March 28, 2023 Highway Investigation Report HIR-23/04

Multivehicle Collision Involving a Milk Tank Combination Vehicle and Stopped Traffic Queue

Phoenix, Arizona
June 9, 2021

Abstract: On the evening of June 9, 2021, a truck-tractor in combination with a tank-trailer hauling milk, operated by Arizona Milk Transport, was traveling eastbound on SR-202 in Phoenix, Arizona, when it crashed into a queue of passenger vehicles that were stopped due to a road closure. The truck driver did not slow down or steer away as he approached the traffic queue at a speed of 62–64 mph. The combination vehicle struck and partially overrode the vehicle at the end of the traffic queue, initiating a series of chain-reaction collisions that involved six other passenger vehicles. Following the initial impacts, the combination vehicle crossed the eastbound travel lanes, struck the concrete median barrier and separated, and the truck-tractor and one passenger vehicle were consumed by fire. Four passenger vehicle occupants died and 11 occupants were injured; the truck driver was uninjured. Safety issues identified in this investigation include the inadequate safety culture of the motor carrier, the need to reduce the risk of fatigue for drivers operating under an agricultural hours-of-service exemption, the need to improve the prioritization of messages displayed on dynamic message signs, the need to increase the use of occupant restraints for all seating positions, and the need to expedite deployment of collision avoidance technologies. The NTSB issues new safety recommendations to the US Department of Transportation, the Arizona Department of Transportation, Arizona Milk Transport, the Commercial Vehicle Safety Alliance, the International Dairy Foods Association, the National Conference for Interstate Milk Shipments, and the International Milk Haulers Association, and reiterates recommendations to the US Department of Transportation, the Federal Communications Commission, the National Highway Traffic Safety Administration, and 38 states and the District of Columbia.

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Acronyms and Abbreviations

ACM	airbag control module
ADOT	Arizona Department of Transportation
AEB	automatic emergency braking
AMT	Arizona Milk Transport
AZDPS	Arizona Department of Public Safety
BASIC	Behavior Analysis and Safety Improvement Categories [FMCSA]
CAMP	Crash Avoidance Metrics Partners
CAS	collision avoidance system
CDL	commercial driver's license
CFR	*Code of Federal Regulations*
CR	compliance review
CVSA	Commercial Vehicle Safety Alliance
DMS	dynamic message sign(s)
DSRC	dedicated short-range communication
DTT	dynamic travel time
ELD	electronic logging device
FCC	Federal Communications Commission
FCW	forward collision warning
FDA	Food and Drug Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
g	force of gravity
GVWR	gross vehicle weight rating
HOS	hours-of-service
HOV	high-occupancy vehicle

IC	incident commander
IIHS	Insurance Institute for Highway Safety
ICC	Interstate Commerce Commission
MAP-21	Moving Ahead for Progress in the 21st Century Act
MCMIS	Motor Carrier Management Information System [FMCSA]
MHz	megahertz
MUTCD	*Manual on Uniform Traffic Control Devices for Streets and Highways*
NAFMP	North American Fatigue Management Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NPRM	notice of proposed rulemaking
NTSB	National Transportation Safety Board
OSA	obstructive sleep apnea
PFD	Phoenix Fire Department
RFC	request for comments
SR-202	State Route Loop 202
TL-4	Test Level 4
TOC	Traffic Operations Center (ADOT)
TTC	time-to-contact
UDA	United Dairymen of Arizona
USDOT	US Department of Transportation
V2I	vehicle-to-infrastructure
V2P	vehicle-to-pedestrian
V2V	vehicle-to-vehicle
V2X	vehicle-to-everything

Executive Summary

What Happened

On the evening of June 9, 2021, a truck-tractor in combination with a tank-trailer hauling milk, operated by Arizona Milk Transport (AMT), was traveling eastbound on SR-202 in Phoenix, Arizona, when it crashed into a queue of passenger vehicles that were stopped due to a road closure. The truck driver did not slow down or steer away as he approached the traffic queue at a speed of 62–64 mph. The combination vehicle struck and partially overrode the car at the end of the traffic queue, initiating a series of chain-reaction collisions that involved six other passenger vehicles. Following the initial impacts, the combination vehicle crossed the eastbound travel lanes, struck the concrete median barrier and separated, and the truck-tractor and one passenger vehicle were consumed by fire. Four passenger vehicle occupants died and 11 occupants were injured; the truck driver was uninjured.

What We Found

The video footage from the inward-facing camera of the commercial vehicle's driver monitoring system showed the truck driver facing forward for 8 seconds before the crash but showed no visible indication that he was aware that the combination vehicle was rapidly approaching the fully conspicuous traffic queue. Based on this video footage, the truck driver was not distracted by an external source, and toxicology testing showed that he was not impaired. Based on the interview with the truck driver and the examination of his phone and work records, he had about 5.5–6 hours of sleep opportunity on the day of the crash.

AMT operated under a federal agricultural hours-of-service (HOS) exemption, which allows unlimited driving hours within a 150 air-mile radius. AMT's safety culture was inadequate; the carrier had no fatigue management program that would have reduced the risk of fatigued operation by its drivers. Moreover, the carrier's oversight of its drivers and enforcement of its own policies regarding the maximum daily and weekly on-duty hours was poor, as the crash-involved driver and several other examined drivers regularly violated those policies.

The federal HOS exemption is granted by statute for transportation of livestock and certain perishable commodities, including milk. Because motor carriers that operate under an agricultural HOS exemption are not required to inform the Federal Motor Carrier Safety Administration when using the exemption, the agency does not have a mechanism to identify those carriers or maintain information about their crash rates.

We also found that, as a result of the Arizona Department of Transportation (ADOT) classifying the road closure as a low-priority event as opposed to a high-priority event, dynamic message signs in the area of the crash displayed alternating messages regarding the road closure and dynamic travel time.

In addition, several of the passenger vehicle occupants in the Phoenix crash were not wearing or were improperly restrained by the available lap/shoulder belts, which increased their risk of ejection and exacerbated their injuries.

We determined that the probable cause of this multivehicle crash was the truck driver's failure to respond to the fully conspicuous traffic queue, likely as the result of fatigue. Contributing to the crash was Arizona Milk Transport's (1) poor oversight of its drivers, (2) lack of fatigue management program, and (3) failure to enforce its own policies, such as those regarding on-duty hours—all a consequence of its inadequate safety culture. Contributing to the severity of injuries to several passenger vehicle occupants was their lack of or improper lap/shoulder belt use.

What We Recommended

As a result of this investigation, we recommended that the US Department of Transportation (USDOT) develop and implement a program to determine the prevalence of for-hire motor carriers operating under agricultural HOS exemptions and study their safety performance, and to report the findings and any recommendations to improve safety to Congress. We further recommended that the USDOT require interstate motor carriers operating under an agricultural HOS exemption to implement a fatigue management program or, if necessary, seek congressional authority to do so.

We also recommended that ADOT revise its policies regarding dynamic message signs to classify single-direction road closures as high-priority messages.

Further, we recommended that AMT implement an improved coaching program to improve driving behavior; implement a process to improve adherence to carrier policies, such as by verifying the accuracy of driver-reported duty hours and cross-referencing other information; and implement a fatigue management program.

To broaden industry awareness of this crash, its findings, and the risk of fatigue when operating beyond traditional HOS, we recommended that the International Dairy Foods Association, the National Conference for Interstate Milk Shipments, and the International Milk Haulers Association inform their members about this crash and encourage motor carriers to establish a fatigue management program. We further recommended that the Commercial Vehicle Safety Alliance, in its promotion of the North American Fatigue Management Program, develop an outreach program focusing on motor carriers that operate under an agricultural HOS exemption.

We also reiterated several safety recommendations pertaining to implementing collision avoidance technologies and increasing the use of seat belts. First, we reiterated Safety Recommendation H-15-5 to the National Highway Traffic Safety Administration (NHTSA) to develop performance standards for forward collision avoidance systems in commercial vehicles. Also to NHTSA, we reiterated Safety Recommendations H-13-30 and -31 to develop performance standards and mandate connected vehicle technology on all new vehicles. Furthermore, we reiterated Safety Recommendation H-22-1 to the USDOT to develop a plan for nationwide deployment of connected vehicle technology, and Safety Recommendation H-22-6 to the Federal Communications Commission to protect communication between connected vehicle devices from harmful interference. We also changed the status of Safety Recommendations H-22-1 and -6 from Open—Await Response to Open—Unacceptable Response.

Finally, we reiterated Safety Recommendation H-15-42 to Arizona, the District of Columbia, and 37 other states to enact legislation that provides for primary enforcement of seat belt use law in all vehicles and all seating positions equipped with a restraint system.

1. Factual Information

1.1 Crash Description

On Wednesday, June 9, 2021, about 10:07 p.m. mountain standard time, a multivehicle crash occurred in the eastbound lanes of State Route Loop 202 (SR-202), near mile marker 4 in Phoenix, Maricopa County, Arizona.[1]

In support of law enforcement activity related to a non-crash incident, all five lanes of eastbound SR-202 were closed at 9:16 p.m. and traffic was diverted to exit 6 (Priest Drive).[2] When the eastbound lanes reopened at 10:00 p.m., the traffic flow in the four lanes resumed, but a traffic queue remained in the far-right lane. About that time, a 2016 Freightliner Cascadia truck-tractor in combination with a 2015 Walker tank-trailer was traveling eastbound on SR-202 from a local dairy farm to United Dairymen of Arizona (UDA), a milk-processing plant. The combination vehicle was operated by Arizona Milk Transport Inc. (AMT) and driven by a 47-year-old driver.

In the area of the crash, SR-202 is a divided highway with a posted speed limit of 65 mph and the eastbound and westbound lanes are separated by a concrete median barrier. The crash occurred in the far-right lane about 200 feet east of exit 4 (see figure 1).

[1] Visit ntsb.gov to find additional information in the public docket for this National Transportation Safety Board (NTSB) investigation (case number HWY21MH008). Use the CAROL Query to search safety recommendations and investigations.

[2] Earlier that evening, a shooting incident occurred on the eastbound lanes of SR-202 in this area. Traffic management related to this event is described in section 1.3.2.

Figure 1. Aerial view of the area of the crash, with an inset showing the position of the vehicles involved in the crash. (Source: Adapted from Google Earth)

The crash sequence began when the combination vehicle approached the traffic queue. Based on the fleet management data and the video from the forward-facing camera in the truck-tractor, the combination vehicle was traveling 62–64 mph during the 8 seconds before the crash sequence began. The truck driver did not slow the truck or steer away as he approached the traffic queue. At 62 mph, the combination vehicle struck and partially overrode the vehicle at the end of the traffic queue—a 2016 Ford Fusion—initiating a series of chain reaction collisions that involved six other vehicles (the figure 1 inset shows the position of these vehicles in the traffic queue at time of impact). The combination vehicle propelled the Ford into a 2013 Toyota Prius ahead of it and pushed both vehicles into a concrete barrier on the right shoulder (see figure 2). The combination vehicle then struck a 2021 Chevrolet Equinox, which became entangled with the front of the truck-tractor. During the collision sequence, the combination vehicle, with the entangled Chevrolet, crossed the four eastbound travel lanes to the left and struck the concrete median barrier. The tank-trailer separated from the truck-tractor, overrode the median barrier, and landed on the westbound left shoulder and in the westbound left travel lane.

The truck-tractor along with the Chevrolet came to rest in the left eastbound lane, where they were consumed by a postcrash fire (see figure 3). As shown inset in figure 1, in addition to the combination vehicle and the vehicles listed above, four other passenger vehicles, positioned in front of the traffic queue, were involved in the crash. The additional passenger vehicles—a 2015 Nissan Altima, a 2015 Dodge Charger, a 2018 Mercedes-Benz C300W, and a 2013 Lexus CT200H—were struck by the vehicles behind them and collided with each other during the crash sequence before coming to rest (the detailed crash sequence is described in section 1.5).

The crash occurred at nighttime with no precipitation. There were no winds about the time of the crash, and roadway lighting was present.

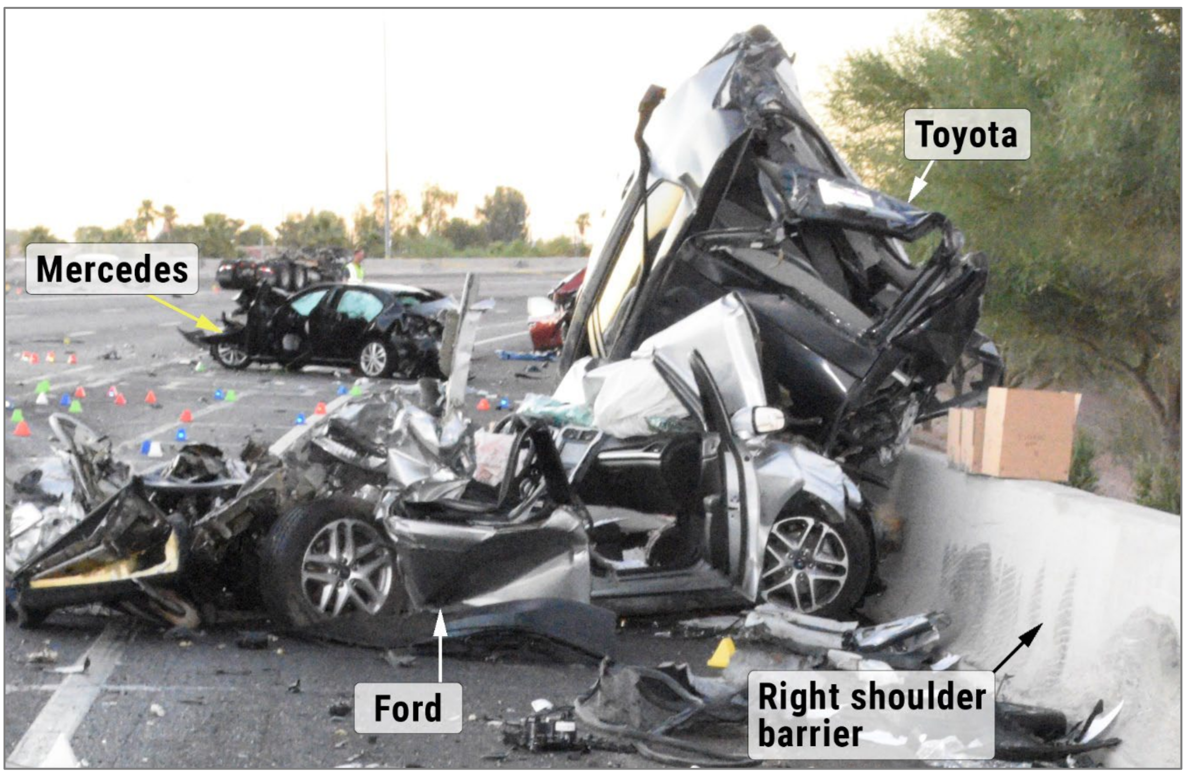

Figure 2. Eastbound view of at-rest positions of three of the crash-involved vehicles. (Source: Arizona Department of Public Safety [AZDPS] with annotations by the NTSB).

Figure 3. At-rest positions of the truck-tractor and Chevrolet. (Source: AZDPS with annotations by the NTSB)

1.2 Injuries, Occupant Protection, and Emergency Response

1.2.1 Injuries

As a result of the crash, four passenger vehicle occupants died, five occupants sustained serious injuries, and six occupants received minor injuries. The truck driver was uninjured. The passenger vehicle occupants ranged in age from 6 to 44 and comprised 7 males and 8 females. Table 1 summarizes the distribution of injury severity.

Table 1. Injury levels for the truck driver and occupants of passenger vehicles.

Injuries					
Vehicle	**Fatal**	**Serious**	**Minor**	**None**	**Total**
2016 Freightliner Cascadia (truck-tractor)	--	--	--	1	1
2016 Ford Fusion	2	2	-	-	4
2013 Toyota Prius	-	1	-	-	1
2021 Chevrolet Equinox	1	-	-	-	1
2015 Nissan Altima	1	1	2	-	4
2015 Dodge Charger	-	1	1	-	2
2018 Mercedes-Benz C300W	-	-	2	-	2
2013 Lexus CT200H	-	-	1	-	1
TOTAL	4	5	6	1	16

[a] Although 49 *Code of Federal Regulations* (*CFR*) Part 830 pertains to the reporting of aircraft accidents and incidents to the NTSB, section 830.2 defines fatal injury as any injury that results in death within 30 days of the accident, and serious injury as any injury that (1) requires hospitalization for more than 48 hours, commencing within 7 days from the date of injury; (2) results in a fracture of any bone (except simple fractures of fingers, toes, or nose); (3) causes severe hemorrhages, nerve, or tendon damage; (4) involves any internal organ; or (5) involves second- or third-degree burns, or any burn affecting more than 5% of the body surface.

Based on the autopsy report, the driver of the Chevrolet died due to thermal injuries with smoke and soot inhalation. The autopsy reports show that the other three passenger vehicle occupants who died sustained blunt-force trauma to the head and torso; two of those occupants were seated on the left side of the Ford that the combination vehicle overrode, and the third occupant—the front seat passenger of the 2015 Nissan Altima—was ejected during the crash sequence.

The five seriously injured passenger vehicle occupants sustained injuries consisting of fractures to multiple body regions. The driver of the 2015 Dodge Charger sustained serious injury to the head due to impact with the steering wheel. The six passenger vehicle occupants with minor injuries sustained lacerations, abrasions, and contusions to multiple body regions. A 6-year-old child, seated in the rear of the 2018 Mercedes-Benz, sustained minor injuries including whiplash and seat belt abrasion to the right side of the neck.

1.2.2 Occupant Protection

The driver's seat of the truck-tractor was equipped with a lap/shoulder belt. According to the video footage from the inward-facing camera and the truck driver's statement, the driver was restrained at the time of the crash. All seating positions in all seven passenger vehicles were also equipped with lap/shoulder belts. As depicted in figure 4, the NTSB determined seat belt use of the passenger vehicle occupants based on vehicle data recording systems, driver and occupant interviews, occupant injuries, and damage to the seat belt webbing.

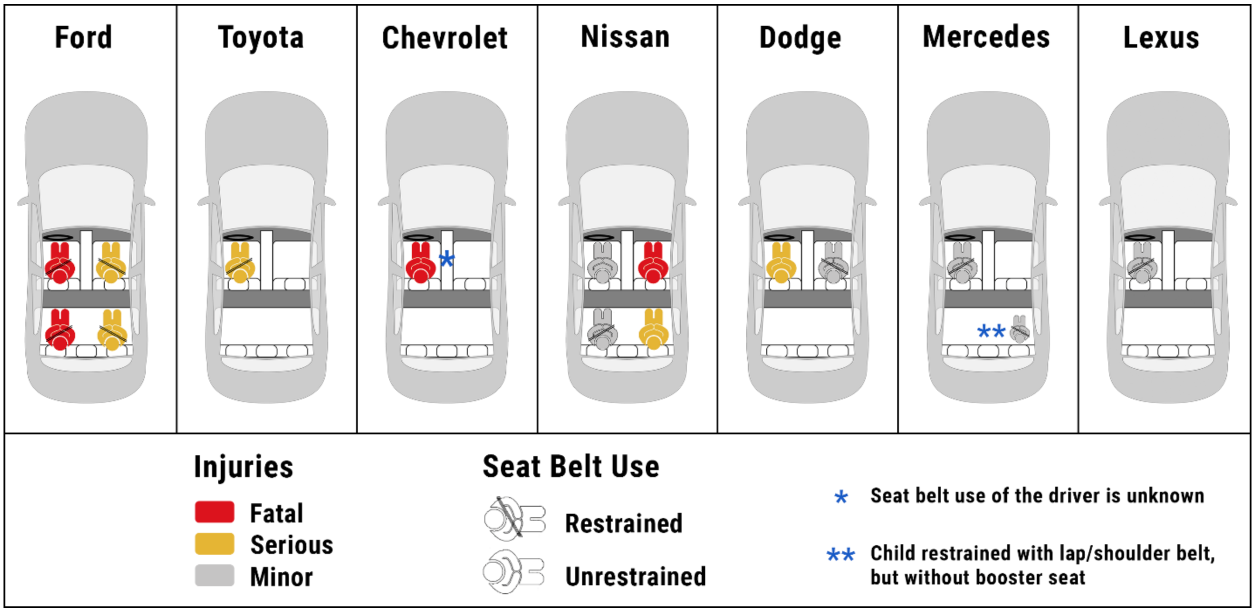

Figure 4. Seating positions of passenger vehicle occupants, showing their injury classification and their seat belt use. The vehicles are presented in order of their position in the traffic queue at the time of the initial impact (rear to front).

The front seat passenger of the Nissan, who was ejected and died during the crash sequence, was unbelted. The driver of the Toyota, who sustained serious injuries, was belted but was partially ejected during the crash sequence. The 6-year-old rear passenger of the Mercedes-Benz was restrained with a lap/shoulder belt but was not placed in a child restraint system. Arizona law requires that children between the ages of 5 and 8 who are less than 58 inches tall use a federally approved child restraint system when riding in a vehicle, as specified in 49 *Code of Federal Regulations* (*CFR*) 571.213.[3] The child in the Mercedes-Benz was less than 58 inches tall. The airbags in all of the passenger vehicles deployed in this crash (see section 1.4.2.2 for airbag control module information).

[3] See Arizona Revised Statutes 28-907. This statute also requires that *all* children under 5 years old be properly secured in a child restraint system.

