion zones sustained serious injuries, which occurred as a result of sidewall breach and intrusion, as well as impact with interior objects. Those passengers and crew located outside of the intrusion and peripheral zones received minor to no injuries.

The NTSB believes that side impact crashworthiness standards for passenger railcars must be amended to ensure that occupants survive highway vehicle collisions. It is recognized that railcar crashworthiness must balance the risks leading to loss of occupant survival space with those affecting the severity of a collision scenario (for example, stiffening railcar sidewalls may increase the chances of derailment). In a previous accident investigation, the NTSB issued Safety Recommendation R-06-6 for the development of minimum crashworthiness standards to prevent telescoping (forward or rearward accidents, in parallel directional force).[115] This recommendation is currently classified "Open—Acceptable Response."

The NTSB maintains that side impact strength standards for passenger railcars should be revised and accompanied by a reasonable timetable for the mandatory removal from service of older equipment that cannot be modified to meet the new standards. The FRA has acknowledged the need to revisit the regulations on passenger railcar side impact strength but has yet to conduct research in this area. Therefore, the NTSB concludes that passenger railcars are vulnerable to the loss of occupant survival space from side impacts because of inadequate side impact strength requirements. The NTSB recommends that the FRA develop side impact crashworthiness standards (including performance validation) for passenger railcars that provide a measurable improvement compared to the current regulation for minimizing encroachment to and loss of railcar occupant survival space. Furthermore, the NTSB recommends that once the side impact crashworthiness standards are developed, the FRA revise 49 CFR 238.217, "Side Structure," to require that new passenger railcars be built to these standards.

2.6.3 Fire Protection

When the accident truck struck the Amtrak crew sleeper railcar, its fuel tanks ruptured and released about 100 gallons of diesel fuel, which instantly ignited, causing a conflagration. Although the lead locomotive engineer and other Amtrak employees attempted to suppress the fire with extinguishers, it eventually spread to the upper level of the railcar and to the following coach railcar.[116] All passengers and crew—other than those killed in the collision impact—were evacuated before the fire engulfed the coach railcar. One passenger was seriously injured from

[115] *Collision Between Two Washington Metropolitan Area Transit Authority Trains at the Woodley Park–Zoo/Adams Morgan Station,* Railroad Accident Report NTSB/RAR-06/01 (Washington, DC: National Transportation Safety Board, 2006).

[116] Amtrak train no. 5 contained 25 fire extinguishers that were rated class ABC dry chemical fire extinguishers appropriate for use on small fires involving ordinary combustible materials, flammable liquids, or electrically energized equipment. The NTSB reviewed the interior components of the accident Superliner railcars and determined that they consisted of ordinary combustible materials and electrically energized equipment.

burns and smoke inhalation, while a number of passengers suffered minor injuries involving smoke and carbon monoxide inhalation.

Because some of the railcar end doors appear to have been left open during the evacuation, the fire may have propagated to adjacent railcars though these openings. Rail passenger equipment safety standards (as found in 49 CFR Part 238) do not require passenger railcar end doors to be fire doors.[117] Fire doors delay the spread of heat, flame, and smoke, which could help to prevent serious or fatal injury without impeding passengers in an emergency situation. The NTSB concludes that fire doors could help limit the spread of fire from one railcar to another. The NTSB recommends that the FRA require that passenger railcar doors be designed to prevent fire and smoke from traveling between railcars.

2.7 Highway

The highway signs and markings generally met or exceeded MUTCD standards. Although there was a 140-foot offset between the advance warning sign and pavement markings on the northbound lane of US 95, this deviation from federal guidance for signal and marking placement was minor. Sight distance testing revealed that the grade crossing could be detected well in advance of the highway's advance warning sign and pavement markings, and the crossing was well protected by two gates and flashing lights, which were mounted above the roadway. However, despite the visibility of the crossing and the additional warning provided by the active grade crossing, the driver did not initiate braking in time to avoid a collision with the train.