Arizona has a secondary enforcement seat belt use law that applies only to front seat occupants.[4] Any passengers under 16 years of age are required to be belted regardless of their seating position.

1.2.3 Emergency Response

The Phoenix Operations Communications Bureau of the Arizona Department of Public Safety (AZDPS) was notified of the crash at 10:11 p.m. through a 911 call, and then its personnel notified the Phoenix Fire Department's (PFD) Regional Dispatch Center of the crash. The AZDPS dispatched one squad vehicle at 10:13 p.m., which arrived on scene 10 minutes later.

The PFD dispatch center immediately assigned one engine unit, which arrived on scene at 10:22 p.m., at which point its captain assumed the role of incident commander (IC). At 10:18 p.m., the PFD dispatched another engine unit and one ladder company, which arrived on scene 6–7 minutes later.

Upon arrival at 10:22 p.m., the IC requested a "balance 1st Alarm," which prompted dispatch of additional engine and ambulance units and a ladder company.[5] At 10:27 p.m., after the initial triage had begun, the IC raised the incident to balance 2nd Alarm, which initiated a request for a crisis care unit and a medic fire response vehicle, as well as additional ambulance and engine units.

At 10:28 p.m., another PFD engine arrived, and its battalion chief assumed the IC role 3 minutes later. The PFD ultimately dispatched a total of nine ambulances, three fire engines, one ladder truck, and one specialized squad with extrication equipment. As part of mutual aid response, two other agencies—Tempe and Mesa Fire Departments—responded with an additional two engine units, one ladder truck, and nine officer and mutual aid vehicles.

Nine ambulances transported the 11 surviving passenger vehicle occupants to area hospitals. The last two surviving passengers were transported from the scene at

[4] See Arizona Revised Statutes 28-909. Secondary enforcement seat belt use laws allow enforcement officers to ticket a driver/vehicle occupant for not wearing a seat belt only after stopping the vehicle for another offense. Primary enforcement seat belt use laws allow enforcement officers to ticket a driver/vehicle occupant for not wearing a seat belt without the driver having committed any other traffic offense.

[5] (a) A *balance 1st Alarm* assignment consists of five engines, two ladder companies, and four command officers. A *balance 2nd Alarm* consists of an additional six engines (for a total of 11), three ladder companies (for a total of five), and three command officers (for a total of seven), as well as one medic fire response vehicle, one rescue fire response vehicle, one crisis care unit, and one utility truck. (b) Most of the units that were dispatched as part of the balance 2nd Alarm remained at the staging area; some of these units responded to the scene when requested.

11:11 p.m. The truck driver, who was uninjured, signed a medical release form on scene and was not transported.

1.3 Highway Factors

1.3.1 Roadway Design, Traffic Characteristics, and Crash History

The crash occurred on eastbound SR-202, between exits 4 and 6, 193 feet east of mile marker 4. The westbound and eastbound directions of travel are separated by a Test Level 4 (TL-4) concrete median barrier.[6] At the location of the crash, the eastbound lanes consist of five 12-foot-wide lanes: one high-occupancy vehicle (HOV) lane on the far left and four through-lanes. The travel lane for exit 4 ended about 200 feet before (west of) the location of the crash.

The eastbound roadway had 10-foot-wide left and right shoulders, which were delineated from the travel lanes by 4-inch-wide solid yellow and white lines, respectively. The HOV lane was delineated from the left through-lane by an 8-inch-wide solid white line. The through-lanes were delineated by a combination of 4-inch-wide dashed white lines and raised bi-directional, retroreflective pavement markers. The shoulders had no rumble strips.

The crash occurred on a straight section of roadway forward of a crest vertical curve and in between two horizontal curves.[7] The straight section that preceded the crash location was about 1,320 feet long. The tangent section continued for another 200 feet past the crash location and then transitioned into a right-hand horizontal curve.

The posted speed limit on SR-202 was 65 mph. The eastbound roadway had numerous advance exit signs, including the sign for Priest Drive (exit 6), which the truck driver reported that he intended to take. The advance exit sign for Priest Drive was located 1.5 miles before that exit and 1,642 feet before the crash location.

As determined by the Arizona Department of Transportation (ADOT) in 2020, the annual average daily traffic for both westbound and eastbound directions of travel on SR-202 near the crash location was 104,271 vehicles; 90% were passenger

[6] The concrete barrier was rated as a National Cooperative Highway Research Program (NCHRP) NCHRP-350 TL-4 barrier. A TL-4 barrier is typically installed for general use on high-speed freeways with a mix of passenger vehicles and truck traffic. The crash test for TL-4 barriers is intended to provide resistance in most real-world crashes where typical impact scenarios do not exceed the practical worst-case scenarios of a 15-degree impact angle at 50 mph with a 19,700-pound single unit truck.

[7] A *crest vertical curve* connects an ascending grade to a descending grade.

vehicles.[8] Examination of the 5-year crash history—from 2016 to 2020—within 4 miles of the crash location in both directions of travel revealed 1,501 crashes, including two fatal rear-end crashes involving heavy vehicles.[9]

1.3.2 Precrash Events and Temporary Traffic Control

Earlier that evening before the crash, AZDPS had established a traffic incident management area in the eastbound lanes of SR-202 with temporary traffic controls in support of law enforcement activity.[10] At 8:53 p.m., the AZDPS contacted the ADOT Traffic Operations Center (TOC), informing them that they would close eastbound SR-202 for a short period to search for perishable evidence. At that time, the AZDPS initiated closure of the eastbound lanes using flares, traffic cones, and police vehicles to set up a travel lane taper in advance of the closed section of the road. At 9:16 p.m., the AZDPS closed all five eastbound lanes, diverting traffic to the Priest Drive exit ramp. The NTSB was unable to obtain information specifying where the AZDPS started lane tapering. At 10:00 p.m., the AZDPS opened all five eastbound lanes at the same time.

As part of traffic control for the road closure, AZDPS coordinated with ADOT TOC to activate two permanent dynamic message signs (DMS) located in advance of roadway closure.[11] The two DMS installations were located at mile marker 1.75 (about 12,080 feet before the crash location) and mile marker 4.1 (about 330 feet after the crash location) and were activated at 9:06 p.m. and 9:09 p.m., respectively. The DMS displayed the following message across three lines:

LAW ENFORCEMENT
AT PRIEST
EXPECT TO STOP

[8] The annual average daily traffic in 2018 for east- and westbound travel on SR-202 in this same location was 157,230 vehicles, 93% of which were passenger vehicles.

[9] The two rear-end crashes occurred in the eastbound direction of SR-202, on March 12, 2016, and on July 16, 2020. The 2016 crash occurred on the right shoulder, during nighttime conditions, and resulted in one fatality. The 2020 crash occurred in the second lane to the left, during daylight, and resulted in two fatalities.

[10] About 7:58 p.m., a shooting incident occurred in the eastbound lanes of SR-202, just forward of exit 6. About an hour later, the AZDPS officers initiated a search for evidence (ammunition shell casings) in the area.

[11] A *DMS* or *changeable message sign* (CMS) is a traffic control device that can display one or more alternative messages. Chapter 2L of the Manual on Uniform Traffic Control Devices for Streets and Highways describes the standard and the guidance for CMSs; ADOT uses the term DMS.

This message alternated every 2 seconds with a dynamic travel time (DTT) message.[12] These messages were still being displayed on the two DMS at the time of the crash; ADOT TOC removed the message related to the precrash road closure at 10:08 p.m.[13]

1.3.3 Guidance for Traffic Incident Management

ADOT relies on the Federal Highway Administration's (FHWA) *Manual on Uniform Traffic Control Devices for Streets and Highways* (*MUTCD*) standards and guidance for installing and maintaining traffic control devices and managing traffic incidents.[14] Chapter 6I of the *MUTCD* provides guidance for controlling traffic through incident management areas.[15] A traffic incident is defined as an "emergency road user occurrence, a natural disaster, or other unplanned event that affects or impedes the normal flow of traffic," and is categorized into three types (minor, intermediate, and major incidents) depending on its duration and travel lane closures.

Minor incidents have an expected duration of less than 30 minutes and typically involve disabled vehicles and minor crashes that may briefly block a travel lane. Minor incidents are usually handled by law enforcement, and due to their short and minor nature, it is typically not practical to set up lane closure with traffic control devices.

Intermediate incidents have an expected duration of between 30 minutes and 2 hours, and usually require traffic control to divert road users around the blockage. Intermediate incidents typically involve multiple lane closures, but full roadway closure may be necessary for a short duration to allow access for traffic incident responders.

Major incidents have an expected duration of more than 2 hours, typically include fatal crashes involving multiple vehicles or hazardous materials, and involve full or partial roadway closure.

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[12] (a) A typical DTT message displays the next major interchange with the estimated time to travel to that interchange. The exact language of the displayed DTT message at the time of the crash is unknown. (b) The warning message about traffic stoppage was inadvertently blanked by TOC personnel between 9:35 p.m. and 9:47 p.m. During these 12 minutes, either a DTT-only message was displayed, or a DTT message alternated with a Covid-19 message.

[13] The DTT message remained on the two DMSs, which started alternating the DTT message with a Covid-19-related message, as was the case before the activation of the warning message about traffic stoppage.

[14] ADOT adopted the current *MUTCD* edition, published in 2009.

[15] See the *MUTCD* for additional details.

1.3.4 Guidance for Using Dynamic Message Signs

Section 2L of the *MUTCD* discusses standards and guidance for using DMS. The messages that ADOT TOC displayed on the two DMS installations in advance of the roadway closure on the evening of the Phoenix crash conformed to *MUTCD* requirements for characters, size, spacing, color, and brightness. The ADOT TOC relied on its operations manual to classify the priority level of messages to be displayed on DMS, which in turn affected whether they would be presented as standalone messages or allowed to alternate with other lower-priority messages. In addition, a DTT message is automatically displayed on relevant DMS installations between 5 a.m. and 11 p.m. Monday through Friday, and between 7 a.m. and 9 p.m. Saturday and Sunday.

The TOC operations manual describes 10 priority levels of messages, sorting them into high and low levels. High-priority messages (levels 1–3) override standard DTT messages and are presented as standalone messages. High-priority messages include (level 1) automated wrong-way messages, (level 2) active unplanned closures of ADOT roads, and (level 3) active planned closures of ADOT roads. Low-priority messages (levels 4–10) can alternate with standard DTT messages and include (level 4) active unplanned lane restrictions or ramp closures, (level 5) active planned lane restrictions or ramp closures, and (levels 6–10) information related to event messages, future construction, and various alerts such as Amber alerts.[16]

ADOT stated that the message regarding law enforcement activity and traffic stoppage was classified as a level-4 message, which allowed the automated display control system to alternate the traffic stoppage warning message with a DTT message.

1.4 Vehicle Factors

1.4.1 Combination Vehicle

1.4.1.1 General Description. The combination vehicle consisted of a 2016 Freightliner Cascadia truck-tractor and a 2015 Walker Stainless Equipment tank-trailer (see figure 5 for an image of an exemplar vehicle). The truck-tractor was equipped with a Detroit Diesel 400-horsepower engine, a 12-speed automatic transmission, and Wabco pneumatic brakes. At the time of manufacture, the truck-tractor had a gross vehicle weight rating (GVWR) of 52,000 pounds; the GVWR of the semitrailer

[16] An *automated wrong-way message* alerts traffic of a driver ahead that is traveling in the wrong direction. An *Amber alert* is an emergency message to the public about a child abduction in that area.

was 65,000 pounds.[17] The combination vehicle was registered with a total GVWR of 80,000 pounds. At the time of the crash, the tank-trailer was loaded with 54,100 pounds of raw milk, and the combination vehicle weighed 81,860 pounds.[18] The speed of the truck-tractor was electronically limited to 68 mph. The truck-tractor was not equipped with forward collision warning or automatic emergency braking, nor was it required to be so equipped.[19]

Figure 5. Right-side view of an exemplar combination vehicle with AMT truck-tractor and UDA tank-trailer.

1.4.1.2 Damage. The entire cab and engine of the truck-tractor sustained severe fire damage (see figure 6). The truck-tractor's frame rails were displaced outward, and the front frame connector was displaced inward, showing signs of impact with melted remnants of other material. The postcrash fire masked evidence of the truck-tractor's contacts with the passenger vehicles. The rear of the truck-tractor was largely undamaged. The two side saddle fuel tanks were not compromised.

[17] *Gross vehicle weight rating* (GVWR) is the total maximum weight that a vehicle is designed to carry when loaded, including the weight of the vehicle itself plus fuel, passengers, and cargo.

[18] The NTSB examined weight scale tickets for the crash-involved driver. Of the 111 examined tickets in the month before the crash, 58 were more than 1,000 pounds over the registered vehicle weight. A commercial vehicle traveling over the GVWR is subject to a fine. According to the contract between UDA and AMT, the carrier is responsible for any fines related to load weight limits. Furthermore, the contract states that UDA compensates AMT for transportation of milk weight only up to the GVWR of 80,000 pounds.

[19] Starting with the 2018 model of the Freightliner Cascadia truck-tractor, forward collision warning and automatic emergency braking are standard equipment.

Figure 6. View of damage to the left side of truck-tractor.

The tank-trailer did not sustain any fire damage. The load of milk spilled onto the roadway through the displaced loading hatch on top of the tank. The kingpin coupler under the front end of the trailer still had the fifth wheel plate from the truck-tractor locked in.[20] The plate was torn away from the sliding fifth wheel assembly on the tractor during the impact with the concrete median barrier. The stainless caps on the front and the end of the tank-trailer were partially detached, exposing the foam insulation (see figure 7). Other damage to the tank-trailer included scuff marks across the entire right side of the trailer and displaced front and rear fenders and their support brackets.

[20] The *fifth wheel assembly* and *kingpin* form the two-part connection between a truck-tractor and a semitrailer. The assembly has a U-shaped top plate on which the semitrailer rests and is mounted to the frame rails of the truck-tractor. The kingpin from the semitrailer then slides into the channel created by the U-shape of the fifth wheel assembly.

Figure 7. View of damage to the front and right side of tank-trailer. The yellow circle highlights the fifth wheel assembly.

1.4.1.3 Mechanical Inspection. The impact and fire damage affected all major mechanical systems of the truck-tractor. Because of the fire damage, functional checks of the truck-tractor's steering, electrical, brake, and suspension systems could not be completed. The steering and electrical systems sustained comprehensive damage. Most of the suspension components on the front axle were missing or damaged from the impact or fire. Most of the suspension components on axles 2 and 3 were intact.

The tires on the front axle were destroyed in the postcrash fire, and the aluminum wheels were damaged and partially melted. The outside tires on the left side of axles 2 and 3 deflated during the crash sequence. The remaining tires on axles 2 and 3 had inflation pressure slightly below the recommended level.[21] The

[21] The recommended inflation pressure for these tires is 105 psi (pounds per square inch). The remaining six tires had a tire pressure between 70 and 100 psi at the time of the postcrash inspection. Because tires can lose pressure during a crash, these psi levels were likely not the levels at the time of the crash.

tread depth of the tires on axles 2 and 3 was between 9/32 and 21/32 inches, well above the minimum requirement of 2/32 inches.[22]

The tank-trailer had pneumatic drum brakes on both axles, and the functional check of the braking system showed that it was operational. All examined brake components met or exceeded minimum specifications, as did the tread depth of the tires.[23]

1.4.1.4 Maintenance and Safety Recalls. The motor carrier's maintenance records indicated that the truck tractor's last annual inspection, as required by federal regulations, was conducted on December 28, 2020.[24] The NTSB examined 2 months of driver-vehicle inspection reports for the truck-tractor, completed by the crash-involved driver; the reports did not state any maintenance deficiencies. The carrier performed regular maintenance of the truck-tractors in its fleet; major repair work was conducted by a Freightliner dealership. Freightliner reported a warranty claim on the truck-tractor for a cracked crossmember, submitted on April 12, 2019; the cracked part was removed and a new one installed.[25]

The tank-trailer was owned by Shamrock Dairy and leased to UDA. UDA had performed preventive maintenance and all required annual inspections on the tank-trailer since February 2018; the last annual inspection was conducted in May 2021.

No safety recalls affected the truck-tractor or the tank-trailer, and the units were not subject to a roadside inspection in the 2 years before the crash.[26]

1.4.1.5 Data Recording Systems. The truck-tractor was equipped with an engine control module, which under certain conditions can record event-related data such as vehicle speed. However, because of damage from the postcrash fire, no usable data were retrieved from the module.

The truck-tractor was also equipped with Lytx DriveCam, a fleet management monitoring and recording device that continually tracks driving performance metrics and records pertinent information when triggered by critical events, such as hard

[22] The minimum tread depth for tires on axles other than the steer (front) axle is 2/32 inches (49 *CFR* 393.75[c] and 49 *CFR* 570.62). The minimum tread depth for tires on the steer axle is 4/32 inches (49 *CFR* 393.75[b]).

[23] (a) According to 49 *CFR* 393.47(d), the minimum brake pad thickness for hydraulic disc or drum brakes is 1.6 millimeters or 1/16 inches on both the steering axle and non-steering axle brakes. (b) The tread depth of the tires on axles 4 and 5 (the trailer) was between 8/32 and 11/32 inches.

[24] See 49 *CFR* 396.3.

[25] A *crossmember* is a beam that provides structural rigidity to the truck-tractor. It is mounted above the transmission and connects frame rails.

[26] The safety recall information was obtained from the [NHTSA safety recall database website]().

braking (rapid deceleration) or stability control activation.[27] The system consists of a two-channel image recorder with forward- and inward-facing cameras, an omnidirectional microphone, a 3-axis accelerometer, and a GPS. The crash had triggered recording of data, including video from the two onboard cameras and the vehicle dynamic parameters. Because the recording is automatically transmitted to the cloud, the postcrash fire did not affect data preservation. The obtained data showed crash-relevant information, including 8 seconds of preimpact and 4 seconds of postimpact events. The video footage from the forward- and inward-facing cameras was recorded at 4 frames per second.

The preimpact data from the system showed that 8 seconds before impact, the combination vehicle was traveling at a speed of 64 mph. During the next 5 seconds, the speed gradually decreased to 62 mph, where it remained at the time of the initial impact. At initial impact, the longitudinal deceleration was 2.72 *g* and lateral acceleration was 1.73 *g*.

The video footage from the system's forward-facing camera shows the combination vehicle traveling in the right lane at the beginning of the video, 8 seconds before impact. At that time, the brake lights from other vehicles in the right travel lane, ahead of the combination vehicle, were visible in the distance for the entire duration of the video (see figure 8). Vehicles in the lanes to the left appeared to be traveling at the approximate speed of the combination vehicle, as they maintained constant longitudinal distance. At 5.5 seconds before impact, the video shows the combination vehicle traveling at 63 mph, and vehicles in the lanes to the left starting to brake with their brake lights illuminated. At 3.2 seconds before impact, the video shows the combination vehicle traveling at 63 mph and passing the exit 4 sign, and the brake lights from the vehicles in the right lane of travel remained illuminated. At 2.2 seconds before impact, the video shows a three-line message on the DMS sign, but the displayed message was illegible due to low resolution of the video.[28] The fourth video capture in figure 8 shows the roadway 0.5 seconds before the crash.

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[27] The threshold for triggering a stability control event is lateral movement of at least 0.4 *g* (force of gravity); for a hard-braking event, the trigger is a 9-mph deceleration in 1 second.

[28] The video footage from the forward- and inward-facing cameras has a resolution of 640 by 368 pixels.

Figure 8. Capture of the video from truck-tractor's forward-facing camera at 8 seconds (top image), 5.5 seconds (second image from top), 2.2 seconds (third image), and 0.5 seconds (fourth image) before impact.

The video footage from the system's inward-facing camera shows that 8 seconds before impact, the truck driver was seated upright in the driver's seat, facing forward, wearing an earphone and glasses, and with his left hand on the steering wheel and his right hand resting in his lap.[29] The video shows the driver remaining largely in the same position until 0.25 seconds before impact, when he lifted his right hand from his lap and gripped the steering wheel. Due to the low resolution, it was not possible to determine whether the driver's eyes were open or closed for the duration of the preimpact sequence.

1.4.2 Passenger Vehicles

1.4.2.1 Damage. Seven passenger vehicles were involved in this crash. The NTSB examined vehicle damage and roadway evidence and interviewed several surviving passenger vehicle occupants to determine the positions of the passenger vehicles in the traffic queue. Of the seven involved passenger vehicles, four sustained catastrophic damage (see figures 9 through 12), which included extensive intrusion into the front and rear occupant seating areas (for all four vehicles), collapsed roof structure (for three vehicles), being overridden by the truck-tractor (for the Ford and the Chevrolet), and comprehensive fire damage, including the disintegration of the fuel tank (for the Chevrolet). Three vehicles sustained major damage, which included extensive rearward/forward displacement of front/rear ends, along with some intrusion into the rear seat areas. Table 2 depicts damage of the passenger vehicles with injuries sustained by their occupants.

[29] (a) Only the earphone in the truck driver's right ear was visible. It could not be determined if he had an earphone in the left ear. (b) According to Arizona Revised Statutes 28-914, a driver is permitted to use headphones or earphones for hands-free communication. According to the Federal Motor Carrier Safety Administration, citizens band (CB) radios and earphones are not prohibited by regulations, as long as such devices do not distract the driver and the driver is capable of complying with the hearing requirements under 49 *CFR* 391.41(b)(11).