AAWSs provide real-time alerts to drivers when a train is approaching. Additionally, V2I technologies under development would place real-time alerts inside the vehicle. Other options are also available for reducing accidents, including decreasing the speed limit on approach to grade crossings to increase perception and decision-making times, and installation of milling rumble strips on the roadway to provide auditory and tactile alerts. Although these options would not provide real-time status information on active grade crossings, they would provide drivers with more time or cues for observing the warnings. In any case, before safety measures are implemented, it is advisable to evaluate all aspects of the grade crossing, such as pertinent accident data and traffic densities and patterns.

As described in SAFETEA-LU, the states are required to conduct and systematically maintain a survey of all highways to identify those grade crossings that may require separation, relocation, or protective devices, and to establish and implement a schedule of projects for this purpose. However, they are not required to create planning documents to outline how they would methodically and systematically reduce grade crossing accidents. The states are required to report on the effectiveness of any improvements. Guidance for selecting and implementing improvements is available in the FHWA *Railroad–Highway Grade Crossing Handbook*. As with other states, Nevada uses a hazard index formula to prioritize grade crossing improvements.

[117] Fire doors are rated by their capability to reduce the spread of heat or smoke and to enable safe egress.

However, relying on the hazard index alone may result in focusing on one crossing without realizing the similar risks at other crossings.[118]

In 2010, a final rule (75 FR 36551) was published that required the 10 states with the most grade crossing accidents to draft action plans. The rule does not, however, require the FRA to create minimum grade crossing safety standards or a model action plan. The rule states that it is beyond its scope to eventually require other states to create action plans, though they may do so if desired. Among the comments received by the FRA prior to publishing the final rule were that it does not detail specific requirements for the plans and that the states do not necessarily have the expertise to prepare action plans.

NTSB review of selected action plans revealed a broad range of strategies to increase safety at grade crossings. The California plan approaches grade crossing safety from a high level, focusing on improved cooperation among state agencies, the FRA, and the FHWA, and on the continued development and evaluation of safety plans already in place. Texas, which has the most grade crossings and the most grade crossing accidents, focuses on funding; continued attention to ongoing rail safety projects; and consideration of new safety initiatives based on engineering, enforcement, and education. The Georgia plan focuses on 17 of its most hazardous grade crossings and details possible engineering, enforcement, and education solutions.

The varied content of the state action plans likely reflects the degree to which grade crossing accidents are an issue, but also the extent to which each state has thus far focused on the problem. An action plan allows each state to better define the characteristics of grade crossing accidents, track progress, and determine other areas that might need attention. The final rule does not require the FRA to evaluate the progress of each state in fulfilling its action plan, nor does it require the states or the FRA to periodically evaluate and update the goals and objectives of the action plans. Not only would periodic evaluation of progress be beneficial to the 10 states, but also it would generate data and lessons learned that other states might incorporate into their action plans.

As such, the NTSB concludes that a combined FHWA–FRA evaluation of the action plans created by the 10 states with the most grade crossing accidents would be valuable to those states and to others interested in creating their own action plans. Additionally, a model action plan, based on the existing *Railroad–Highway Grade Crossing Handbook* and other definitive sources, might promote consistency and help each state create, evaluate, and improve its action plan. The FRA's recently published report, *Data Analysis of Grade Crossing Incidents*,[119] confirms that the current use of the DOT action plans has been an effective tool in reducing the number of grade crossing accidents. However, the postcrash actions taken by NDOT to improve grade crossing safety show that state-based initiatives may also be employed as a complementary tool to improve safety at grade crossings. The NTSB concludes that a model grade crossing action plan and updated guidance would help each state focus on the problem of grade crossing safety and develop improvements specific to their highway systems. The NTSB recommends

[118] A hazard index rating describes the accident severity risk at a particular grade crossing. It does not identify or describe the characteristics that make the crossing dangerous or whether other crossings in the state have similar risk factors.

[119] FRA Report No. RR-27.

that the FRA and the FHWA work together to develop a model grade crossing action plan that can be used as a resource document by all states. At a minimum, such a document should incorporate information from DOT publications, industry studies, and the American Association of State Highway and Transportation Officials, as well as the best practices and lessons learned at the conclusion of the 5-year grade crossing action plans developed in response to 49 CFR 234.11, "State Highway–Rail Grade Crossing Action Plans."