Figure 9. Overhead view of damage to Ford. The red circle on the vehicle's roof highlights tire marks made by the truck-tractor.

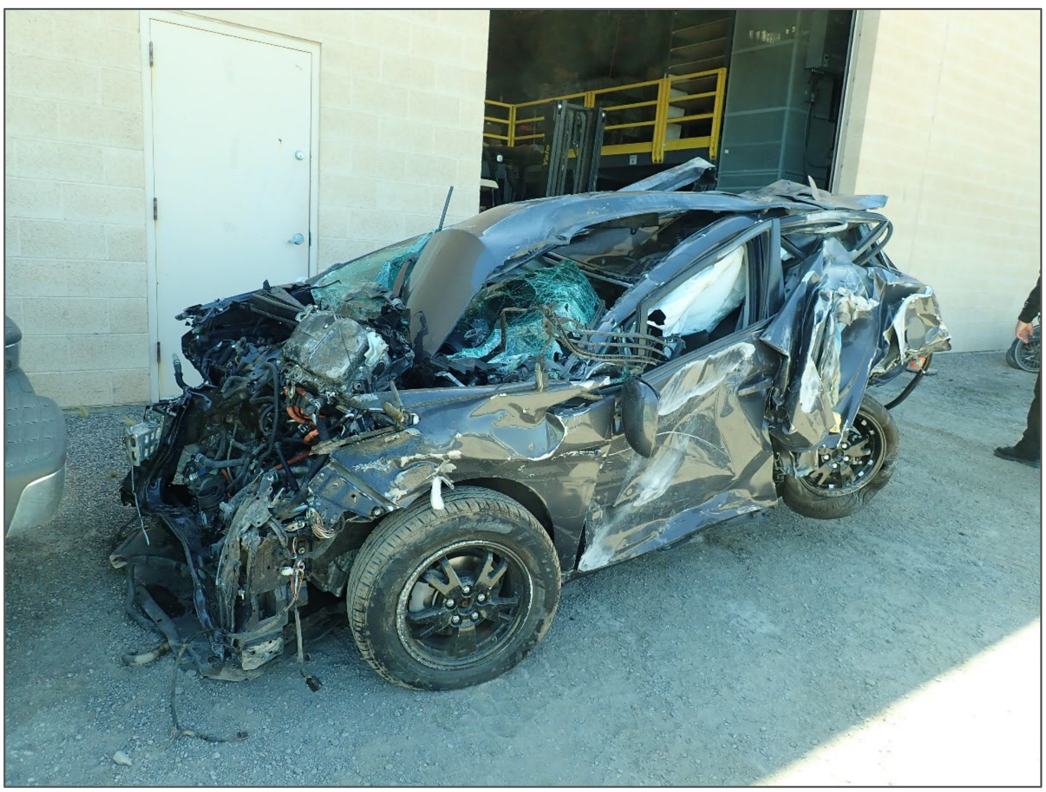

Figure 10. Left and front view of damage to Toyota.

Figure 11. Left-side view of damage to Chevrolet.

Figure 12. Right-side view of damage to Nissan.

Table 2. Passenger vehicle damage description.

Vehicles [a]	Occupant Injuries	Damage [b]
2016 Ford Fusion	- 2 fatal - 2 serious	- Catastrophic damage with extensive loss of survivable space in front and rear seat areas - Truck-tractor left tire marks along the left side of the roof
2013 Toyota Prius	- 1 serious	- Catastrophic damage with extensive deformation of front and rear seat areas
2021 Chevrolet Equinox	- 1 fatal	- Catastrophic damage with extensive loss of survivable space; engulfed in fire - Pushed by the truck to final rest location
2015 Nissan Altima	- 1 fatal - 1 serious - 2 minor	- Catastrophic damage with extensive intrusion into rear seat area. Considerably more damage on the right side than the left - Struck by truck-tractor with entangled Chevrolet
2015 Dodge Charger	- 1 serious - 1 minor	- Major damage - Primary impacts to the front and rear ends with extensive intrusion into rear seat area
2018 Mercedes-Benz C300W	- 2 minor	- Major damage - Primary impacts to the front and rear ends; driver seatback damage
2013 Lexus CT200H	- 1 minor	- Major damage - Primary impact to the rear end and limited intrusion into rear seat area

[a] Vehicles are listed in the order of their position in the traffic queue, with the Ford being at the end and struck first by the combination vehicle.

[b] For a comprehensive description of damage, see the technical reconstruction and survival factual reports in the docket for this investigation.

1.4.2.2 Data Recording Systems. All seven passenger vehicles were equipped with an airbag control module (ACM). The primary function of an ACM is to control deployment of the vehicle's supplemental restraint system, such as airbags. The ACM typically also contains a data recorder, which records certain parameters related to the activation of the restraint systems, vehicle speed, and application of the brake and accelerator. The NTSB and AZDPS retrieved the ACM data from six of the seven involved passenger vehicles. The ACM on the Chevrolet sustained extensive fire damage and data on the module were not readable.

Each of the six recovered ACMs contained data related to the crash, specifically to the initial impact each ACM detected. The ACMs recorded 5 seconds of data before the triggering event. Due to their additional recording capabilities, five of the six ACMs recorded additional events capturing subsequent impacts by or into other vehicles; the Nissan recorded data related only to the initial impact into the Nissan by another vehicle.

The recorded data from the passenger vehicles' ACMs showed that all vehicles except the Lexus were stationary for at least 4.6 seconds before each vehicle's ACM issued a command for deployment of the supplemental restraint system—before the impact. The Lexus was stationary for at least 4 seconds, until about half a second before the ACM triggered airbag deployment, at which point the Lexus driver stopped applying the brake and engaged the accelerator.

In summary, the vehicle data showed that the seven passenger vehicles in the queue were stopped when the combination vehicle struck the rear of the queue, initiating the crash sequence.

1.5 Crash Sequence

The NTSB examined vehicle damage and roadway documentation to ascertain the crash sequence, including the positions of passenger vehicles in the traffic queue. We also relied on the video from the truck-tractor's forward-facing camera to identify the passenger vehicles at the end of the traffic queue. The roadway evidence, which stretched diagonally for about 667 feet across the eastbound lanes, consisted of numerous roadway surface scrapes and gouges, fluid trails, tire friction marks, vehicle component debris, and contact with roadway hardware.

The crash sequence (see figure 13) started with the combination vehicle striking the rear of the Ford in the right lane of SR-202. The Ford was propelled into the rear of the Toyota, which showed evidence of being underridden.[30] The force of impact by the combination vehicle pushed both the Ford and the Toyota toward the right shoulder and into the right concrete barrier. As the combination vehicle continued eastward, the rear axles of the truck-tractor overrode the left side of the Ford.

[30] The rear bumper of the Toyota was displaced downward, rotated inward and then upward, indicating that the Ford partially intruded underneath the rear of the Toyota.

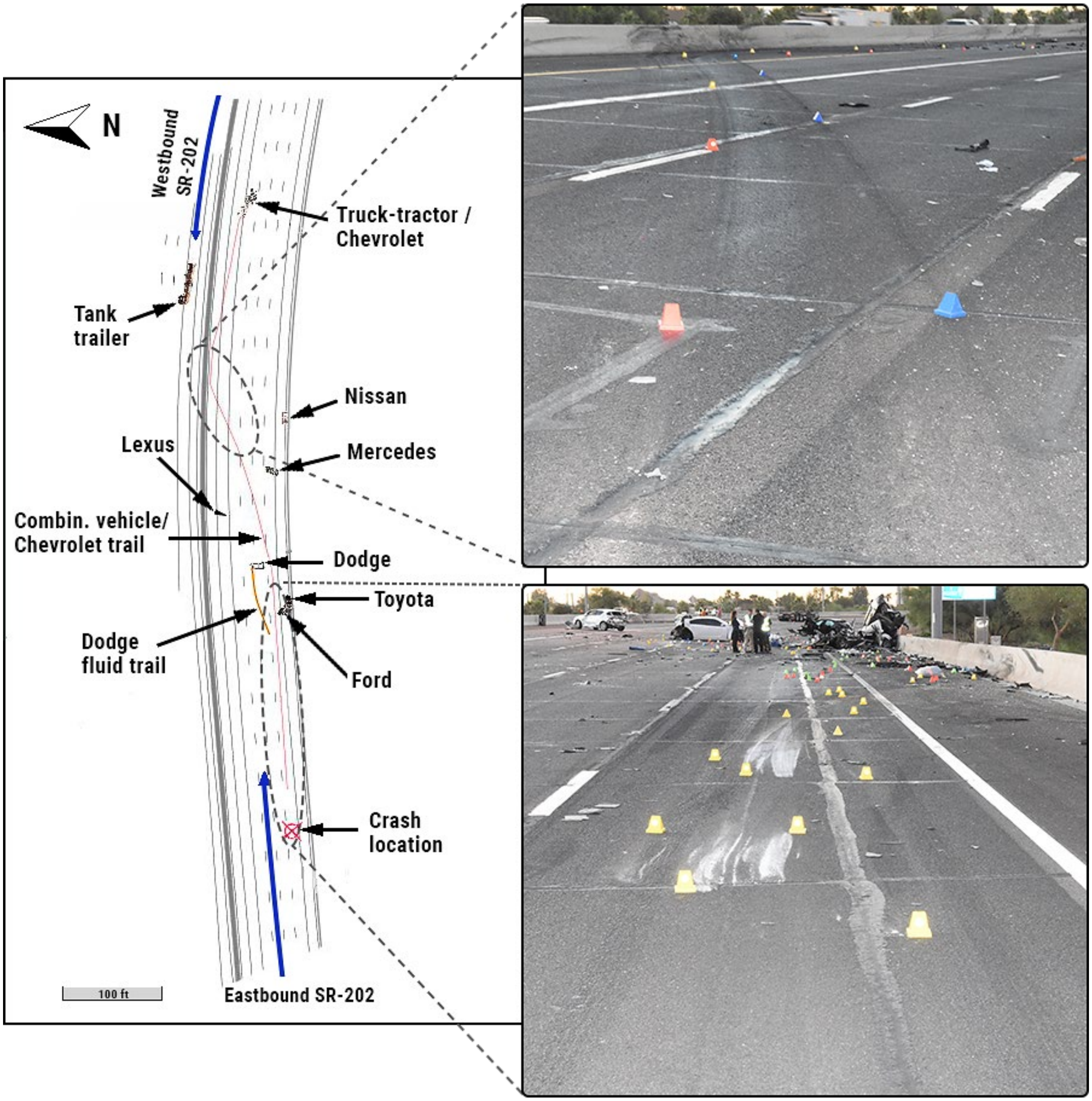

Figure 13. Postcrash scene diagram depicting the locations of rest of the truck-tractor, tank-trailer, and the seven passenger vehicles. Two insets show areas of significant roadway evidence leading to the concrete median barrier (upper) and toward the right concrete barrier (lower). (Insets source: AZDPS)

The combination vehicle then struck and partially overrode the rear of the Chevrolet, which became entangled with the front end of the truck-tractor. The combination vehicle together with the entangled Chevrolet struck the rear of the Nissan, which was pushed into the rear of the Dodge, which in turn was pushed into the rear of the Mercedes-Benz. As the combination vehicle with the entangled Chevrolet continued in the northeasterly direction, the Nissan and the Mercedes-

Benz continued in the eastbound direction, colliding with each other before coming to rest. Finally, as the combination vehicle with the entangled Chevrolet moved across the travel lanes toward the median barrier, it struck the rear of the Lexus, which came to rest in the left lane. As previously described, when the combination vehicle struck the concrete median barrier, the tank-trailer separated from the truck-tractor and overrode the barrier, and the truck-tractor and the entangled Chevrolet came to rest in the left eastbound lane. No collisions occurred in the westbound lanes after the tank-trailer overrode the median barrier and came to rest in the left westbound lane and on the left shoulder.

1.6 Truck Driver

1.6.1 Licensing, Employment History, and Driving Record

The 47-year-old truck driver started working for motor carrier AMT in November 2008. At the time of the crash, he held an Arizona class A commercial driver's license (CDL), with endorsements that allowed him to operate double-, triple-, and tank-trailers, and with a restriction prohibiting him from operating a commercial vehicle without corrective lenses.[31] His CDL was renewed in April 2021, with an expiration date of April 2026. He obtained his first CDL in 2000 after graduating from a trucking school in California, after which he worked as a commercial driver at five other companies before joining AMT in 2008.

The truck driver also had a valid permit to sample and haul grade "A" raw milk, as required by the Food and Drug Administration (FDA) and the state of Arizona.[32] Information about milk transportation is included in section 1.7.3.

A review of the National Highway Traffic Safety Administration (NHTSA) National Driver Register, CDL information systems, and the National Law Enforcement Telecommunications System indicated that the driver did not have any convictions, violations, or crashes.

The AMT records documented eight incidents involving the truck driver in the 3 years before the crash. These incidents occurred while the driver was driving, loading/unloading, or parked. In January 2019, the truck driver noticed smoke from

[31] According to 49 *CFR* 383.71, a class A CDL allows drivers to operate a single vehicle with a GVWR greater than 26,000 pounds, and it allows towing another vehicle weighing over 10,000 pounds.

[32] (a) For the FDA requirement, see *Grade "A" Pasteurized Milk Ordinance*. US Department of Health and Human Services Public Health Service, Food and Drug Administration, 2019 revision. (b) For the Arizona requirement, see *Bulk Milk Hauler/Sampler Study Materials*. Arizona Department of Agriculture, January 2015.

the rear trailer axle, stopped to examine the cause, but continued driving after the smoke dissipated. When he arrived at the UDA milk-processing facility, he realized that the rear axle dual wheels on the driver's side had separated earlier.[33] In March 2020, the driver damaged a fifth wheel crossmember while dropping off a trailer. On September 7, 2020, motor carrier AMT reprimanded the driver for using a cell phone while driving, warning him that such conduct could lead to termination; the warning was based on the recorded video from the DriveCam system (see section 1.7.6.2 for additional information).[34]

1.6.2 Medical Certification, Health, and Toxicology

The truck driver obtained his most recent US Department of Transportation (USDOT) CDL medical certificate in August 2020; it was valid for 2 years.[35] On the medical certification form, the driver reported not having any illness or injury and that the only medication he had taken in the past 5 years was an over-the-counter medication for seasonal allergies. The driver's corrected visual acuity was reported as 20/20, and the medical examiner noted the driver to be overweight with a body mass index of 29. The driver reported to the NTSB that he did not have any health conditions, was not taking prescription medication, did not consume alcohol or use illicit drugs, and did not have a primary care physician.

During the application process with motor carrier AMT, the truck driver underwent two preemployment urine drug tests in November 2008; the test results were negative. AMT also requested that the driver undergo alcohol and other drug tests following the two minor incidents in January 2019 and March 2020, as described in section 1.6.1; the test results were negative on both occasions. The truck driver was also subject to a random drug test in November 2019; the results were negative.

After the collision, AMT had the truck driver take the USDOT postcrash drug tests, as required by 49 *CFR* 382.303. The test for alcohol was conducted as a breathalyzer test, and no alcohol was detected. The test for other drugs was

[33] Dual wheels may separate from a vehicle when critical components—lug nuts, axle hub, and spindle—that secure the wheels to a rear axle fail. Drivers may not necessarily feel the loss of dual wheels on certain trailers while driving, and any damage to the axle hub or spindle would not be noticed by drivers during a regular pretrip inspection.

[34] The remaining five incidents involved a citation for leaving a truck unattended and idling, an unfounded accusation of rear-ending a passenger vehicle (no evidence of damage), a UDA yardman noticing missing right front wheels on the trailer that the driver picked up, and two incidents in which another vehicle impacted the truck operated by the crash-involved driver (both resulted in minor damage).

[35] Title 49 *CFR* 391.41 and 391.43 specify the medical certification requirements for CDLs.

conducted as a urine test, which was collected at 3:42 a.m., about 5.5 hours after the crash; the result was negative.[36]

1.6.3 Route History and Activities Before the Crash

The truck driver had relatively consistent routes that he operated, transporting raw milk from several dairy farms within a 150 air-mile radius of the UDA milk-processing facility in Tempe, Arizona. (Radius is illustrated in figure 14. For further discussion about the exemption from hours-of-service (HOS) regulations if operating within this radius, see the next section). The truck-tractor that he operated at the time of the crash was the assigned truck that he had been operating for 3 years. No other drivers operated this truck-tractor.

The truck driver's commute from home to the AMT yard was about 45 minutes to an hour. His shift would begin upon arrival at the yard where he would complete a pretrip safety inspection of the truck-tractor and then drive to the UDA facility to get an assigned tank-trailer. After completing steps related to milk sanitization and safety (see section 1.7.3), he would drive the combination vehicle to a dairy farm. There, he would complete steps related to milk sanitization and verification of milk safety before accepting the load into the tank-trailer, after which the vehicle would be weighed at the dairy farm's scale. Next, he would return the combination vehicle to the UDA facility, weigh the load at UDA's scale, complete steps related to verification of milk safety, and then unload the tank-trailer. During each shift, he would complete two or three trips between the UDA facility and a dairy farm. At the end of each shift, he would drop off the last tank-trailer at the UDA facility, refuel the truck-tractor as needed, and then return the truck-tractor to the AMT yard where he completed a post-trip inspection. The AMT yard and the UDA facility are about 1/2 mile apart and about 4 miles south of the crash location.

At the time of the crash, the truck driver was driving the combination vehicle from Stotz Dairy, about 50 miles west of the crash location, to the UDA facility (figure 14). This was his second load of the day.

The NTSB used information obtained from interviews with the truck driver, his cell phone records, AMT and UDA records, AMT security videos, DriveCam videos, and witness statements to reconstruct the truck driver's activities before the crash. His work records, including the self-reported timesheets, are further discussed in section 1.7.6. He told the NTSB that he always slept 7–8 hours a night and that he would sometimes start his shift late in order to obtain sufficient sleep. He reported waking up about 10:30 a.m. on June 7, and also reported typically waking up at

[36] The USDOT-required urine drug test must be administered within 32 hours of the crash, and it checks for amphetamines, marijuana, phencyclidine, cocaine, opioids, MDA analogues, oxycodones, and 6-Acetylmorphine.

7 a.m. or 8 a.m. due to family obligations. In the postcrash interview with the AZDPS, the driver stated that on the day of the crash he woke up about 10:30 a.m.–11 a.m. His phone records for the 3 days before the crash indicate regular cell phone use—outgoing calls and text messages through short message service (SMS)—during his work hours, although it is not possible to determine whether he was driving during those times.[37] The phone records also indicate a 39-minute phone call that started shortly after 9 a.m. on Monday, 2 days before the crash. Figure 14 shows the truck driver's activities in the 3 days before and on the day of the crash.

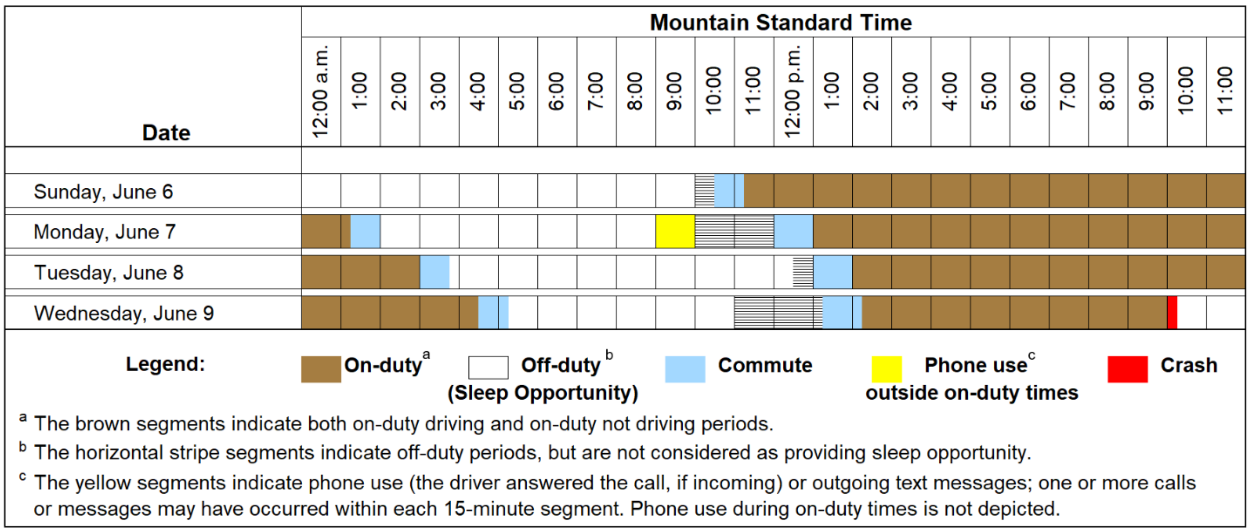

Figure 14. Precrash activities of truck driver, June 6–9, 2021. Phone use during duty hours is not depicted in the figure.

The truck driver did not work on June 5. On June 6, after about a 10-hour opportunity for sleep, he arrived at the AMT yard and began his shift about 11:30 a.m. He completed the shift about 1:15 a.m. on June 7, and returned home about 2 a.m. On June 7, after about a 7-hour opportunity for sleep, he arrived at the AMT yard and started his shift about 1 p.m. He completed his shift and returned home about 3:30 a.m. on June 8. On June 8, after about an 8.5-hour opportunity for sleep, he arrived at the AMT yard and started his shift about 2 p.m. He completed his shift and returned home about 5 a.m. on June 9.

On the day of the crash, June 9, after having an approximately 5.5–6-hour opportunity for sleep, the truck driver left his home about 1:15 p.m. and arrived at the AMT yard at 2:16 p.m., at which time he performed a pretrip inspection of the truck-tractor. He then left the yard and drove to UDA to pick up the tank-trailer. He left UDA

[37] In his interview with the NTSB, the truck driver stated that he kept his cell phone in the truck-tractor and might answer an incoming call through wireless headphones, but that he never physically handled the phone while driving. Between June 6 and June 9, during his work and commute hours, he made eight phone calls and sent 25 text messages.

about 3 p.m. and drove to Buckeye, Arizona, to pick up his first load at Rainbow Valley Dairy, arriving about 4:15 p.m. After accepting the load, he left the dairy farm about 5:00 p.m. and returned to the UDA facility, arriving about 6:30 p.m. He finished unloading the milk at 7:45 p.m. and then drove to Buckeye to pick up the next load at Stotz Dairy, arriving about 8:40 p.m. After accepting the load, he left the dairy farm about 9:25 p.m. and started returning to the UDA facility. The crash occurred about 30 minutes after the departure from Stotz Dairy. Although the truck driver was using his cell phone at various times that day, phone records indicate that he was not using it at the time of the crash.[38]

In his postcrash interview with the AZDPS, the truck driver stated that, before the crash sequence began, he noticed brake lights in the distance indicating a backup, and that he later saw smoke. He further stated that smoke and flames suddenly appeared from around the truck's steer axle, although he said he did not know where the smoke originated. The truck driver reported pressing hard on the brakes and that smoke completely obscured his vision. He then reported colliding with something, but also stated that he did not know whether it was a vehicle or a concrete wall. He stated that, at the end of the crash sequence, the driver's side of the truck-tractor collided with the median barrier, which almost caused the vehicle to overturn. The truck driver also reported that when the vehicle finally came to rest and he saw flames entering the truck cab, he exited the truck-tractor. He said he was unable to estimate the time between first seeing the smoke and feeling the collision. The video footage from the truck-tractor's forward- and inward-facing cameras does not show any smoke or fire before the initial impact with the Ford.

1.7 Motor Carrier and Milk-Processing Operations

1.7.1 Overview of Arizona Milk Transport

AMT, a for-hire intrastate non-hazardous-materials motor carrier located in Tempe, Arizona, obtained USDOT authorization to operate in November 2005. At the time of the crash, the carrier operated 26 truck-tractors and employed 35 CDL drivers; the carrier did not own or lease any trailers. AMT was contracted by UDA to transport raw milk in the Phoenix metropolitan area.

[38] (a) The truck driver stated that he was not using the cell phone at the time of the crash. (b) Although records show that the driver had used his cell phone earlier in the day (outgoing calls and sent text messages), due to the lack of other evidence (such as continuous data from the vehicle's electronic control module), it could not be determined whether the driver's use of his cell phone earlier in the day occurred while driving.

The AMT chief executive officer stated that because the carrier transported raw milk within a 150 air-mile radius, AMT followed the Federal Motor Carrier Safety Administration (FMCSA) agricultural exemption under 49 *CFR* 395.1(k).

1.7.2 Agricultural Hours-of-Service Exemption

1.7.2.1 History of Hours-of-Service Regulations and Exemptions. In 1935, Congress passed the Motor Carrier Act, which gave the Interstate Commerce Commission (ICC) the authority to regulate interstate truck and bus companies, including maximum driver HOS. At that time, several industries were exempted from these HOS regulations, including "motor vehicles used in carrying property consisting of ordinary livestock, fish (including shellfish), or agricultural (including horticultural) commodities . . ."[39] Although not mentioned specifically, raw, pasteurized, and homogenized milk was implicitly included in this Act as exempt agricultural commodities (Campbell 1960).

When the ICC was dissolved in 1995, other agencies assumed relevant regulatory duties.[40] At that time, Congress passed the National Highway System Designation Act, which confirmed the exemption for many agricultural commodities, but also limited the exemption radius to a 100 air-miles travel distance from a vehicle's point of origin.[41]

In January 2005, Congress passed the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), which included some revisions to the agricultural exemption and codified the exempt commodities in 49 *CFR* 395.2.[42] The exemption radius remained at 100 air-miles.

In October 2012, Congress passed the Moving Ahead for Progress in the 21st Century Act (MAP-21), which confirmed and expanded the list of commodities covered under agricultural exemption. MAP-21 also increased the operating radius eligible for the agricultural exemption from 100 to 150 air-miles (figure 15).[43] In November 2021, Congress passed the Infrastructure Investment and Jobs Act, which expanded the agricultural exemption to drivers transporting livestock within a 150

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[39] See the Motor Carrier Act of 1935, Section 203(b)(6).

[40] The regulatory power and authority of the ICC was eventually divided among other federal agencies before the ICC was disbanded in the ICC Termination Act of 1995.

[41] See section 345 of the National Highway System Designation Act, Public Law 104-59, November 28, 1995.

[42] The 2005 Act redesignated the agricultural exemption as a new section 229 of Title II of the Motor Carrier Safety Improvement Act of 1999, and defined the terms "agricultural commodity" and "farm supplies for agricultural purposes."

[43] See section 32101(d) of MAP-21 Act.

air-mile radius from the final destination of the livestock.[44] Although states determine the regulations for intrastate commercial transportation, virtually all have adopted the federal regulations pertaining to agricultural exemption, including Arizona.

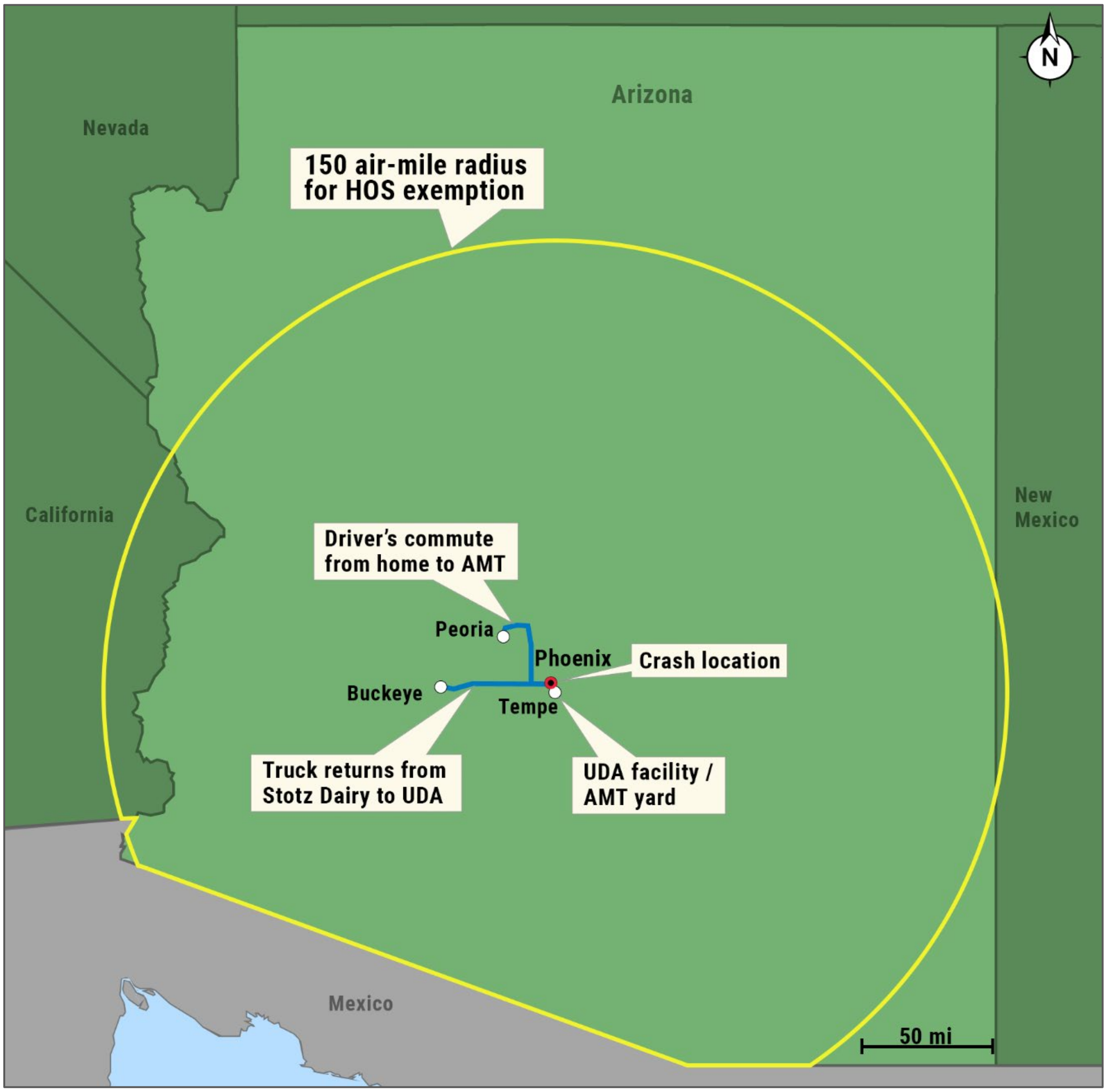

Figure 15. The 150 air-mile radius of the agricultural HOS exemption, overlaid on a map of the state of Arizona. The truck driver's route is also outlined on the map.

The HOS regulations for non-exempt carriers have been largely unchanged from the time of their establishment until 2003. During that period, the maximum on-duty period was limited to 15 hours in a single shift, and 60 hours in a 7-day

[44] See section 23018 of the Act.

period.[45] In 2003, the FMCSA reduced the maximum on-duty time in a single shift to 14 hours, increased the minimum off-duty period between shifts to 10 hours (previously 8 hours), and increased the maximum allowable drive time in a single shift to 11 hours (previously 10 hours).[46] In 2011, the FMCSA made regulatory changes that affected drivers' rest, such as instituting a mandatory 30-minute break during a single shift and requiring two nighttime off-duty periods between each weekly period.[47] The FMCSA stated that the final 2011 rule "will reduce the risk of fatigue and fatigue-related crashes." The maximum on-duty periods in a single shift in the above-mentioned HOS regulations apply to interstate property-carrying commercial motor vehicle drivers; the short-haul drivers were typically limited to 12 on-duty hours in a single shift.

On June 1, 2020, the FMCSA published the most recent revision to the HOS regulations, in which the agency redefined the operating radius of intrastate short-haul motor carriers from 100 air-miles to 150 air-miles and also expanded the number of hours a short-haul driver may operate from 12 to 14 hours.[48] This ruling affects carriers that do not operate under an agricultural HOS exemption.

1.7.2.2 Current HOS Regulations and Exemptions. Transportation of certain agricultural commodities within a 150 air-mile radius—including livestock, bees, horses, fish used for food, and other commodities that meet the definition of *agricultural commodity* under 49 *CFR* 395.2—is exempt from HOS regulations as specified under 49 *CFR* 395.1(k) and 49 *CFR* 395.3(b). A driver operating under an agricultural HOS exemption and within a 150 air-mile radius is also exempt from the electronic logging device (ELD) or paper log requirements specified in 49 *CFR* 395.8.

However, when a driver who operates under an agricultural HOS exemption drives beyond the 150 air-mile radius, the HOS regulations start to apply (starting at 0 hours), and the driver also must maintain a record of duty. Any on-duty hours spent within the 150 air-mile radius do not count toward the driver's daily and weekly on-duty limits of HOS when traveling beyond the mileage limit. When the driver returns to the 150 air-mile radius zone, the HOS stop counting. Drivers who operate under an

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[45] See the 2005 FMCSA final rule, *Hours of Service of Drivers*, ([Federal Register :: Hours of Service of Drivers]), for further detail about the historical changes to HOS regulations.

[46] These changes apply to property-carrying motor carriers. Carriers transporting passengers are subject to different HOS regulations, as outlined in 49 *CFR* 395.5.

[47] (a) See the 2011 FMCSA final rule, *Hours of Service of Drivers* ([FR-2011-12-27.pdf (govinfo.gov)]). (b) The nighttime periods are times between 1 a.m. and 5 a.m.

[48] *Short-haul* operators are those that operate within a 150 air-mile radius of the normal work reporting location, and the driver does not exceed a maximum duty period of 14 hours (also see section 1.7.2.2).

agricultural exemption are still required to follow fitness-for-duty requirements, as stated in 49 *CFR* 392.3, and not operate a vehicle when ill or fatigued.

Short-haul carriers—intrastate motor carriers operating within a 150 air-mile radius and meeting the requirements of 49 *CFR* 395.1(e)—that operate *without* an agricultural exemption are still required to adhere to HOS requirements as defined under 49 *CFR* 395.3(b). As stated under 49 *CFR* 395.1(e), as long as these non-exempt carriers remain within the 150 air-mile radius, their drivers are not required to maintain logs using an ELD or paper logbook; however, these carriers are required to retain, for 6 months, the accurate on-duty time record of their drivers.

Carriers that transport the exempted agricultural commodities within a 150 air-mile radius are automatically exempted from HOS regulations. The exemption is granted by statute, and the carriers are not required to apply or seek approval for the exemption. Moreover, these carriers do not inform—and they are not required to inform—the FMCSA that they are operating under an agricultural HOS exemption, and drivers of these carriers are not required to carry documentation showing their exemption from HOS regulations. However, the FMCSA has informed motor carriers that they have a burden of proof to demonstrate to roadside inspectors that they meet the requirements for an HOS exemption, such as a bill of lading that documents the commodity and transportation locations.[49]

1.7.3 United Dairymen of Arizona

UDA is a milk cooperative and processing plant, located in Tempe, Arizona, and established in 1960, that serves the greater Phoenix region. The processing plant operates 24 hours a day, 7 days a week. The UDA membership consists of 61 dairy farms, and the cooperative contracts five motor carriers to transport milk from the dairy farms to the processing plant. UDA owns or leases all tank-trailers used in its daily operation.

UDA requires drivers employed by the five carriers to complete training on proper milk-hauling and sampling procedures and pass an annual knowledge test to

[49] See (1) FMCSA guidance on exempt agricultural commodities at this link: Agricultural Commodity | FMCSA (dot.gov); (b) ELD requirements for exempt carriers at this link: ELD Hours of Service (HOS) and Agriculture Exemptions | FMCSA (dot.gov); and (c) the FMCSA presentation about the HOS exemption at this link: Microsoft PowerPoint - Ag Webinar Slides Final 4 [Read-Only] (dot.gov).

maintain the milk sampler license.[50] UDA provides monthly training to new drivers and annual refresher training to all drivers. Also, UDA provides drivers with tablet computers for keeping track and recording details of load transports, including the required milk safety and sanitation processes at three main stages of milk transport.[51]

UDA generates dispatch orders, about 175 to 180 routes each day, for the five contracted carriers. Each carrier then assigns specific loads to its individual drivers. UDA requires the five contracted carriers to fulfill several obligations, including keeping their truck-tractors in legal and safe operating condition, adhering to all federal and state regulations, and having their drivers trained and licensed as milk samplers. When interviewed by the NTSB, UDA stated that the cooperative had not been checking the safety records of its contracted carriers and reported being unaware that operating with an agricultural exemption meant being exempt from HOS regulations.[52]

1.7.4 AMT Hiring, Training, and Compliance

AMT's hiring policy was based on the recommendations by the carrier's insurance provider. AMT required that drivers have no serious violations or preventable crashes with injuries in the previous 3 years, and no more than four moving violations or crashes in the previous 3 years, or two in the previous year. All new drivers were required to complete a 4-day training program with the safety manager, which included watching safety videos and receiving hands-on experience loading and unloading cargo tanks at dairy farms and the processing plant. As discussed in section 1.7.3, all drivers were also required to hold current milk-testing

[50] The training covers the follow topics: (1) sanitation and personal cleanliness, (2) milk-sampling and weighing procedures, (3) proper equipment cleaning and use, and (4) recordkeeping requirements. All the milk-hauling and sampling processes must be inspected by an Arizona Department of Agriculture representative prior to issuing the sampling certification and at least once every 2 years for recertification.

[51] (a) The tablets recorded various information including that pertaining to driver and tank-trailer, weight scale (before collecting and when dropping off a tank-trailer), bar code, seal information, and obtained milk sample. (b) The following are some of the basic milk sanitization and safety steps that drivers were required to follow: (1) when picking up a tank-trailer at UDA: ensure that the trailer has been washed and that plastic seals are in place, weigh the combination vehicle; (2) at a dairy farm: before accepting the milk load into the tank-trailer, verify that the temperature of the milk meets the requirements, obtain a sample of milk for testing at UDA, sanitize the hose and the tank-trailer rear valve, weigh the loaded combination vehicle; and (3) when dropping off a tank-trailer at UDA: deliver the milk sample for testing, and sanitize the hose and the tank-trailer rear valve before unloading the milk.

[52] One of the five contracted carriers, Milkyway Transport, had one Behavior Analysis and Safety Improvement Categories (BASICs) element crash indicator in alert status in June 2021. The BASICs information regarding AMT is discussed in section 1.7.7.

qualifications. Drivers were paid by each load they delivered from a dairy farm to the UDA facility.[53]

As required by 49 *CFR* 391.51, AMT had a complete driver qualifications file for the crash-involved driver, as well as complete documentation for several other drivers, which the NTSB examined.[54] The carrier also maintained a drug testing program, as required by 49 *CFR* Part 382, Subpart C; the crash-involved driver was in the carrier's random test pool.

1.7.5 AMT Policies

AMT's Safety/Conduct Policy is a 24-page booklet containing guidance on numerous topics including HOS, timesheets, defensive driving, safety compliance, safety awards, and other company policies. The policy did not provide any explanation or guidance regarding agricultural exemption to HOS.

The AMT policy required drivers to use timesheets for record-of-duty purposes, which needed to include drivers' start time, end time, and total hours worked. The carrier's policy required drivers to complete a log sheet for each day in which the driver (1) operated outside a 100 air-mile radius, (2) was on-duty for more than 12 hours, (3) had less than 10 off-duty hours between separate 12-hour on-duty days, or (4) exceeded 11 on-duty-driving hours following 8 off-duty hours.[55]

AMT had specific policies regarding maximum on-duty and driving hours in a single shift, including (1) 11 hours of driving, (2) 14 on-duty hours, and (3) 60 on-duty hours in a consecutive 7-day period.[56] The carrier's safety manual stated that these policies were based on USDOT rules designed to control driver fatigue.

The carrier's safety manual includes specific actions and oversight activities regarding timesheet and logbook violations, including that "Log compliance is legally

[53] Drivers also received compensation when their unloading queue at UDA was longer than 90 minutes.

[54] Among other documentation, driver qualification files are required to include (1) the driver's employment application; (2) a copy of the driver's license or CDL; (3) motor vehicle records obtained within 30 days of hire and annually after hiring; (4) investigation into the driver's background and safety record, including crashes that do not result in towing of vehicles; and (5) a copy of the driver's medical certification.

[55] Some of these policies—100 air-mile radius and 12 on-duty hours—mimic the federal requirements for *non-exempt* intrastate property-carrying short-haul carriers that existed prior to adoption of the MAP-21 Act, while another—8 off-duty hours—reflects the HOS requirement for passenger-carrying motor carriers.

[56] These policies match the current HOS requirements for *non-exempt* intrastate property-carrying short-haul carriers under 49 *CFR* 395.1(e). AMT drivers were exempt from these HOS requirements.

required by federal and state agencies"; that "Driver logs will be audited at the end of every pay period"; and that "Drivers who do not maintain compliance with federal and state regulations as well as Arizona Milk Transport's company policies, will be subject to disciplinary action."

The AMT quarterly safety awards gave monetary compensation to drivers who were not involved in any preventable crashes, did not have any driver or vehicle out-of-service violations during roadside inspections, and worked on average at least 40 hours a week. Additionally, the carrier awarded annual safety bonuses to drivers who, in addition to the safety requirements, were available for work for at least 50 weeks.

The AMT safety policy manual did not contain a standalone fatigue policy. Rather, fatigue was mentioned in relation to some of the maximum on-duty and driving policies and log violations. For example, the manual states that "The DOT has established three basic rules designed to control driver fatigue" (in a section setting maximum on-duty and driving hours), and that "Driver's daily logs are a necessary tool in monitoring fatigue . . ." (in a section on log violations).

1.7.6 Carrier's Oversight of Drivers

1.7.6.1 Hours Worked. AMT required its drivers to submit bi-weekly (every 2 weeks) timesheets on which drivers would report the number of hours worked and the number of loads they delivered each day.[57] The top of the timesheet included a reminder to drivers, stating "Driver's log sheet required for any day which exceed [sic] 12 hours."

The NTSB examined timesheets of the crash-involved driver for the period between May 16 and June 8, and verified the reported hours by examining his bills of lading, phone records, UDA documentation, AMT's yard security videos, fuel logs, and weight scale tickets. Based on these supporting records, NTSB investigators reconstructed the hours that the truck driver had worked in this period. The reconstructed hours show that the crash-involved truck driver had regularly worked more than the self-reported hours on his timesheets (see table 3). The driver did not report working more than 12 hours a day in the examined period. As such, he did not submit log sheets for any of those days.