Because 49 CFR 234.11 specifies that each of the 10 states implement a 5-year action plan, a comprehensive evaluation of the plans cannot be undertaken for some time. In the interim, the FHWA website could be updated to document the action plans, allowing them to be used as a resource by all of the 50 states. Additionally, once completed, the model grade crossing action plan could also be placed on the website. Updating the FHWA website would facilitate the reporting of public grade crossing improvements in the biennial report to Congress. The NTSB concludes that making the 10 state action plans available on the FHWA website will provide resource documents that can be used by all states until a model grade crossing action plan is developed. The NTSB recommends that the FRA and the FHWA work together to update the FHWA website on the annual reporting requirements for railway–highway crossings, to include comprehensive information on the individual grade crossing action plans developed by the states pursuant to 49 CFR 234.11, "State Highway–Rail Grade Crossing Action Plans."

3 Conclusions

3.1 Findings

1. The following were not factors in this accident: (1) malfunctioning or lack of grade crossing warning devices, (2) alcohol or drug use, and (3) weather.

2. The emergency response was sufficient, given the rural location of the accident.

3. The accident could have been avoided had the truck driver been more attentive and responsive to the visual cues available to him or had the brakes on the truck been in adjustment and operational.

4. The driver was capable of seeing the flashing lights and the descending gate at the grade crossing.

5. The ambient noise in the truck cab likely masked the sound of the train horn.

6. Possible reasons for the driver's delayed braking include fatigue, distraction from using his hand-held cell phone, and distraction from pain associated with his medical ailment.

7. By not disclosing all previous employers on his job application, the accident driver failed to provide John Davis Trucking with a complete record by which it could make an informed hiring decision, and there is currently no means by which a company can verify the completeness of information provided by a driver applicant.

8. Requiring motor carriers to access the comprehensive driving history contained in the Commercial Driver's License Information System and the National Driver Register would help them better evaluate driver applicants.

9. Because the Nevada Highway Patrol did not follow the pushrod stroke measurement procedure described in the Commercial Vehicle Safety Alliance out-of-service criteria, it is not possible to make a definitive statement regarding the number of brakes that were out of adjustment on the accident truck.

10. A tow truck company that responded to the accident scene "backed-off" the brakes during vehicle recovery operations, thereby destroying evidence and precluding further brake measurements.

11. John Davis Trucking used improper brake maintenance procedures by manually adjusting the automatic slack adjusters, disabling the antilock braking system on the trailers, failing to maintain brakes in adjustment, equipping two axles with mismatched and incorrectly sized brake chambers, and operating with 11 of the 16 brake drums in service worn beyond specified limits.

12. Had the accident truck been equipped with an onboard brake stroke monitoring system, the truck driver would have had information about the out-of-adjustment and inoperative brakes.

13. Passenger railcars are vulnerable to the loss of occupant survival space from side impacts because of inadequate side impact strength requirements.

14. Fire doors could help limit the spread of fire from one railcar to another.

15. A combined Federal Highway Administration–Federal Railroad Administration evaluation of the action plans created by the 10 states with the most grade crossing accidents would be valuable to those states and to others interested in creating their own action plans.

16. A model grade crossing action plan and updated guidance would help each state focus on the problem of grade crossing safety and develop improvements specific to their highway systems.

17. Making the 10 state action plans available on the Federal Highway Administration website will provide resource documents that can be used by all states until a model grade crossing action plan is developed.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of the Miriam, Nevada, accident was the truck driver's delayed braking and the failure of John Davis Trucking to adequately maintain the brakes on the accident truck. Contributing to the number of fatalities and severity of injuries was insufficient passenger railcar side impact strength.