[57] This NTSB report uses both *hours worked* and *on-duty* hours when discussing the AMT drivers' operating hours. These terms are synonymous.

Table 3. Truck driver's self-reported and NTSB-reconstructed on-duty hours.

Date [a]	Driver-Reported On-Duty Hours [b]	NTSB-Reconstructed On-Duty Hours [c]	HOS Regulations for Non-Exempt Drivers
May 16–18	12 (each day)	13.25; **14.5**; 14	Drivers for non-exempt carriers are allowed a maximum of 14 on-duty hours in a single shift.
May 19	10	13.5	
May 20–21	12 (each day)	13.5; **14.5**	
May 23–26	12 (each day)	13; 14; **15**; 12.5	
May 27	10	10.25	
May 28	12	12.5	
May 30–June 1	12 (each day)	12.25; 13.25; 12.5	
June 3–4	12 (each day)	13; 12.5	
June 6–8	12 (each day)	14; 14; **14.5**	
Total weekly period			
May 16–22:	**70**	**83.25**	Drivers for non-exempt carriers are allowed a maximum of 60 on-duty hours in a 7-day period.
May 23–29:	**70**	**77.25**	
May 30–June 5:	60	**63.5**	
June 6–8 (3 days)	36	42.5	

[a] The driver was off-duty on May 22, May 29, June 2, and June 5. He reported working 0 hours on those days. Individual dates indicate the day on which the driver started the shift.

[b] On days that the driver reported working 12 hours, he completed delivery of 3 loads. On days that he reported working 10 hours, he completed delivery of 2 loads.

[c] The AMT security camera only saved the recording for the 3 days before the crash. For the earlier dates, NTSB investigators estimated the truck driver's on-duty time between arriving at AMT and the first documented step at UDA or a dairy farm, as well as between the last documented step at UDA and the completion of post-trip inspection at AMT. Minutes are rounded to the nearest quarter hour.

[d] The bolded on-duty hours indicate occasions that would have exceeded HOS regulations for non-exempt carriers.

The self-reported hours worked by the truck driver differed from the reconstructed hours in all 20 examined days; they were all underreported. The reconstructed hours revealed an underreported discrepancy of 30.5 hours in these 20 days, an average of 1.5 hours per shift.

The NTSB and AZDPS randomly selected six other AMT drivers and obtained their timesheets for a 1-month period, along with bills of lading for that time.[58] The following is a summary of the drivers' self-reported timesheets:

- Four of the six drivers submitted timesheets that showed they worked more than 60 hours in a 7-day pay period; there were 11 separate occurrences.
  - Two drivers submitted timesheets that showed they worked more than 80 hours in a 7-day period, one for 84 hours and another for 89 hours.[59] (For comparison, drivers for non-exempt carriers are allowed a maximum of 60 on-duty hours in a 7-day period.)
- Two of the six drivers submitted timesheets that showed they worked more than 12 hours in a day; 19 days were marked as such.
  - Neither of these two drivers completed a log sheet for any of these 19 days.

About 2 months after the crash, the NTSB met with AMT's chief executive officer and safety manager and again discussed driver timesheets. At that time, AMT produced updated timesheets for the additional six drivers that the NTSB and AZDPS investigators examined earlier. The carrier made corrections on the timesheets for four of these drivers, intended to reflect actual on-duty times. Although the carrier-modified timesheets still included five instances of drivers' exceeding the AMT policy of 60 on-duty hours in 7 days, the carrier had reclassified some of the load and wait times as off-duty periods. Because the carrier was exempt from HOS requirements, classifying load/unload times as being off-duty hours did not violate any federal regulations. For drivers who must follow HOS regulations, load/unload times are classified as on-duty hours.[60]

AMT did not modify any of the timesheets of the crash-involved driver.

1.7.6.2 DriveCam. All truck-tractors in the AMT fleet were equipped with Lytx DriveCam systems. The NTSB subpoenaed AMT for DriveCam records for all AMT drivers for the calendar year 2021. The obtained records listed all "exception-based"

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[58] The investigators obtained May 2021 timesheets for three drivers and June 2021 timesheets for the other three drivers. AZDPS investigators were conducting a postcrash compliance review, as discussed in section 1.7.7.

[59] The 7-day period for these two drivers spanned two different pay periods. These two drivers worked 12–14 hours each day within a continuous 7-day period.

[60] According to 49 *CFR* 395.2, the loading and unloading process is classified as an *on-duty not driving* period, even if the driver is not actively participating in that process. This regulation applies to non-exempt CDL drivers only.

video safety events (that is, triggered safety-related events) recorded by the DriveCam devices, sorted by truck-tractor identification number and driver's name, if assigned. Each event, at a minimum, also contained the time of the event and a description of the activity that triggered the event. For example, events could be triggered by numerous factors such as hard braking, rolling a stop, following too closely (less than 1 second, or between 1 and 2 seconds), or departing a lane. Then, AMT staff can review the recorded videos and manually add the name of the driver and note any additional safety issues related to the driver, such as not wearing a seat belt or using a handheld cell phone.

The obtained records for the calendar year 2021 showed that the crash-involved driver had two DriveCam events: a sudden deceleration event pertaining to the June 9 crash, and an event for hard braking on May 13, 2021. The records for the May 13 event also reported "Cell Handheld – Observed." AMT had no documentation showing that the driver was coached about this event. Furthermore, the obtained records showed 11 other events associated with the crash-involved truck-tractor, but the driver was not identified (AMT staff did not add the driver's name).[61] Additionally, the obtained records showed that nearly all drivers had DriveCam events; many drivers had dozens of events, including one with 135 events in the calendar year 2021. However, most events could not be associated with a specific driver because 77% of the reported events had an unidentified driver (AMT never added a driver's name for those events).

In an interview with the NTSB, the AMT chief executive officer stated that the carrier did not have any recorded historical DriveCam events for the crash-involved driver, and that they had never coached the crash-involved driver regarding DriveCam events.[62] However, the written warning that the crash-involved driver received for using a cell phone while driving on September 7, 2020, as discussed in section 1.6.1, was based on a DriveCam event. The incident document also shows that an AMT supervisor had coached the driver about his behavior.

In conversation with the NTSB, Lytx stated that, as part of a standard process for the basic subscription package that ATM had, Lytx sends a notification to the carrier each time a DriveCam event is detected in one of their vehicles.[63] At that time, the carrier is expected to view the recorded DriveCam event in the online portal created by Lytx, and then coach the driver regarding that event. In a July 29, 2021, interview, the AMT chief executive officer stated that the carrier had purchased new

[61] Nine of the other 11 events were triggered due to hard braking and vehicle stability (fast cornering) events. The remaining two events were triggered due to "other" reasons.

[62] The AMT safety manager was also present during this interview.

[63] E-mail conversation with Lytx staff on December 5, 2022.

Lytx DriveCam systems for the entire fleet, and the carrier had started regularly reviewing DriveCam events and coaching its drivers.

1.7.7 Federal and State Oversight

1.7.7.1 Federal Oversight. Because AMT operates only in intrastate commerce, it has never been part of the FMCSA's New Entrant Safety Program—as described in 49 *CFR* Part 385, Subpart D—and has never had an FMCSA compliance review (CR). The FMCSA's oversight of intrastate carriers is typically limited to regulations pertaining to CDLs and testing of alcohol and other drugs.

The FMCSA's Motor Carrier Management Information System (MCMIS) database showed that AMT had seven reportable crashes between January 2018 and June 2021; one in 2018, two in 2019, and four in 2020.[64] At the time of the crash, AMT had no alerts in the Behavior Analysis and Safety Improvement Categories (BASICs).[65] AMT's only score in BASICs was for the *crash indicator* category; the score was below the alert threshold.[66] The FMCSA did not initiate a CR following this crash.

1.7.7.2 Arizona Oversight. The AZDPS provides oversight of commercial motor carriers in Arizona and conducts CRs of intrastate carriers. Before this crash, the AZDPS had never conducted a CR of AMT. After the crash, the AZDPS conducted a CR that did not identify any violations. Because the CR did not include examination of HOS compliance—which AMT was not required to follow—the CR was scored as non-rated.

[64] One of these crashes, in 2019, was classified as resulting in an injury.

[65] The FMCSA uses data from roadside inspections—including all safety-based violations, state-reported crashes, and the Federal Motor Carrier Census—to quantify a carrier's performance in seven BASICs. These BASICs are (1) unsafe driving, (2) HOS compliance, (3) driver fitness, (4) controlled substances and alcohol, (5) vehicle maintenance, (6) hazardous materials compliance (if applicable), and (7) crash indicator.

[66] AMT's score for the crash indicator category was 28%. The BASICs' threshold for alert for property-carrying motor carriers is 65%. AMT was not scored on other categories due to an insufficient number of roadside inspections; depending on a category, a minimum of either three or five inspections is required, and AMT only had two in the previous 2 years.

2. Analysis

2.1 Introduction

On the evening of June 9, 2021, a truck-tractor in combination with a tank-trailer hauling milk was traveling eastbound on SR-202 in Phoenix, Arizona, when it crashed into a queue of passenger vehicles that were stopped due to a road closure, after which the combination vehicle crossed the eastbound travel lanes, struck the concrete median barrier, and separated; the truck-tractor and one passenger vehicle were consumed by fire. Four occupants of passenger vehicles died, and 11 occupants were injured; the truck driver was uninjured.

The analysis first examines factors that can be excluded as causal or contributory to the crash, and then discusses the truck driver's actions (section 2.2). Next, the analysis discusses the following safety issue areas:

- Inadequate safety culture of the motor carrier (section 2.3)
  - Failure to use the available information from the fleet management and driver monitoring system (section 2.3.1)
  - Poor oversight of drivers' hours of operation and enforcement of carrier's policies (section 2.3.2)
  - Deficient management of the risk for driver fatigue (section 2.3.3)
- Need to reduce the risk of fatigue for drivers operating under an agricultural HOS exemption (section 2.4)
- Need for ADOT to improve the prioritization of messages displayed on DMS (section 2.5)
- Need to increase the use of occupant restraints for all seating positions (section 2.6)
- Need to expedite deployment of collision avoidance technologies (section 2.7)

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

- ***Truck driver's licensing and experience:*** The truck driver had a valid CDL with appropriate endorsements and more than 20 years of experience driving commercial motor vehicles.

- ***Cell phone use, alcohol or other drugs, and medical issues:*** Cell phone records indicate that the truck driver was not engaged in texting or cell phone conversation at the time of the crash. Postcrash toxicology test results revealed no evidence that the driver had used alcohol or other tested-for drugs before the crash. Records do not indicate any potential medical issues that could have contributed to the crash.

- ***Mechanical condition of the combination vehicle and passenger vehicles:*** The postcrash examination of the combination vehicle did not identify any preexisting mechanical conditions that could have contributed to the crash. The conditions of the passenger vehicles, which were stopped in the traffic queue, were not a factor.

- ***Highway design:*** The section of SR-202 where the crash occurred conformed to current roadway design guidance and had appropriate regulatory and warning signs. Although the highway design was not a factor in the crash, traffic incident management and use of DMS are discussed in section 2.5.

The NTSB therefore concludes that none of the following were factors in the crash: (1) the licensing or driving experience of the truck driver; (2) cell phone use, use of alcohol or other drugs, or medical conditions of the truck driver; (3) the mechanical condition of the combination vehicle or the passenger vehicles; and (4) highway design.

The investigation found that the emergency responders were swiftly dispatched, surviving passengers were quickly transported from the scene, and appropriate communication protocols were followed. The NTSB therefore concludes that the emergency response was timely and adequate.

2.2 Truck Driver Actions

In an interview with the AZDPS, the truck driver reported that, before the crash sequence started, he noticed brake lights in the distance and then saw smoke and flames, which suddenly appeared from around the truck’s steer axle. The driver reported pressing hard on the brakes and that he then felt that he collided with something. However, the video and data evidence from the fleet management system shows that the driver did not brake or take other avoidance maneuvers before the crash, and that smoke and fire were the result of the crash; the forward-facing video does not show any smoke before the first impact.

The truck driver’s recollection of the crash event is inconsistent with the facts of the crash. The video from the DriveCam forward-facing camera shows a queue of vehicles in the right lane with brake lights visibly illuminated at the beginning of the video, 8 seconds before the crash. The brake lights on these vehicles remained illuminated up to the point of impact. This video also shows vehicles in the lanes to the left moving about the speed of the combination vehicle; those vehicles would have provided a reference point, a strong perceptual cue that the vehicles in the right lane were stopped or moving very slowly. This video also shows vehicles in the left lanes starting to brake at 5.5 seconds before impact.

The video footage from the DriveCam inward-facing camera shows the driver facing forward for the duration of the 8-second precrash segment but shows no visible indication that the driver was aware that the combination vehicle was rapidly approaching the traffic queue. The video shows that the driver had his left hand on the steering wheel and his right hand in his lap, the position that he maintained until 0.25 seconds before striking the Ford, at which time he lifted his right hand from his lap and gripped the steering wheel.

Due to the low resolution of the video, investigators could not conclusively determine whether the driver's eyes were open during these 8 seconds. However, about 14 seconds before the crash, the combination vehicle had driven along a curve before entering the straight roadway section on which the crash occurred, an action that would have required the driver to have his eyes open.[67] It is unlikely that the driver's eyes were closed for the entire 8 seconds, considering that he maintained control of the combination vehicle in the traveling lane. Presuming that the truck driver's eyes were open for at least a portion of these 8 seconds, and considering that the tail and brake lights from the vehicles in the traffic queue were fully conspicuous and that the driver was facing forward and showing no indication that he had detected the approaching hazard, his complete lack of avoidance response indicates inattention blindness.

In a driving situation, inattention blindness is characterized by failure of a driver to consciously perceive an unexpected hazard after directly viewing it (Mack 2003). Inattention blindness occurs when a person fails to devote sufficient attentional resources to a stimulus to raise it to a *conscious level*. This typically occurs when a driver is simultaneously engaged in a secondary task, such as having a conversation with a passenger, or is in a diminished alert state, such as while impaired or fatigued.

The toxicology results confirm that the truck driver was not impaired, and the video footage from the inward-facing camera shows that he was not engaged in an overt secondary task. Talking on a cell phone or with a passenger are examples of external (overt) sources that can produce cognitive distraction. But not all cognitive distraction arises from overt secondary tasks. Mindwandering or off-task thoughts

[67] The crash occurred 1,320 feet or about a quarter of a mile into the straight roadway section. At a constant speed of 64 mph, the combination vehicle would have required 14.06 seconds to travel that distance.

entail shifting attention away from the primary task (such as driving) and toward task-irrelevant thoughts (Smallwood and Schooler 2006). Mindwandering can also be thought of as cognitive distraction with an internal source, and is accompanied by reduced vigilance, slowed reaction times, and narrowing of visual attention (Giambra 1995; Smallwood, McSpadden and Schooler 2007; Robertson and others 1997). However, in the absence of laboratory equipment to measure a driver's attentional focus and alertness, determination of mindwandering or cognitive distraction with an internal source could only be inferred through exclusion of other factors.[68]

In the 3 nights before the crash, the truck driver arrived home about 2 a.m., 3:30 a.m., and 5 a.m., and according to his statement he typically woke up at 7 a.m. or 8 a.m., although he also reported waking up at 10:30 a.m. on Monday (2 days before the crash) and about 10:30 a.m.–11 a.m. on the day of the crash. Considering the driver's inconsistencies in self-reporting his wake-up times, determining his opportunity for sleep June 6–8 is challenging. Based on the self-reported typical wake-up time (around 7 a.m. to 8 a.m.), he had a maximum of 8-, 6-, and 4.5-hour opportunities for sleep in the 3 days before the crash, respectively. If not taking into account his statement about typical wake-up time, he had sufficient opportunity for sleep (7–8.5 hours) in the 3 days prior. However, it is not possible to determine whether he used the available opportunities to obtain restful sleep, and his failure to respond to the fully conspicuous traffic queue could be explained by fatigue. Fatigue leads to slowed reaction times and reduced vigilance; it also affects the visual scanning pattern and the basic components of human attention and perception (Dinges and Kribbs 1991; Schleicher and others 2008).

The NTSB concludes that the truck driver's lack of avoidance response—evident in the vehicle data and video from the fleet management system—to the bright and conspicuous tail and brake lights of the vehicles in the traffic queue ahead was likely the result of fatigue.

The following sections of the report explore the safety issues of operating beyond traditional HOS limits (those mandated for non-exempt carriers) and the risk of fatigued driving, within the context of AMT's safety culture (section 2.3), as well as the broader context of the agricultural HOS exemption across the exempt industries (section 2.4).

[68] Eye-trackers capable of reliably detecting eye movements have been used to detect scanning strategies indicative of mindwandering. Event-related potential (a brain response to a perceptual or cognitive event) offers a definitive metric of a driver's awareness of an upcoming hazard, but its application in production vehicles would be very challenging.

2.3 AMT's Inadequate Safety Culture

A motor carrier's safety culture is reflected in individual and group values, perceptions, and competencies regarding the company's approach to safety management.[69] A good safety culture is supported by a stable framework of policies and oversight mechanisms that establish and maintain appropriate safety risk management.

Adherence to federal and state regulations can represent a metric for examining the adequacy of a carrier's safety culture. However, there are many policies, oversight mechanisms, and structural and technological implementations that are not required by federal or state regulations yet are considered best practice in establishing and maintaining a strong safety culture. The AZDPS conducted a postcrash compliance review of AMT; the review did not identify any violations. AMT complied with all federal and state requirements related to its drivers (maintained complete driver qualification files) and vehicles (had a systemic program for vehicle inspection and maintenance) and had established and maintained an alcohol and drug testing program.

AMT operated with an agricultural exemption; its drivers were not required to adhere to federal HOS requirements specified under 49 *CFR* 395.1(k). Yet despite being exempt from HOS regulations, AMT had a policy regarding the maximum on-duty hours its drivers could operate. These AMT policies largely mimicked several HOS requirements under 49 *CFR* Part 395—such as maximum on-duty hours for *non-exempt* carriers; the existence of these policies could be viewed as an indicator of a cautious approach to reduce safety risks associated with drivers being on duty for extended periods without adequate opportunity for rest.[70]

However, although the carrier was compliant with all applicable state and federal regulations and had written policies to limit on-duty hours, this investigation revealed several instances of AMT's poor oversight of drivers and failure to enforce its own policies. For example, the examination of weight scale tickets of the crash-involved driver showed that he regularly operated combination vehicles that were

[69] Although there is no single definition of safety culture, a version of the one proposed by the United Kingdom's Advisory Committee on the Safety of Nuclear Installations in 1993 is often cited: "The safety culture of an organisation is the product of individual and group values, attitudes, competencies, and patterns of behaviour that determine the commitment to, and the style and proficiency of, an organisation's health and safety management."

[70] (a) The AMT policies regarding drivers' maximum driving and on-duty hours were a combination of older and current federal requirements intended for different types of short-haul carriers (those operating on a continual basis and those operating less than 7 days a week). (b) The safety risks associated with driving unlimited hours under an agricultural exemption are discussed in section 2.4.

loaded beyond the maximum GVWR, in violation of Arizona law.[71] Although the weight of the combination vehicle had no effect on the crash, this pattern highlights the carrier's poor oversight of its drivers. The following sections examine the crash-pertinent consequences of AMT's poor oversight of its drivers in terms of inadequate application of its fleet management system (section 2.3.1) and the lack of adherence to carrier policies (section 2.3.2), as well as of the failure to appropriately manage the risk of driver fatigue (section 2.3.3).

2.3.1 Driver Performance Monitoring

AMT's fleet of truck-tractors is equipped with Lytx DriveCams, which could automatically detect and record various safety-relevant events, including hard braking or loss of vehicle stability. The recorded events could then be reviewed by AMT staff who could note other safety-critical behaviors of drivers, such as use of cell phones or failure to use lap/shoulder belts. As a fleet management and driver monitoring tool, DriveCam is typically used to coach drivers to improve their behavior by using the recorded events as training opportunities. Such fleet management systems could also be used to identify potential fatigue, as certain DriveCam events such as frequent hard braking could indicate a fatigued driver (Mollicone and others 2019).

It should also be noted that a recorded DriveCam event may not necessarily be the driver's fault but could instead be due to other vehicles or environmental factors (such as a vehicle cutting in front of the truck-tractor, requiring a driver to brake, which could trigger a DriveCam event).

In September 2020, the truck driver was reprimanded by AMT for using a cell phone while driving and was warned that future such activity could lead to termination; the AMT incident document shows that this warning was issued after viewing video footage from a DriveCam event. The NTSB review of DriveCam records for the calendar year 2021 indicated that, other than the present crash, the crash-involved driver had another event, on May 13, 2021, when the system detected a hard braking event, and AMT's review noted that the driver was using a handheld cell phone. However, AMT did not terminate or discipline the driver despite the warning he received 9 months earlier; AMT had no documentation that the carrier coached the driver regarding this incident. DriveCam records also show 11 additional events associated with the truck-tractor that only the crash-involved driver operated; AMT had no documentation of coaching regarding these incidents either.

The examination of DriveCam records for other AMT drivers showed that nearly all had DriveCam events; many drivers had dozens of events, including one

[71] See Arizona Revised Statute 28-1100.

driver with 135 DriveCam events in 2021. The number of events for individual drivers is substantially undercounted, as 77% of examined DriveCam events were associated with an unidentified driver, due to AMT not entering that information in the records. The examination of these DriveCam recorded events—for identified or unidentified drivers—shows a variety of observed behaviors of drivers, including being unbelted, following a vehicle at a distance of less than 1 second, using handheld or hands-free cell phone, or failure to stop. The records of identified drivers also show that they continually repeated the same unsafe behaviors, indicating an ineffective implementation of the fleet management system.