4 Recommendations

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

To the Federal Motor Carrier Safety Administration:

Create a mechanism to gather and record commercial driving-related employment history information about all drivers who have a commercial driver's license, and make this information available to all prospective motor carrier employers. (H-12-54)

Using the mechanism developed in Safety Recommendation H-12-54, require motor carriers to conduct and document investigations into the employment records of prospective drivers for the 10 years that precede the application date. (H-12-55)

Require motor carriers to retrieve records from the Commercial Driver's License Information System and the National Driver Register for all driver applicants so that they can obtain a complete driving and license history of prospective drivers. (H-12-56)

Inform commercial vehicle inspectors of (1) the importance of taking pushrod stroke measurements within the specified pressure range, (2) the relationship between pushrod stroke and specific air pressure, and (3) the consequence of taking measurements outside of this range. (H-12-57)

To the National Highway Traffic Safety Administration:

Develop minimum performance standards for onboard brake stroke monitoring systems for all air-braked commercial vehicles. (H-12-58)

Once the performance standards in Safety Recommendation H-12-58 have been developed, require that all newly manufactured air-braked commercial vehicles be equipped with onboard brake stroke monitoring systems. (H-12-59)

To the Federal Highway Administration:

Work with the Federal Railroad Administration to develop a model grade crossing action plan that can be used as a resource document by all states. At a minimum, such a document should incorporate information from US Department of Transportation publications, industry studies, and the American Association of State Highway and Transportation Officials, as well as the best practices and lessons learned at the conclusion of the 5-year grade crossing action plans developed in response to 49 *Code of Federal Regulations* 234.11, "State Highway–Rail Grade Crossing Action Plans." (H-12-60)

Work with the Federal Railroad Administration to update your website on the annual reporting requirements for railway–highway crossings, to include comprehensive information on the individual grade crossing action plans developed by the states pursuant to 49 *Code of Federal Regulations* 234.11, "State Highway–Rail Grade Crossing Action Plans." (H-12-61)

To the Federal Railroad Administration:

Develop side impact crashworthiness standards (including performance validation) for passenger railcars that provide a measurable improvement compared to the current regulation for minimizing encroachment to and loss of railcar occupant survival space. (R-12-39)

Once the side impact crashworthiness standards are developed in Safety Recommendation R-12-39, revise 49 *Code of Federal Regulations* 238.217, "Side Structure," to require that new passenger railcars be built to these standards. (R-12-40)

Require that passenger railcar doors be designed to prevent fire and smoke from traveling between railcars. (R-12-41)

Work with the Federal Highway Administration to develop a model grade crossing action plan that can be used as a resource document by all states. At a minimum, such a document should incorporate information from US Department of Transportation publications, industry studies, and the American Association of State Highway and Transportation Officials, as well as the best practices and lessons learned at the conclusion of the 5-year grade crossing action plans developed in response to 49 *Code of Federal Regulations* 234.11, "State Highway–Rail Grade Crossing Action Plans." (R-12-42)

Work with the Federal Highway Administration to update its website on annual reporting requirements for railway–highway crossings, to include comprehensive information on the individual grade crossing action plans developed by the states pursuant to 49 *Code of Federal Regulations* 234.11, "State Highway–Rail Grade Crossing Action Plans." (R-12-43)

To the Nevada Highway Patrol:

Inform commercial vehicle inspectors of (1) the importance of taking pushrod stroke measurements within the specified pressure range, (2) the relationship between pushrod stroke and specific air pressure, and (3) the consequence of taking measurements outside of this range. (H-12-62)

To the Commercial Vehicle Safety Alliance:

Inform commercial vehicle inspectors of (1) the importance of taking pushrod stroke measurements within the specified pressure range, (2) the relationship between pushrod stroke and specific air pressure, and (3) the consequence of taking measurements outside of this range. (H-12-63)

Inform your members to avoid backing off air brake slack adjusters after a vehicle has been involved in an accident. (H-12-64)

To the American Trucking Associations and the Owner-Operator Independent Drivers Association:

Inform your members of the circumstances of this accident and encourage them to conduct proper maintenance on brake systems with automatic slack adjusters and to install onboard brake stroke monitoring systems on their commercial motor vehicles. (H-12-65)

To the Towing and Recovery Association of America Inc.:

Inform your members to avoid backing off air brake slack adjusters after a vehicle has been involved in an accident. (H-12-66)

To the American Bus Association and the United Motorcoach Association:

Inform your members of the circumstances of this accident and encourage them to install onboard brake stroke monitoring systems on their commercial motor vehicles. (H-12-67)

To John Davis Trucking Company, Inc.:

Revise your vehicle maintenance to follow recommended practices, particularly with regard to automatic slack adjusters and antilock braking systems. (H-12-68)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

DEBORAH A. P. HERSMAN
Chairman

ROBERT L. SUMWALT
Member

CHRISTOPHER A. HART
Vice Chairman

MARK R. ROSEKIND
Member

EARL F. WEENER
Member

Adopted: December 11, 2012

Member Weener filed the following concurring statement on December 18, 2012.