Some motor carriers have reported considerable improvements in driver safety when using fleet management systems such as Lytx DriveCam. For example, Greyhound, the largest for-hire passenger carrier in the United States, started to deploy Lytx DriveCam in 2011. The carrier reported having a 90% coaching success rate for DriveCam events; coaching was considered successful when the affected driver did not repeat that DriveCam event—for example, not having another *following too closely* event—in the next 90 days.[72] Greyhound reported an overall 75% reduction in all DriveCam events between the first and the next 5 years of deployment, as well as a 27% reduction in the number of USDOT-reportable crashes between 2017 and 2019.[73]

Comprehensive implementation of a fleet management system, including regular and effective coaching, can lead to considerable safety improvements. Although AMT reviewed DriveCam events and noted various unsafe behaviors and violations of company policies regarding cell phone and seat belt use, the records show frequent repeat violations of those policies.

The NTSB concludes that although AMT equipped its vehicles with a fleet management and driving monitoring system, the carrier's implementation of the system—which includes coaching of drivers—was ineffective in improving the driving behavior of its drivers and in reducing violations of carrier safety policies. Therefore, the NTSB recommends that AMT implement an improved coaching program as part of its fleet management and driving monitoring system that would improve driving behavior and reduce instances of violations of carrier safety policies.

[72] Phone and e-mail communication with Greyhound's director of safety October 27, 2022, and November 10, 2022.

[73] The 75% reduction took place between period 1 (March 2011–January 2016) and period 2 (February 2016–December 2020).

2.3.2 Driver On-Duty Hours

The NTSB examined the crash-involved driver's timesheets and then verified the self-reported hours by comparing them to the driver's bills of lading, phone records, UDA and dairy farms' documentation, weight scale tickets, and AMT yard security videos.

The NTSB's reconstructed work hours of the crash-involved driver differed substantially from the hours the driver reported on his timesheet; the reconstruction revealed an underreported discrepancy of 24 hours worked in the 3 weeks before the crash, and of 6.5 hours in the 3 days before the crash.[74] In the 3 weeks before the crash, he worked 83.25, 77.25, and 63.5 hours in each 7-day period, violating the carrier's policy of a maximum of 60 on-duty hours in a 7-day period. During this time, on four occasions, he also violated the policy regarding 14 maximum on-duty hours in a single shift. As a comparison, drivers for non-exempt carriers are allowed a maximum of 60 on-duty hours in a 7-day period, and a maximum of 14 on-duty hours in a single shift. The driver never reported more than 12 hours on duty on days that he worked during this period; when operating over 12 hours, the AMT policy requires drivers to complete an additional log sheet. Because the driver was paid by the load, his underreporting of hours worked did not affect his wage. The reconstructed on-duty hours showed that the driver's shift was longer than 12 hours on 19 of the last 20 days that he worked.

The AMT policies stated that "Driver's logs will be audited at the end of every pay period." The carrier did not audit the truck driver's timesheet and logs in the weeks before the crash; as such, the carrier did not discipline the truck driver for these policy violations. The driver's continued violations of the carrier's policies on hours worked and log sheet maintenance were only possible due to AMT's poor oversight.

The crash-involved driver was not the only driver who regularly violated the AMT policies on hours worked and log sheet maintenance. The examination of timesheets of six randomly selected AMT drivers for a 1-month period showed that four of the drivers reported working more than 60 hours in a 7-day period on 10 separate occasions, including two drivers who reported working more than 80 hours in a 7-day period. Moreover, two drivers reported working more than 12 hours a shift on 19 separate occurrences, yet neither driver submitted a log sheet for any of those days. Although these drivers reported hours exceeding AMT's policies on daily and weekly limits, the carrier did not oversee their work hours or

[74] The driver's timesheet underreported the hours worked for each of the 3 weeks before the crash, including (a) 13.25 hours during May 16–22, (b) 7.25 hours during May 23–29, and (c) 3.5 hours during May 30–June 5.

enforce its policies regarding maximum on-duty hours and associated log sheet completion.

In the weeks before the crash, AMT did not adhere to its own policy to audit drivers' log sheets nor did it ensure that drivers complied with AMT's own policies on maximum on-duty hours.

The NTSB concludes that AMT's lack of oversight to ensure adherence to company policies allowed the crash-involved driver and other drivers to operate well beyond the carrier-allowable hours of operation. Because the AMT drivers' self-reporting of hours worked was largely inaccurate, an audit with timesheets as the only source of information would also be unreliable. One method that would provide accurate information about drivers' hours worked would be electronic recording of times when drivers arrive at and leave the AMT yard, which could be easily implemented. Therefore, the NTSB recommends that AMT implement a process to improve adherence to carrier policies and regularly verify the accuracy of drivers' reported hours of operation, such as by reviewing the drivers' records of duty status and cross-referencing other available information.

2.3.3 Fatigue Management

AMT had no standalone fatigue management policy, as is an industry best practice. AMT's safety policy manual contained only cursory references to fatigue management. For example, in a section describing the carrier's policies on maximum on-duty hours, the AMT safety manual stated that USDOT rules on maximum hours of operation are designed to control fatigue. Furthermore, AMT relied on drivers' logs as a means of monitoring fatigue, stating in the safety manual that "Driver's daily logs are a necessary tool in monitoring fatigue . . ." However, as indicated above, AMT did not review the drivers' logs and cross-reference other available information to ensure accuracy. AMT's poor oversight of drivers' hours worked and failure to audit timesheets and log sheets negated the usefulness of timesheets as a fatigue management tool.

Furthermore, AMT did not educate its drivers about fatigue nor schedule their routes with fatigue management in mind and did not have a sleep disorder screening and treatment program. These are only some of the components of the North American Fatigue Management Program (NAFMP), a comprehensive approach to managing the risk of fatigue for commercial vehicle drivers that was developed by the FMCSA and several Canadian transportation organizations. The NAFMP was launched in 2013 as a voluntary program free of cost to motor carriers, and it includes the following components:

- Developing corporate safety culture that actively combats fatigue.
- Incorporating fatigue considerations into driver scheduling practices.
- Educating drivers, their families, managers, shippers, receivers, and dispatchers on fatigue management.
- Establishing sleep disorders screening and treatment practices.
- Exploring use of fatigue management and fatigue detection technologies.

Training modules take about 15 hours to complete, and are geared for different roles—drivers, managers, schedulers, dispatchers—and detail the frameworks for establishing and following various fatigue-mitigating strategies.

The criticality of having a comprehensive fatigue mitigation strategy has been recognized by many carriers, including Greyhound. In response to Safety Recommendation H-00-6 (issued as a result of the NTSB's investigation of a 1998 crash in Burnt Cabins, Pennsylvania, involving a motorcoach roadway departure), Greyhound initiated changes in the organization's mitigation of fatigue safety risks (NTSB 2000).[75] The carrier educated its drivers about mitigation strategies to reduce fatigue safety risks, trained dispatchers in fatigue management, and redesigned scheduling to minimize mixing work cycles. In 2002, Greyhound conducted a voluntary external review of the company's risk factors for fatigue. As a result of this review, Greyhound incorporated numerous other enhancements to its fatigue mitigation strategies, including furthering education training, implementing sleep disorder monitoring practices, and incorporating fleet management systems. As a result of these improvements, Safety Recommendation H-00-6 was classified Closed—Acceptable Action in 2008.

Greyhound continued enhancing its fatigue management program. In 2011, the carrier started to require all its drivers to be screened for obstructive sleep apnea (OSA) and started to monitor treatment compliance for those diagnosed with sleep disorders.[76] In 2019, Greyhound started a voluntary program to monitor the sleep cycles of its drivers diagnosed with OSA to better predict fatigue risk.

Another large motor carrier followed a similar trajectory as Greyhound. In response to Safety Recommendation H-15-22, issued as a result of the NTSB's investigation of a 2014 crash in Cranbury, New Jersey, involving a fatigued driver

[75] For the description of the external evaluation, see the Greyhound correspondence in the CAROL database regarding Safety Recommendation H-00-6.

[76] Phone and e-mail communication with Greyhound's director of safety October 27, 2022 and November 10, 2022.

(NTSB 2015a), Walmart—one of the nation's largest freight-carrying motor carrier—implemented comprehensive organizational changes to address the safety risks of fatigued operation by its drivers. Many of these changes are similar to those implemented by Greyhound, and also included periodic evaluations of the various fatigue mitigation elements. As a result of these improvements by Walmart, Safety Recommendation H-15-22 was classified Closed—Acceptable Action in 2020.[77]

The crash-involved driver and most of the other AMT drivers that the NTSB examined frequently operated well beyond the carrier's maximum-allowable on-duty hours. In its safety manual, AMT explicitly stated that those limits were based on USDOT rules designed to control driver fatigue. By not enforcing these policies, AMT failed to provide appropriate mitigation of fatigue risk for its drivers. A good safety culture and fatigue-considered scheduling practices would have provided AMT with tools to provide appropriate oversight of its drivers, have accurate information about the drivers' on-duty and commute hours, and be able to develop schedules that reduce the risk of fatigue. The NTSB concludes that by not having a fatigue management program and by not incorporating considerations for fatigue in its policies and monitoring mechanisms, AMT failed to mitigate the risk of fatigue for its drivers who frequently operated beyond maximum HOS limits for non-exempt carriers. Therefore, the NTSB recommends that AMT develop and implement a fatigue management program based on the NAFMP.

2.4 Addressing the Risk of Fatigue in Carriers Operating Under an Agricultural HOS Exemption

The limited federal safety regulations (specifically, drivers' HOS requirements) for milk motor carriers such as AMT is the primary reason the carrier received no violations during the AZDPS postcrash compliance review. Multiple federal agencies, including the Public Health Service, the FDA, and the Department of Agriculture exercise oversight of the milk industry. At the state level, regulatory and oversight authority of the milk industry typically resides with each state's agriculture department, including in Arizona, which oversees the production, processing, safety, and manufacturing of milk and milk products in the state.

Many of these federal agencies, all states, and various stakeholders in the dairy industry are members of the National Conference for Interstate Milk Shipments. This conference is a cooperative program between the FDA, the states, and the dairy industry designed to establish regulatory standardization and state reciprocity agreements regarding milk and milk products. Milk-processing cooperatives such as

[77] For additional details about the changes that Walmart implemented, see the Walmart correspondence in the CAROL database regarding Safety Recommendation H-15-22, and Walmart's submission to the NTSB in the docket associated with Cranbury, New Jersey, investigation.

UDA are also members of the International Dairy Foods Association, which represents more than 90% of the dairy industry, including 160 dairy processors and the majority of large milk-processing cooperatives. Finally, many of the milk motor carriers, such as AMT, are also members of the International Milk Haulers Association, which represents about 200 milk motor carriers.

However, except for the oversight of milk safety during transportation from dairy farms to milk processing plants—ensuring that sanitation, temperature stability, testing, and other safety procedures are followed—these federal and state agencies do not provide the basic transportation-safety oversight of milk motor carriers. The transportation-safety oversight of these carriers is conducted by the FMCSA and the states' transportation oversight agencies. Critical to this oversight is the Commercial Vehicle Safety Alliance (CVSA), an alliance of commercial motor vehicle safety officials and the industry, which establishes the out-of-service violation criteria for roadside inspections.[78]

The following sections examine (1) the role of each of these stakeholders in providing oversight of milk motor carriers operating under an agricultural HOS exemption, and (2) the overall safety risks associated with fatigue and operating beyond traditional HOS limits, regardless of the exempt commodity being transported. The focus of these sections is on the safety of motor carriers that are exempt from HOS regulations.

2.4.1 Broader Oversight

The HOS exemptions have a long history, starting with the passage of the Motor Carrier Act in 1935, which gave the ICC authority to regulate truck and bus companies, including setting maximum hours that their drivers could operate. At that time, several industries were exempt from HOS requirements, including motor carriers transporting livestock, fish, and agricultural commodities, including milk.

These exemptions were established to protect livestock and agricultural commodities to ensure that animals and commodities would not perish or spoil during transportation from farm to market. However, milk transport is typically local and operated on a continual basis to ensure the safety of the milk product. Storage

[78] (a) Roadside inspections are examinations of commercial motor vehicles or drivers conducted by specially trained inspectors on behalf of the FMCSA to check that they are in compliance with the *Federal Motor Carrier Safety Regulations* and/or *Hazardous Materials Regulations*. The CVSA establishes the out-of-service criteria that are adopted by states for roadside inspections. The FMCSA relies on the information from roadside inspections to establish the BASICs scores. These scores are not public, under law. (b) The CVSA is a nonprofit association of commercial motor vehicle safety officials and industry representatives. Although frequently working on behalf of the FMCSA, the CVSA is not a part of that or any other federal or state agency.

limitations at dairy farms are typically cited as the reason for round-the-clock operations of milk-processing plants and motor carriers that haul the commodity.

Considering that HOS regulations have been remarkably consistent since their establishment—ranging between 10–12 maximum *on-duty driving* hours and between 12–15 total *on-duty* hours a day—it is prudent to examine the safety risk posed by operating without HOS limits and the associated lack of federal oversight in this area.[79] Earlier research shows that general crash risk increases significantly when driving beyond 8–11 hours (Kaneko and Jovanis 1992; Insurance Institute for Highway Safety [IIHS] 1987; Hamblin 1987). For example, the IIHS study found that the relative crash risk of commercial drivers operating more than 8 hours was twice that of drivers operating fewer hours. Similar crash risk numbers were reported in a more recent study that showed that drivers operating 10–11 hours had a 3.59 times higher crash rate than drivers operating in the first hour (Park and Jovanis 2010). In the FMCSA's 2000 notice of proposed rulemaking (NPRM) regarding HOS, which includes a comprehensive overview of decades of fatigue-related research, the agency referenced crash rate data showing a considerable increase in fatigue-related crashes after 11 and 12 hours of driving (FMCSA 2000).

As the USDOT described and as AMT cited in its safety manual, the HOS regulations are designed to mitigate driver fatigue. Yet the carriers that transport eligible commodities are allowed to operate beyond traditional HOS limits and are not required to implement or follow any fatigue-reducing safety mechanisms in lieu of adhering to the HOS regulations. The expansion of the eligible HOS-exemption radius to 150 air-miles further increased the ability to operate without HOS limits. As shown in figure 15 earlier, the eligible HOS-exemption radius for a carrier in the Phoenix area covers much of the state of Arizona and even stretches into California. Allowing certain carriers to be exempt from HOS regulations introduces potential increased risk of fatigue due to operating beyond traditional HOS limits. Although not all carriers operating with an agricultural exemption will ignore the effects of fatigue in their operations, as exemplified by this crash, some carriers may have limited or non-existent fatigue mitigation policies, provide poor oversight of their drivers' hours of operation, or allow their drivers to frequently operate well beyond traditional maximum HOS. Under such conditions, those drivers would be at an increased risk of fatigued operation. The NTSB therefore concludes that drivers operating under an agricultural exemption, which allows them to operate beyond traditional HOS limits, would be at greater risk of fatigued operation.

The NTSB has long supported implementing fatigue management programs and policies, including applying them across the entire motor carrier fleet. Following

[79] For an extended discussion of the history of HOS regulations, see the FMCSA notice of proposed rulemaking (NPRM) from August 2019 (84 FR 44190). As discussed in section 1.7.2.1, the FMCSA issued the most recent changes to HOS in June 2020.

a 2009 crash in Miami, Oklahoma, in which a fatigued commercial driver failed to respond to a queue of stopped vehicles on a highway (NTSB 2010), the NTSB recommended that the FMCSA require all motor carriers to adopt a fatigue management program based on the NAFMP (Safety Recommendation H-10-9). This crash, and some of the more recent crashes that the NTSB has investigated, provide useful reminders that operating within HOS requirements is not an assurance of safety and an indicator of well-rested drivers.[80] The FMCSA responded that the recommendation would be difficult to implement, and that it would represent a significant cost to the industry, expressed in time that drivers, dispatchers, and supervisors would spend in training. Although the FMCSA continued to promote the NAFMP as a voluntary approach to fatigue management, the agency did not mandate fatigue management programs as recommended. The NTSB reiterated Safety Recommendation H-10-9 three times before classifying it Closed—Unacceptable Action in 2017.[81] The investigation of the crash in Phoenix shows that an adequate fatigue management program is critical for all motor carriers, particularly for carriers that operate under an agricultural HOS exemption.

The criticality of having a comprehensive fatigue mitigation strategy has been recognized by many carriers, such as the already discussed Greyhound, which has developed and implemented its own fatigue management programs. Existing studies of occupations across industries—nurses, firefighters, ground transportation workers—examining the impact of a fatigue management intervention show improvements across relevant factors, such as increased sleep duration and decreased self-reports of sleepiness (Sprajcer and others 2022). A 2010 study, examining the impact of implementing a fatigue management program for commercial drivers in the United States and Canada, showed comprehensive improvements post-intervention. These drivers obtained longer and higher quality sleep; exhibited reduction in microsleep episodes; had fewer crashes, near misses, and roadway infractions; and of those drivers treated for OSA, showed improvement on psychomotor vigilance task (Smiley and others 2010).[82]

The NTSB concludes that motor carriers can considerably reduce fatigue-related crash risk and improve safety by implementing a fatigue management program.

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[80] For a recent investigation, see the Arlington, Wisconsin, report (NTSB 2022b). For an examination of causal factors in 182 crashes, see the safety study on heavy truck crashes (NTSB 1990).

[81] The NTSB reiterated Safety Recommendation H-10-9 as a result of the investigations of the New York City, New York, Doswell, Virginia, and Cranbury, New Jersey, crashes (NTSB 2012a, 2012b, and NTSB 2015a).

[82] Microsleep episodes typically last up to 15 seconds during which a person falls asleep, losing awareness and conscious control of their motor performance.

As described in the previous sections, this investigation revealed several safety deficiencies with the carrier, AMT, that highlight the potential safety risks associated with HOS exemptions. However, a comprehensive understanding of the safety performance of drivers that use HOS exemptions is lacking, as the FMCSA has never examined that risk.

When asked by the NTSB, the FMCSA stated that the agency cannot determine how many carriers are operating under an agricultural exemption, nor could the FMCSA answer questions about the number of milk motor carriers, their crash rate, and the severity of crashes.[83] The FMCSA also stated that the agency does not have a mechanism to identify or track motor carriers that operate under an agricultural HOS exemption.[84] Because the exemption is granted automatically for commercial motor carriers of eligible commodities and because no requirements exist for carriers to inform the FMCSA when using the agricultural HOS exemption, the FMCSA does not have or maintain information regarding the exempt carriers, their crash rate, or even the basic prevalence of the use of the agricultural HOS exemption.[85]

In addition to the FMCSA's inability to identify carriers that use agricultural HOS exemptions, the agency's primary safety evaluation tool—BASICs—would have limited applicability. Because carriers operating under an agricultural HOS exemption cannot be cited for HOS violations during roadside inspections, their BASICs scores are automatically skewed toward implying that a carrier is performing better than it actually is. This fact also affects the application of the FMCSA's threshold for classifying at-risk carriers.[86] A non-exempt carrier classified as *moderate-risk* with the HOS BASIC in alert could have the at-risk classification removed and the subsequent compliance review canceled, had it operated under an agricultural HOS exemption.

At the same time, the FMCSA is aware of the safety risks posed by HOS exemptions. The agency expressed these concerns in its denial of a recent request to be exempt from HOS regulations from a group of associations representing carriers

[83] E-mail conversation with FMCSA staff November 19, 2021, and November 29, 2021.

[84] E-mail conversation with FMCSA staff August 23, 2022.

[85] A 2010 FMCSA study to assess the safety performance of agricultural commodity carriers that are exempt from HOS regulations had methodological limitations, resulted in inconsistent findings, and exposed the challenges of examining this topic using available data sources (FMCSA 2010). The FMCSA study acknowledged these shortcomings.

[86] The FMCSA defines a moderate-risk carrier as one that has (1) two or more of the following BASICs over intervention threshold: crash indicator, HOS compliance, unsafe driving, or vehicle maintenance, and (2) no intervention in the previous 12 months and no warning letters in the previous 6 months. The FMCSA defines a high-risk property-carrying carrier as one that for at least two consecutive months has (1) a rating of least 90% in two of the following BASICs: crash indicator, HOS compliance, unsafe driving, or vehicle maintenance, and (2) no onsite inspection in the previous 18 months.

transporting livestock, insects, and aquatic animals.[87] This group requested that, when the drivers operate beyond the 150 air-mile radius, they be allowed to drive through the 16th consecutive hour after coming on duty. These driving hours would be in addition to 6 or more hours the drivers would operate within the 150 air-mile radius. In the rejection of this request, the FMCSA stated that the HOS regulations are intended to "reduce the possibility of cumulative fatigue" and that research has shown that crash risk increases with work hours.

The FMCSA's recognition of the benefits of fatigue management programs for HOS-exempt carriers is also evident in one of the requests for an HOS exemption that the FMCSA has granted. In that request, two associations of railroad workers requested that a subset of their members who are commercial motor vehicle drivers be exempt from HOS when responding to unplanned and emergency situations, such as derailments and other railtrack safety issues.[88] The associations asked that those drivers be allowed to operate up to 17 hours a day and extend the 7- and 8-day limits by 6 hours, and that those exemptions be applied to a 300 air-mile radius of drivers' work-reporting location.[89] In the request, the associations stated that the drivers operating under this exemption would receive fatigue mitigation resources and be required to complete several modules from the NAFMP. In granting the request, the FMCSA cited the expected infrequent use of the exemption and highlighted the fatigue mitigation strategies proposed by the associations, as well as the fatigue-related resources available on the Federal Railroad Administration's website.

Based on the FMCSA's rationale for granting the special exemption, the agency considers implementation of at least basic fatigue mitigation strategies as a necessity for reducing the increased risk of fatigue when operating beyond traditional HOS limits. But the type of transported commodity does not change the impact of fatigue on driver safety. Carriers that transport milk or other exempt-by-regulation commodities and allow their drivers to operate beyond traditional HOS limits without implementing any fatigue mitigation strategies *are* following regulations but *are not* engaging in safe transportation practices. The FMCSA's concerns about fatigue due to prolonged hours of operation are evident, but the regulations—49 *CFR* 395.1(k) and 395.3(b)—do not require the carriers transporting exempt-by-regulation commodities to implement any fatigue mitigation policies or even afford the agency basic data to evaluate the safety risk of HOS exemptions.

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[87] See *Federal Register*, Vol. 87, No. 228, Tuesday, November 29, 2022. Docket No. FMCSA-2018-0334.

[88] See *Federal Register*, Vol. 85, No. 247, Wednesday, December 23, 2020. Docket No. FMCSA-2020-0171.

[89] Under 49 *CFR* 395.3(b), commercial motor vehicle drivers are allowed to operate a maximum of 60 or 70 hours within a 7- or 8-day period, respectively.

The use of the agricultural HOS exemption was never intended to be an unmonitored operation. Upon dissolution of the ICC in 1995, Congress confirmed the agricultural HOS exemption in the National Highway System Designation Act, which also references responsibilities and potential actions by the Secretary of Transportation. Specifically, section 345(d), which confirms the agricultural HOS exemption, also states that

> The Secretary shall monitor the commercial motor vehicle safety performance of drivers of vehicles that are subject to an exemption under this section. If the Secretary determines that public safety has been adversely affected by an exemption granted under this section, the Secretary shall report to Congress on the determination.

Because no data exist on the safety impact of HOS exemptions and because the FMCSA has no means of obtaining such data, the extent of the potential increased risk of fatigued driving in industries exempt from HOS regulations and the associated crash rate is unknown. This uncertainty can be remedied by the USDOT, as was expected in the National Highway System Designation Act. The USDOT would have to change the regulations pertaining to agricultural HOS exemptions, or instruct the FMCSA to do so, to set a framework to obtain data needed to evaluate the safety of agricultural HOS exemptions.

The NTSB concludes that due to the limited oversight and lack of monitoring of motor carriers operating under an agricultural HOS exemption, the extent to which these motor carriers operate beyond traditional HOS limits—which can increase the risk of fatigued operation by drivers—is unclear. Because the FMCSA has no mechanisms for identifying and therefore evaluating the safety risk of HOS exemptions, and because Congress had assigned the monitor role to the Secretary of Transportation, the USDOT is best positioned to provide such evaluation. The NTSB recommends that the USDOT develop and implement a program to determine the prevalence of for-hire motor carriers operating under an agricultural HOS exemption and study their safety performance, including but not limited to (1) fatigue-related crashes, (2) risk of fatigued operation, and (3) adherence to fatigue management principles. Report the findings and any recommendations to improve safety to Congress, as expected in the National Highway System Designation Act, and make them publicly available.

While the USDOT starts to collect data to monitor and examine the safety risk and to evaluate the necessity of agricultural HOS exemption or possible modification of the regulation, the Department can implement an intermediate measure to reduce the safety risk of fatigued operation of drivers operating under an agricultural HOS exemption. Therefore, the NTSB recommends that the USDOT require interstate motor carriers operating under an agricultural HOS exemption to implement a fatigue management program or, if necessary, seek authority from Congress to do so.

2.4.2 Role of Associations

The recommendations to the USDOT are intended to create long-term and effective countermeasures to address the safety risk of fatigued driving when operating beyond traditional HOS limits, regardless of the type of the exempt commodity being transported. In the meantime, other interim measures could provide a more immediate safety impact on carriers operating under an agricultural HOS exemption, particularly those in the milk industry. The various associations serving the milk industry, described in this section, as well as the CVSA, can serve as conduits to implement these interim measures.

In 1977, the FDA established a memorandum of understanding between the FDA and the National Conference for Interstate Milk Shipments, delineating the FDA's and states' responsibilities for ensuring uniform enforcement of milk safety regulations, under the umbrella of the Pasteurized Milk Ordinance.[90] The National Conference for Interstate Milk Shipments is a cooperative program between the FDA, the states, the dairy industry, and other stakeholders. Every 2 years, the participants meet to update the Pasteurized Milk Ordinance, but the conference can also serve as a platform for transportation safety issues. The NTSB presented at the meeting on June 21, 2022, highlighting the risks of fatigued driving when operating under an agricultural HOS exemption and beyond traditional HOS limits. The National Conference for Interstate Milk Shipments recognized the importance of promoting the transportation safety message to its members.

The crash-involved motor carrier AMT was one of five motor carriers contracted by the milk-processing plant UDA. UDA's oversight of its contracted carriers was primarily limited to milk-handling procedures, although the cooperative maintained tank-trailers and required the carriers to keep their truck-tractors in safe operating condition and adhere to all federal and state regulations. Furthermore, UDA stated that it was unaware that operating under an agricultural exemption also meant that the drivers of its contracted carriers were exempt from HOS requirements, which suggests that UDA did not recognize that those drivers would also be subject to accompanying safety risks due to potential fatigue. UDA is in a position to influence its contracted carriers, requiring them to address concerns about driver fatigue and mitigate the potential safety risks due to operating without HOS limits.

The International Dairy Foods Association represents more than 90% of the dairy industry, including most dairy-processing plants and nearly all large milk-processing cooperatives; UDA is a member. Some of these dairy-processing plants operate their own fleets, while others contract with carriers like AMT. Considering

[90] (a) The original memorandum of understanding was revised several times, including the latest revision in 2017. (b) The Pasteurized Milk Ordinance was first issued in 1924, and the latest revision occurred in 2019.

that the basic ingredient of dairy is raw milk, many of the motor carriers serving these dairy-processing plants and cooperatives would operate under an agricultural HOS exemption. Similar to UDA, processing plants that contract with motor carriers are in a position to require the carriers to adequately address concerns about fatigue and potential safety risks due to operating without HOS limits. Finally, many milk motor carriers are members of the International Milk Haulers Association, which represents about 200 milk motor carriers; AMT is a member of the association.

The NTSB concludes that by including a transportation safety component in the oversight of milk and dairy production and transportation, milk cooperatives and dairy-processing plants can mitigate the risk of fatigued driving. Therefore, the NTSB recommends that the International Dairy Foods Association and the National Conference for Interstate Milk Shipments inform their members of the circumstances of this crash and encourage those members that contract with motor carriers to request that the carriers implement a fatigue management program based on the NAFMP.

The NTSB further recommends that the International Milk Haulers Association inform its members of the circumstances of this crash and encourage them to implement a fatigue management program based on the NAFMP.

Although these three associations were identified by the NTSB as being conducive to implementing these safety recommendations, their scope is limited to motor carriers transporting milk-related exempt commodities. However, the broader safety impact of the interim measure can be achieved through the CVSA.

In December 2021, the FMCSA awarded a contract to the CVSA to operate the NAFMP.[91] The CVSA plans, in cooperation with the FMCSA and Transport Canada, to grow the program and develop future iterations. The CVSA has started creating webinars, moderating virtual and in-person sessions, offering educational events at forums and conferences, and hosting meetings to discuss program improvements.

Through these educational activities and already ongoing regular contact with motor carriers through roadside inspections, the CVSA can directly reach motor carriers and promote the NAFMP. In a meeting with the NTSB in February 2022, the CVSA stated that it had already scheduled several webinars and conference sessions and indicated an intention to publish articles in its magazine to inform the industry about the benefits of implementing fatigue management programs.[92] However, the CVSA's initial strategies for promotion do not specifically target motor carriers that

[91] See the press release about the announcement, dated December 14, 2021.

[92] NTSB investigators met with the CVSA program manager and the FMCSA chief and project manager on February 7, 2022.

may be at higher risk of fatigued operation, such as those operating with an agricultural HOS exemption.

The NTSB concludes that the CVSA, as the operator of the NAFMP, can directly influence all motor carriers in reducing the risk of drivers operating while fatigued, including those that operate under an agricultural HOS exemption. Therefore, the NTSB recommends that the CVSA, as part of its promotion of the NAFMP, develop a dedicated outreach plan that focuses on motor carriers that operate under an agricultural HOS exemption.

2.5 Prioritization of DMS Messages

Before this crash, a shooting incident occurred in the eastbound lanes of SR-202. In response to that event, the AZDPS established a temporary traffic incident area to conduct a search for evidence. The AZDPS initiated traffic control at 8:53 p.m. and fully closed the eastbound roadway at 9:16 p.m., diverting traffic to the Priest Drive exit ramp.

The AZDPS coordinated with ADOT to activate two DMS installations in advance of road closure. The DMS are operated by the TOC of ADOT. After communicating with the AZDPS regarding the nature of the traffic incident, the TOC input the text of the message to be displayed into its display control software, and classified the message as level 4 priority. Based on the priority level, the display control software automatically began showing the message about traffic stoppage on an alternating schedule with a DTT message. Every 2 seconds, the message "LAW ENFORCEMENT, AT PRIEST, EXPECT TO STOP" would alternate with a message about expected travel time to a destination. However, displaying a DTT message on a closed roadway with its traffic diverted lacks usefulness.

The TOC operations manual describes 10 message priority levels to be displayed on DMS. High-priority messages, classified as levels 1–3, are automatically presented as a standalone message, while low-priority messages, classified as levels 4–10, can alternate with other low-priority messages. Level 2-priority messages are reserved for "active unplanned closures of ADOT roads," while level 4-priority messages are reserved for "active unplanned lane restrictions, or ramp closures (crashes, debris, etc.)."

The ADOT definitions of level 2 and level 4 priority messages clearly differentiate between closure of ADOT roads (for level 2) and lane restrictions (for level 4). At the location of the crash, SR-202 is a divided roadway separated by a concrete median barrier, where traffic in one direction is fully insulated from the traffic in the opposite direction. For practical purposes, each direction of travel is a road by itself. Based on the ADOT manual, the incident that preceded the crash should have been viewed as a closure of an ADOT roadway and, as such, granted a high-priority message.

Had the message about traffic stoppage received a high-priority status as it should have, and had it been displayed as a standalone message, it would have been visible to motorists for twice the amount of time. Nevertheless, the information about the traffic stoppage was available to the truck driver through two DMSs before he reached the traffic queue, even if the critical message was displayed for half the duration it should have been. Finally, the fully conspicuous brake lights from the vehicles in the traffic queue in front of the truck driver, combined with the flow of the vehicles in the left lanes, provided the driver with sufficient cues to take appropriate evasive action and prevent the crash from occurring. The NTSB therefore concludes that although the ADOT TOC classification of the road closure message as low priority deemphasized the safety risk of the ongoing traffic incident, it is unlikely that the low-priority message level affected the truck driver's failure to notice the fully conspicuous traffic queue. However, it is critical that the presentation of a DMS message matches the safety risk of the traffic incident. Therefore, the NTSB recommends that ADOT revise its DMS operational policies to classify single-direction road closures as high-priority messages.

2.6 Increasing the Use of Occupant Restraints

Lap/shoulder belts enhance the protection for occupants in a crash by allowing the occupant to move with the vehicle and benefit from the crashworthiness of the vehicle's structure in a crash. Further, lap/shoulder belts are designed to control an occupant's motion during a crash and reduce impacts both inside and external to the vehicle and position the occupant to benefit from deploying airbag systems. Unbelted, drivers and passengers are thrown from their seats, impacting structures at speeds that can cause injury and are also at risk of ejection during a crash.

Vehicle occupants not wearing a lap/shoulder belt are 30 times more likely to be ejected in a crash, a critical factor considering that 75% of ejected vehicle occupants die in fatal crashes (NHTSA 2009). NHTSA estimates that for front-seat occupants of passenger vehicles and light trucks, lap/shoulder belts reduce fatalities by 45% and 60%, respectively (Kahane 2015).[93]

All the vehicles involved in this crash were equipped with lap/shoulder belts in all seating positions, and all their airbags deployed during the crash. Although this crash was catastrophic in nature, particularly for the passenger vehicles and their occupants who were directly struck by the combination vehicle, it also provided examples of the benefits of using seat belts. However, the crash also exemplifies the

[93] *Light truck* or *light-duty truck* is a US classification for vehicles with a GVWR up to 8,500 pounds.

consequence of not using or improperly using the available restraints (for an illustration of the level of injury by vehicle, please see figure 4).

Although all four occupants of the Ford were belted, the vehicle was struck directly from behind by the combination vehicle at a speed of 62 mph and then partially driven over, sustaining catastrophic damage to the interior of the vehicle. The driver and the left rear-seat passenger died, as no survivable space remained on the left side of the vehicle. The right front-seat and the right rear-seat passengers sustained serious injuries, most likely as a result of the roof collapse. The seat belts used by these two passengers likely reduced their level of injury.

The Toyota was struck in the rear and pushed into the vehicle ahead before veering off and striking the right concrete barrier and flipping over. The driver was belted, and although he was partially ejected and seriously injured, the seat belt likely prevented him from being fully ejected during the crash sequence. Although it could not be determined whether the Chevrolet driver was belted, the catastrophic nature of the impact by the truck-tractor and the postcrash fire were not survivable.

The Nissan was struck in the rear by the Chevrolet and pushed into the rear of the Dodge, sustaining catastrophic damage. Additionally, the right side of the Nissan sustained considerably more damage and intrusion than the left side. Only one of the four occupants of the Nissan was belted; she was seated behind the driver and received minor injuries. The driver, though unbelted, also received minor injuries. The front seat passenger was not belted, was ejected, and died. Had this passenger been belted, she would have remained inside the vehicle and had a greater chance of survival. The other rear seat passenger was also unbelted and sustained serious injuries.

The driver of the Dodge was unbelted and sustained serious head injuries from impacting the steering wheel. Had the driver been belted, he likely would have benefited from the restraining action of the belt and the airbag deployment, thus reducing his risk of injury from a direct contact with the steering wheel. The front-seat passenger of the Dodge was belted; she sustained minor injuries.

The 6-year-old child in the rear seat of the Mercedes-Benz was restrained with a lap/shoulder belt but was not using a booster seat, as required by Arizona law. The minor injuries that the child sustained—seat belt abrasion to the neck and whiplash—likely would have been prevented by the adjustable belt positioning of a booster seat or use of a child safety seat. Arizona laws require young and small children to use a federally approved safety seat or device when riding in a vehicle. All 50 states, the District of Columbia, and Puerto Rico have seating requirements for young children to be restrained by a child safety seat, including a booster seat, depending on their age, height, and weight.[94]

The NTSB concludes that the use of lap/shoulder belts by the passenger vehicle occupants would have reduced serious and fatal injuries and the risk of ejection. Furthermore, the NTSB concludes that the use of a lap/shoulder belt without an appropriate child safety restraint system contributed to the injuries of the child occupant. Transportation safety advocates and state and federal agencies, including the NTSB, regularly conduct outreach to increase awareness and proper use of child seats. The NTSB is issuing Safety Alert SA-085 on this topic (see Safety Alerts (ntsb.gov)).

The NTSB's advocacy for seat belts extends more than half a century.[95] While the early advocacy focused on equipping all vehicles with seat belts, ensuring seat belt use soon became the primary focus. Lap/shoulder belts are effective in improving occupant survivability during crashes only when they are properly used. As such, the NTSB has promoted efforts and advocated for enacting legislation to require the use of seat belts in all vehicles and in all seating positions.

In 1991, the NTSB recommended that the 12 states that, at the time, did not have seat belt use laws mandate seat belt use in all passenger vehicles in all seating positions.[96] More recently, following an investigation of a 2014 crash in Davis, Oklahoma, involving a seat belt-equipped medium-size bus (NTSB 2015b), the NTSB extended this advocacy for seat belt use in all vehicles, issuing the following recommendation to all 50 states, the District of Columbia, and Puerto Rico:

> Enact legislation that provides for primary enforcement of a mandatory seat belt use law for all vehicle seating positions equipped with a passenger restraint system. (H-15-42)[97]

This recommendation was issued, in part, based on the considerable research showing an increase in seat belt use and a decrease in fatalities following the

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[94] Some state laws apply to children up to age 9. See the Insurance Institute for Highway Safety summary of child seat laws by state.

[95] In a 1968 report about a rollover crash in Baker, California (NTSB 1968), the NTSB recommended expediting a process to require seat belts on commercial motor carriers (Safety Recommendation H-68-18).

[96] Safety Recommendation H-91-13 was classified Closed—Acceptable Action for 11 states and Closed—Unacceptable Action for New Hampshire. This recommendation was associated with the NTSB's 1988 safety study concerning the performance of lap/shoulder belts in 167 crashes (NTSB 1988).

[97] Safety Recommendation H-15-42 superseded a recommendation issued in 1997 (Safety Recommendation H-97-2).

transition from secondary to primary enforcement (Beck and West 2011; Chen 2015; Farmer and Williams 2004; Douma and Tilahun 2012).

Arizona has a secondary enforcement seat belt use law that applies only to front seat occupants. In 2019, the Arizona State Legislature considered but failed to pass a bill requiring seat belt use in both the front and rear seating positions. Although this proposed bill did not include consideration of motorcoaches and other buses and would have maintained secondary enforcement, it nonetheless represented an attempted positive action. Given the consideration for the attempted change in state legislation, Safety Recommendation H-15-42 for Arizona was classified Open—Acceptable Alternate Response. The recommendation remains open for 38 states and the District of Columbia, with the overall classification of Open—Acceptable Alternate Response.[98]

According to NHTSA's observational survey data, seat belt use for adults in Arizona in 2021 was 88.8% (NHTSA 2022), and the seat belt use for adults in states with primary enforcement seat belt use laws for front and rear seat occupants in passenger vehicles and light trucks is 4% higher than in other states—91% compared to 87%.[99]

The impact of primary enforcement on seat belt use and crash survivability can also be examined through fatal crash data. A high percentage of belted fatally injured vehicle occupants indicates catastrophic crashes in which restraint systems were not sufficient for survival. But a high percentage of unbelted fatally injured occupants would include some less severe crashes that could be survivable with seat belt use. According to 2020 NHTSA data from the Fatality Analysis Reporting System, 46% of fatally injured occupants in the front and rear seats of passenger vehicles and light trucks in Arizona were unbelted.[100] As a comparison, the percentage of *unbelted* fatally injured occupants is higher in states without primary enforcement than in other

[98] Of the 38 states and the District of Columbia with open classifications, three are classified Open—Acceptable Response (Alabama, Mississippi, New York), 23 are classified Open—Acceptable Alternate Response (Arizona, Arkansas, Colorado, Connecticut, Florida, Georgia, Idaho, Iowa, Massachusetts, Missouri, Montana, Nebraska, Nevada, New Hampshire, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, South Dakota, Vermont, Virginia, Wyoming), and 13 are classified Open—Unacceptable Response (the District of Columbia, Hawaii, Kansas, Kentucky, Louisiana, Maryland, Michigan, New Jersey, New Mexico, South Carolina, Tennessee, Texas, and West Virginia).

[99] See NHTSA's Fact Sheets Traffic Safety Facts for Arizona and other states. The primary enforcement states have primary enforcement of seat belt use laws that apply for front and rear seats in passenger vehicles and light trucks. See the Insurance Institute for Highway Safety compilation of seat belt use laws by state.

[100] The 46% of killed occupants in Arizona were unbelted, and the belt use of the remaining killed occupants is unknown. See NHTSA's Traffic Safety Facts Annual Report Tables, the States: Occupants section.

states—49% compared to 42%. This indicates that states with primary enforcement would have had more crashes that could have been survivable with seat belt use.

Considering the benefits that seat belt use could have had in this crash and that primary enforcement seat belt use laws increase seat belt usage, the NTSB reiterates Safety Recommendation H-15-42 to the District of Columbia and the 38 states with open classification (see list in earlier footnote).

2.7 Increasing Deployment of Collision Avoidance Technologies

The NTSB has a long history of advocating for collision avoidance technologies in vehicles. This advocacy started in 1995 following the investigation of a crash in Menifee, Arkansas, which occurred in foggy conditions and involved nine vehicles and a series of rear-end collisions (NTSB 1995).

This safety need was initiated with a recommendation to the USDOT to research collision warning technologies in partnership with motor carriers; the safety need focused on sensor-based collision avoidance technologies.[101]

A second area of improvement focused on collision prevention technologies based on communication—described as vehicle-to-everything (V2X)—and was initiated with a recommendation to the Federal Communications Commission (FCC) to allocate a dedicated spectrum for transportation safety technologies.[102]

The following sections discuss the extent to which forward collision avoidance systems and V2X may have affected this crash.