Board Member Statement

Notation 8341A
Member Earl F. Weener, concurring:

The underlying investigation of this unfortunate accident was comprehensive and sound, and I support the probable cause statement as amended at the Board Meeting. However, the final accident report falls short of the Board's professional standard in several ways. In brief, it fails to provide sufficient technical detail and explanation in a balanced manner to support the findings.

Initially, as provided by the investigation and found amply supported in the accident docket, the facts of this accident describe a conditional probability. Both independent conditions, the driver's delayed braking ***and*** the defective brakes, were necessary to achieve the outcome. If either of these events had not occurred the accident would not have occurred. The report, however, does not adequately describe the depth of analysis conducted by the staff and the findings in terms of the condition of the accident truck brakes. Nor does it provide detail regarding how the specific brake defects affected the outcome. For example, as provided in the docket, the investigation revealed the pushrod stroke measurements were improperly measured and the evidence was altered, preventing accurate measurements to be taken. Yet, faced with this challenge, the staff pursued the investigation using alternate methods to identify and assess the various brake defects and their respective impact. The report, in turn, only provides a brief summary of this testing and analysis, and provides no detail on the severity of each of the defects discovered or the degree of correlation between the various investigative methods employed to address informational gaps in the evidence. Instead of properly reflecting the analytical rigor employed to ascertain the mechanical deficiencies of the accident vehicle, the report merely lists each discovered brake defect and concludes, summarily, the brakes were out of adjustment and partially inoperative.

Notably, this is not the standard for Board reports. In fact, the Board has a lengthy history of providing reports with extensive technical detail to underpin the accident report findings and probable cause, demonstrating the expertise and dedication of the staff. Just in recent times the Board has issued several reports, spanning the Board's jurisdiction, which provide extensive technical detail in support of conclusions and probable cause statements.[1] Alternatively, the

[1] (a) *Crash During Experimental Test Flight, Gulfstream Aerospace Corporation GVI (G650), N652GD, Roswell, New Mexico, April 2, 2011*, Aircraft Accident Report NTSB/AAR-12/02 (Washington, DC: National Transportation Safety Board, 2012). (b) *Pilot/Race 177,* The Galloping Ghost *North American P-51D, N79111, Reno, Nevada, September 16, 2011*, Aircraft Accident Report NTSB/AAR-12/01 (Washington, DC: National Transportation Safety Board, 2012). (c) *Allision of Passenger Ferry Andrew J. Barberi With St. George Terminal, Staten Island, New York, May 8, 2010*, Marine Accident Report NTSB/MAR-12/01 (Washington, DC: National Transportation Safety Board, 2012). (d) *Miami International Airport, Automated People Mover Train Collision with Passenger Terminal Wall, Miami, Florida, November 28, 2008*, Rail Accident Report NTSB/RAR-11/01 (Washington, DC: National Transportation Safety Board, 2011). (e) *Pacific Gas and Electric Company Natural Gas Transmission Pipeline Rupture and Fire, San Bruno, California, September 9, 2010*, Pipeline Accident Report NTSB/PAR-11/01 (Washington, DC: National Transportation Safety Board, 2011). (f) *Loss of Control While Maneuvering Pilatus PC-12/45, N128C, Butte, Montana, March 22, 2009*, Aircraft Accident Report NTSB/AAR-11/05 (Washington, DC: National Transportation Safety Board, 2011).

sections of this report addressing the brake defects appear to over generalize and shy away from providing much technical detail, particularly in comparison to the sections dedicated to driver attentiveness. Considering both the driver's delayed braking ***and*** the brake defects are identified as the probable cause of this accident, the report would benefit from additional explanation on the testing, investigative analysis and conclusions concerning the brake defects.

It is troubling for the two requisite conditions to receive disparate treatment, particularly taking into account the work conducted during the investigation. Without dismissing the importance of the human factors analyses, which were specific to the individual driver, the mechanical issues involved in this accident have relevancy beyond the specific accident vehicle. The identification of the operator's lax maintenance practices enables action to be undertaken to change such practices and prevent future accidents. Further, the aspects of the investigation focused on the mechanical issues yielded hard, tangible evidence, enabling staff to draw conclusions; unlike the human factors analyses which, although thorough and comprehensive, due to a lack of evidence could only yield possibilities. This is not to suggest or imply the human factors discussion in the report was unnecessary or inappropriate; to the contrary, it calls for a more balanced approach to addressing the mechanical issues involved in this accident.

The Board's credibility is heavily dependent on its ability to be objective, relying on facts and analysis, rather than emotions or trends. When accident reports do not properly reflect investigation findings and analyses in a balanced manner the Board stands open to criticism of pursuing an agenda, rather than fulfilling its mission to provide an objective, independent review of an accident.

As stated, I support the underlying investigation and probable cause statement; however, I believe the final accident report did not do justice to the mechanical issues involved in this accident.

Earl F. Weener
December 18, 2012

Appendix A: Investigation

The National Transportation Safety Board (NTSB) received notification of this accident on June 24, 2011, and launched highway investigators to address motor carrier, survival factors, human factors, vehicle, and highway issues. Additionally, the NTSB launched rail and fire investigators to address train operations, mechanical, survival factors, signals, and fire issues. The NTSB team included staff from the Transportation Disaster Assistance office. Member Earl Weener was the spokesman on scene. Parties to the investigation were the Federal Highway Administration, the Federal Motor Carrier Safety Administration, the Federal Railroad Administration, the Nevada Department of Transportation, the Nevada Department of Public Safety, the Churchill County Sheriff's Office, Union Pacific Railroad, the United Transportation Union, the Brotherhood of Locomotive Engineers and Trainmen, the National Railroad Passenger Corporation (Amtrak), and John Davis Trucking Company, Inc. No public hearing was held in connection with this accident, and no depositions were taken.

The Miriam accident was the first accident in which the NTSB exercised its rail passenger family assistance statutory authority under the Rail Safety Improvement Act of 2008 (Public Law 110-432).

Appendix B: Pilot Oversight Recommendations

Section 2.4.3 of this report refers to the following safety recommendations to the Federal Aviation Administration:[1]

> Require all airlines operating under 14 CFR Parts 121 and 135 and independent facilities that train pilots for the airlines to maintain pertinent standardized information on the quality of pilot performance in activities that access skills, abilities, knowledge, and judgment during training, check flights, initial operating experience, and line checks and to use this information in quality assurance of individual performance and of the training programs. (A-95-116)
>
> Require all airlines operating under 14 CFR Parts 121 and 135 and independent facilities that train pilots for the airlines to provide the FAA, for incorporation into a storage and retrieval system, pertinent standardized information on the quality of pilot performance in activities that assess skills, abilities, knowledge, and judgment during training, check flights, initial operating experience, and line checks. (A-95-117)
>
> Maintain a storage and retrieval system that contains pertinent standardized information on the quality of 14 CFR Parts 121 and 135 airline pilot performance during training in activities that assess skills, abilities, knowledge, and judgment during training, check flights, initial operating experience, and line checks. (A-95-118)
>
> Require all airlines operating under 14 CFR Parts 121 and 135 to obtain information from the FAA's storage and retrieval system that contains pertinent standardized pilot training and performance information for the purpose of evaluating applicants for pilot positions during the pilot selection and hiring process. The system should have appropriate privacy protections, should require the permission of the applicant before release of the information, and should provide for sufficient access to the records by an applicant to ensure accuracy of the records. (A-95-119)

[1] *Uncontrolled Collision with Terrain, Flagship Airlines, Inc., dba American Eagle Flight 3379, BAe Jetstream 3201, Morrisville, North Carolina, December 13, 1994,* Aircraft Accident Report NTSB/AAR-95/07 (Washington, DC: National Transportation Safety Board, 1995).