2.7.1 Forward Collision Avoidance Systems

Since the initial recommendation following the investigation of the Menifee crash, the NTSB has issued more than 20 recommendations pertaining to sensor-based forward collision avoidance systems (CAS), specifically forward collision warning (FCW) and automatic emergency braking (AEB). In 2015, the NTSB published a special investigation report in which we issued recommendations to vehicle manufacturers and to NHTSA regarding deployment of forward CAS in all highway vehicles and for the rating of forward CAS and expansion of the New Car Assessment Program (NTSB 2015c). Because the NTSB recognizes differences in CAS performance parameters between passenger and commercial vehicles, many recommendations referenced development of these systems specifically for

[101] Safety Recommendation H-95-44 to the USDOT was classified Closed—Unacceptable Action in 1999.

[102] Safety Recommendation H-95-46 to the FCC was classified Closed—Acceptable Action after the FCC allocated 75 megahertz (MHz) on a 5.9-gigahertz spectrum, in 1999.

commercial vehicles. As such, in the special investigation report, the NTSB recommended that NHTSA—

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

As of the date of this report, Safety Recommendation H-15-5 is classified Open—Unacceptable Response. On June 7, 2022, NHTSA stated it was drafting an NPRM on performance standards for AEB in commercial vehicles. As of the date of this report, NHTSA has not issued an NPRM on this topic.

In 2019, NHTSA issued a request for comments (RFC) seeking public input about research test protocols for forward CAS in commercial vehicles.[103] The proposed test protocols include three typical scenarios for evaluation of forward CAS: (1) encountering a stopped vehicle in the same lane of travel, (2) encountering a slower-moving vehicle in the same lane of travel, and (3) following a vehicle that decelerates after a period. The first scenario fits the basic description of this crash. However, in NHTSA's research test parameters, the stopped lead vehicle scenario is conducted at the single test vehicle speed of 25 mph.

In responding to NHTSA's RFC, the NTSB expressed concern about the test speeds being far below typical highway speeds at which commercial vehicles travel, stating that "we strongly believe that it is important to strive for the performance we want the systems to be able to reach, not merely to test to the current capabilities of the systems."[104]

Although the basic geometric parameters of this crash meet the characteristics of NHTSA's stopped lead vehicle scenario—occurring on a straightaway and directly approaching the rear of another vehicle—the 62-mph velocity differential in this crash far surpasses the speed in NHTSA's research test procedures, despite the fact that this velocity differential is commonly encountered on US highways.

Current forward CAS may be able to, at least in some conditions, mitigate rear-end crashes involving a high velocity differential. As part of an investigation of a 2016 crash in San Jose, California, in which a motorcoach struck a previously damaged crash attenuator and a concrete barrier, the NTSB conducted testing to evaluate the capacity of a forward CAS to detect such hazards (NTSB 2017). The testing included a truck-tractor traveling at different speeds and approaching a crash attenuator under different conditions. The onset of an FCW alert and AEB activation was recorded and

[103] See the request for comments.

[104] See the NTSB's response to NHTSA's RFC, "Advanced Driver Assistance Systems Draft Research Test Procedures," published at 84 *Federal Register* 64405 (November 21, 2019).

expressed as time-to-contact (TTC).[105] At an approach speed of 55 mph, the system's FCW alerted the driver at 2.05–2.6 seconds TTC and engaged the AEB at 1.5–1.7 seconds TTC.

The truck driver in the Phoenix crash had an opportunity to read an early warning message on a DMS about potential traffic stoppage and had a prolonged clear view of a fully conspicuous queue of stopped vehicles, yet he failed to brake. The primary goal of an FCW is to orient drivers' attention toward the source of a potential hazard, allowing them to execute an avoidance maneuver. A bi-modal alert (visual and auditory) from a vehicle's FCW is more effective in capturing drivers' attention than a single visual message presented outside the vehicle, such as on a DMS (Lewis and others 2013; Ho, Reed and Spence 2007; Kiefer, LeBlanc and Flannagan 2005). However, the benefits of an in-vehicle warning—even with bi-modal alert—are reduced when a driver is fatigued (Gaspar and others 2019). The benefits of AEB in combination vehicles, such as the one involved in this crash, may be reduced due to the weight of the vehicle and its limited braking capacity. Although avoidance of an impact may not be feasible, based on the timing of AEB activation in the San Jose tests (1.5–1.7 TTC), the reduction in impact speed would reduce the crash severity.

The benefits of forward CAS are dependent on the system detecting the forward hazard, but the overall system detection performance can be incentivized through performance standards and testing protocols that mirror real-world conditions that push the upper limits of system capabilities.

As such, the NTSB concludes that the speed differential in this crash was well outside the parameters of NHTSA's research test protocols for forward CAS in heavy vehicles. Therefore, the NTSB reiterates Safety Recommendation H-15-5 to NHTSA.

2.7.2 V2X

V2X technology relies on direct communication between vehicles, and between vehicles and infrastructure and other targets, such as motorcyclists, bicyclists, and pedestrians. This communication is done through devices that transmit and receive messages indicating the speed, heading, brake status, and other information pertinent to safe roadway operation.[106] When compared to vehicle-resident sensor systems, such as forward CAS, V2X technology has considerably

[105] TTC referred to the time before impact with the cylinder based on the direction and speed of the truck-tractor. The test driver would take an evasive action moments before the impact.

[106] Some of the more frequent communication pairings include vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), and vehicle-to-pedestrian (V2P). The term V2X encapsulates all types of communication pairings.

longer conflict detection distances, the ability to "see" around corners or through objects, and is unaffected by inclement weather. Although both V2X technology and vehicle-resident sensor systems, such as forward CAS, have the capacity to mitigate and prevent crashes on their own, they can provide greater safety benefits when combined.

2.7.2.1 Research and Early NTSB Recommendations. Since the FCC's original allocation of the safety spectrum in 1999, many federal and state government agencies, academic institutions, and industry groups have been conducting extensive research examining the implementation, application, and effectiveness of V2X technology. Various USDOT agencies led many of these research projects, frequently in collaboration with other entities and institutions. In some of the earlier research projects, NHTSA estimated that about 80% of all crash scenarios involving nonimpaired drivers could be addressed by this technology (Wassim and others 2010, NHTSA/Crash Avoidance Metrics Partners [CAMP] 2011). The maximum safety benefits of this technology will be obtained only if it is widely deployed. In one of the largest V2X naturalistic studies, the USDOT's Intelligent Transportation Systems Joint Program Office collaborated with the University of Michigan Transportation Research Institute to conduct a Safety Pilot Model Deployment that included more than 2,800 V2X-equipped vehicles and 2,500 infrastructure locations equipped with V2X devices. One of the most remarkable findings from this 1.5-year-long deployment is that no missed FCW alerts occurred; of the 368 encountered rear-end near-crash scenarios, the V2X devices alerted the drivers in all of those scenarios (USDOT 2015).

With the continued research and increased roadside deployment, the NTSB recognized the necessity of widespread deployment of the technology. Following an investigation of a 2012 fatal crash in Chesterfield, New Jersey (NTSB 2013), in which a school bus entered an intersection into the path of a refuse truck, the NTSB issued the following safety recommendations to NHTSA:

> Develop minimum performance standards for connected vehicle technology for all highway vehicles. (H-13-30)
>
> Once minimum performance standards for connected vehicle technology are developed, require this technology to be installed on all newly manufactured highway vehicles. (H-13-31)

In January 2017, NHTSA issued an NPRM to mandate V2X technology for new passenger vehicles based on the dedicated short-range communication (DSRC) standard, and to standardize the communication requirements of vehicle-to-vehicle

(V2V) messages.[107] The NTSB supported the proposed ruling but criticized the exclusion of heavy vehicles from the mandate.[108]

However, in December 2018, the USDOT issued an RFC in which the agency acknowledged the significant progress made in the development of DSR-based V2X, but also recognized the recent developments in cellular-based communication technology, and sought comments regarding differences between these two technologies.[109] The NTSB responded to this RFC, restating our position about the benefits and the necessity of V2X technology.[110] Although we did not comment on the technical distinction between different communication protocol technologies, in our response we stated that ". . . DOT should not put existing technologies, such as DSRC, on hold while waiting for the next emerging technology to arrive . . ."

There has been no regulatory activity by the USDOT or NHTSA on this issue since the 2018 RFC. Due to lack of progress, Safety Recommendations H-13-30 and -31 are classified Open—Unacceptable Response. The NTSB has previously reiterated these recommendations five times, and this investigation reveals yet another example of a crash that could have been prevented with this technology.[111]

Preventing rear-end crashes with high velocity-differentials is well within the described capabilities of V2V, with a specified minimum communication range of 300 meters (984 feet) in an open-space environment.[112] With these operational characteristics, V2V communication between only one of the passenger vehicles in the traffic queue and the truck-tractor would have been sufficient for identification of the stopped vehicle hazard. As discussed in the forward CAS section, the primary

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[107] (a) See Docket No. NHTSA–2016–0126, NPRM "Federal Motor Vehicle Safety Standards (FMVSS): V2V Communications," published at 82 Federal Register 3854, January 12, 2017.

(b) DSRC is a communication protocol / technology for V2X applications. NHTSA's proposed standard largely adopted the DSRC standards developed by SAE International: SAE J2735 and SAE J2945.

[108] See the NTSB letter sent on March 29, 2017, to Rules Docket No. NHTSA-2016-0126 in response to the NPRM.

[109] See the Notice of Request for Comments: V2X Communications (83 *Federal Register* 66338 on December 26, 2018).

[110] See the NTSB letter to Rules Docket No. DOT-OST-2018-0210, sent March 11, 2019, in response to the RFC "V2X Communications," published at 83 *Federal Register* 246, December 26, 2018.

[111] Safety Recommendations H-13-30 and -31 were reiterated in the following reports: Williston, Florida (NTSB/HAR-17/02); Bicycle Safety on US Roadways (NTSB/SS-19/01); Rochester, Indiana (NTSB/HAR-20/02), Mt. Pleasant Township, Pennsylvania (NTSB/HIR-22/01), and Fort Worth, Texas (NTSB/HIR-23/01).

[112] In the 2017 NPRM, NHTSA discusses the communication transmission range.

goal of an in-vehicle alert (whether obtained through data from sensors or V2X communication) is to capture and orient a driver's attention to the upcoming hazard. Such an alert can potentially benefit a distracted or even drowsy driver (by reducing the cognitive cost of inattention), although the benefits are greater for an alert driver (Lee and others 2002; Mohebbi, Gray and Tan 2009; Gaspar and others 2019). Similar safety benefits could be obtained through vehicle-to-infrastructure (V2I) communication, had that location been equipped with a roadside V2X communication device.

The NTSB concludes that had the truck-tractor and at least one of the vehicles in the traffic queue been equipped with V2X capabilities, the truck driver would have been alerted of the stopped traffic queue well in advance to take necessary action to prevent the crash from occurring or at least mitigate its severity. Therefore, the NTSB reiterates Safety Recommendations H-13-30 and -31 to NHTSA.

2.7.2.2 Industry Activities, Recent FCC Actions, and NTSB Recommendations. Several significant industry actions occurred after NHTSA's proposed rulemaking in 2017. General Motors started to equip Cadillac CTSs with DSR-based V2X capabilities, beginning with the 2017 model year, and in 2018 announced plans to start expanding V2X deployment across its Cadillac fleet in 2023.[113] In April 2018, Toyota announced plans to start equipping portions of its fleet with DSR-based V2X capabilities by 2021.[114] However, several months after the USDOT's December 2018 RFC, Toyota announced that it was suspending its plans for V2X deployment based on DSRC technology.[115] Toyota stated that the suspension was due to regulatory uncertainty about the dedicated spectrum, as well as due to the lack of significant deployment plans from other manufacturers.

In October 2021, after several years of preparatory regulatory activity, the FCC finalized a ruling that decreased the transportation safety band from 75 MHz to 30 MHz, allowed unlicensed devices not associated with transportation to operate in the reallocated lower 45 MHz band, allocated the new 30-MHz band only for cellular-

[113] (a) The Cadillac CTS continued being equipped with V2X capabilities through model year 2019. GM has not expanded deployment across its Cadillac fleet. The following sections describe the FCC ruling that terminated the broadcast of DSR-based V2X devices. (b) See the GM letter "Ex Parte Presentation, ET Docket No. 13-49: Cadillac Expands Use of V2X Communications," sent July 13, 2018, to the FCC Secretary.

[114] For more details, see the Toyota announcement.

[115] (a) Toyota described its decision in a comment letter, sent on April 26, 2019 to the FCC (ET docket No. 13-49, GN docket No. 18-357). (b) In May 2018, Toyota had also received a letter from the FCC informing the manufacturer that there are several factors "that Toyota should keep in mind when committing capital expenditures to DSRC technology," including that the FCC, USDOT, and National Telecommunications and Information Administration were currently evaluating the potential for DSRC sharing the 75 MHz safety spectrum with V2X and with unlicensed devices.

based V2X technology, and ordered discontinuation of DSR-based V2X technology.[116]

The impact of the FCC rulemaking is multifold. First, the ruling ordered states and other entities to terminate the use of the lower 45 MHz of the original safety band by July 2022. This ruling forced state DOTs and local governments to end most of the existing V2I deployment projects which were based on DSRC technology. Second, the introduction of unlicensed devices, such as those that use wi-fi, into the neighboring band introduced a high risk of harmful interference to the communications of V2X devices. Concerns regarding interference, supported by research, were strongly expressed to the FCC before the ruling.[117] A wide range of stakeholders expressed those concerns, including the automotive industry, various USDOT agencies, and the NTSB.[118] Multiple studies showed that, in certain conditions, the intrusion of signals from unlicensed devices into the 30 MHz transportation safety band would severely compromise V2X applications that rely on low latency and high reliability (NHTSA 2019, CAMP 2020); the rear-end crash in Phoenix is an example of an imminent crash scenario that requires low latency and high reliability of communication.[119] Third, the reduced safety band precludes many advanced V2X applications, including vehicle-to-pedestrian and vehicle-to-other vulnerable road users, truck platooning, and shared perception with future automated vehicles.[120] The reduced safety band also brings into serious question the feasibility of provisions related to vulnerable road users in the Infrastructure Investment and Jobs Act, which Congress passed in November 2021.[121] The NTSB

[116] (a) See the final rule, issued in October 2021. (b) In 2013, the FCC published an NPRM to reduce the transportation safety spectrum and allocate the reclaimed bandwidth for use of unlicensed devices. See ET Docket No. 13-49, published on February 20, 2013. (c) The V2X is an umbrella term for LTE-V2X and 5G-V2X technology. These are distinct communication protocols and require separate frequency band for communication. In the May 2021 NPRM, the FCC proposed that the newly formed 30-MHz band be allocated for LTE-V2X.

[117] The FCC issued an NPRM in February 2020. See 85 *Federal Register* 6841 (February 6, 2020).

[118] See the NTSB response to the FCC's 2020 NPRM.

[119] In addition to NHTSA and CAMP research, also see the Ford letter "Comments of the Ford Motor Company," sent on March 9, 2020, to the FCC ET Docket No. 19-138.

[120] (a) See the Intelligent Transportation Society of America (ITS America) report for more information. (b) Truck platooning refers to two or more combination vehicles traveling on a highway and following each other very closely to improve fuel economy.

[121] Section 24219 of the Infrastructure Investment and Jobs Act, enacted on November 15, 2021, requires NHTSA and the FHWA to collaborate with the ITS Joint Program Office, to expand V2P research to incorporate bicyclists and other vulnerable road users, and to analyze how all these applications can be "accommodated within existing spectrum allocations for connected vehicle systems."

discussed these topics in a 2022 video series, in which the NTSB conducted in-depth interviews with experts in federal and state governments, industry, and academia.[122]

Our investigation of a 2020 crash that occurred in Mt. Pleasant Township, Pennsylvania, provided the first opportunity for the NTSB to examine the V2X deployment obstacles post-FCC action (NTSB 2022a). This crash occurred on the Pennsylvania Turnpike in nighttime during inclement weather and involved several combination vehicles traveling along a curve as they encountered an overturned motorcoach that was on its side blocking all travel lanes. The circumstances of this crash highlighted the limitations of vehicle-resident sensor CAS, such as those supporting AEB, but also emphasized the importance of V2X as complementary technology.

Supported by knowledge gained in the V2X video series, the Mt. Pleasant report explored the reasons for lack of broad V2X deployment and identified regulatory uncertainty as the critical issue, characterized by the USDOT's lack of concrete steps since NHTSA's 2017 NPRM, the FCC's planned and executed reduction of the transportation safety spectrum, and industry division regarding communication protocol technology, all of which fueled automakers' reluctance to invest in the uncertain environment. These critical factors indicated an absence of national leadership, which was particularly concerning considering that the broader auto industry indicated a need for government regulations regarding V2X.[123] As a result, the NTSB issued the following safety recommendations:

> To the USDOT: Implement a plan for nationwide connected vehicle technology deployment that (1) resolves issues related to interference from unlicensed devices, such as those that use wi-fi; (2) ensures sufficient spectrum necessary for advanced connected vehicle applications; and (3) defines communication protocols to be used in future connected vehicle deployment. (H-22-1)

> To the FCC: Implement appropriate safeguards to protect vehicle-to-everything communications from harmful interference from unlicensed devices, such as those that use wi-fi. (H-22-6)

[122] See the four-part Most Wanted List interview video series hosted by NTSB Board Member Michael Graham. Episode 1 of the series provides an overview of V2X technology and effectiveness research, as well as a discussion of harmful interference from unlicensed devices. Episode 2 discusses the impact of FCC actions and global advancements in V2X technology. Episode 3 examines infrastructure deployment and state DOT perspectives. Episode 4 is focused on the obstacles to deployment with perspectives from two major auto manufacturers.

[123] See episodes 2 and 4 of the NTSB V2X video series.

Because the USDOT and the FCC did not respond to Safety Recommendations H-22-1 and -6, they had remained classified Open—Await Response.[124] In August 2022, the USDOT held the V2X Communications Summit, during which USDOT agencies described the research projects they have been conducting and the NTSB, industry, and state DOTs expressed their concerns about the regulatory uncertainty and called for leadership by the USDOT.[125] At that time, the Alliance for Automotive Innovation, an association representing nearly all automakers in the United States, published a set of policy recommendations that included calling for the USDOT to develop a national V2X vision and strategy.[126] As of the date of this report, the USDOT has reported no further progress on this activity.

Considering the lack of reported progress, continued regulatory uncertainty, and automakers yet to begin deploying this lifesaving technology, it remains essential for the USDOT to take a prominent leadership role in creating a path for nationwide deployment, and to not allow this lifesaving technology to remain unused. Due to this lack of progress, Safety Recommendations H-22-1 and -6 are classified Open—Unacceptable Response. In the investigation of the Phoenix crash, we found that, had the truck-tractor and at least one of the vehicles in the traffic queue been equipped with V2X capabilities, the truck driver would have been alerted of the stopped traffic queue well in advance to take necessary action to prevent the crash from occurring. Therefore, the NTSB reiterates Safety Recommendation H-22-1 to the USDOT. The NTSB also reiterates Safety Recommendation H-22-6 to the FCC.

[124] On June 7, 2022, NHTSA sent official correspondence regarding Safety Recommendation H-22-1 (as well as H-13-30 and -31), describing the research that the agency has been conducting. However, Safety Recommendation H-22-1 was issued to the USDOT rather than to NHTSA because the NTSB believes that implementing a nationwide V2X plan as described in the recommendation requires leadership by the USDOT. In a November 7, 2022, response to the USDOT, the NTSB expressed thanks for NHTSA's response and stated that we were awaiting official correspondence from the Secretary of Transportation's office.

[125] See the USDOT webpage for additional information about the V2X Summit.

[126] See the publication *V2X The Road Ahead*.

3. Conclusions

3.1 Findings

1. None of the following were factors in the crash: (1) the licensing or driving experience of the truck driver; (2) cell phone use, use of alcohol or other drugs, or medical conditions of the truck driver; (3) the mechanical condition of the combination vehicle or the passenger vehicles; and (4) highway design.

2. The emergency response was timely and adequate.

3. The truck driver's lack of avoidance response—evident in the vehicle data and video from the fleet management system—to the bright and conspicuous tail and brake lights of the vehicles in the traffic queue ahead was likely the result of fatigue.

4. Although Arizona Milk Transport equipped its vehicles with a fleet management and driving monitoring system, the carrier's implementation of the system—which includes coaching of drivers—was ineffective in improving the driving behavior of its drivers and in reducing violations of carrier safety policies.

5. Arizona Milk Transport's lack of oversight to ensure adherence to company policies allowed the crash-involved driver and other drivers to operate well beyond the carrier-allowable hours of operation.

6. By not having a fatigue management program and by not incorporating considerations for fatigue in its policies and monitoring mechanisms, Arizona Milk Transport failed to mitigate the risk of fatigue for its drivers who frequently operated beyond maximum hours-of-service limits for non-exempt carriers.

7. Drivers operating under an agricultural exemption, which allows them to operate beyond traditional hours-of-service limits, would be at greater risk of fatigued operation.

8. Motor carriers can considerably reduce fatigue-related crash risk and improve safety by implementing a fatigue management program.

9. Due to the limited oversight and lack of monitoring of motor carriers operating under an agricultural hours-of-service (HOS) exemption, the extent to which these motor carriers operate beyond traditional HOS limits—which can increase the risk of fatigued operation by drivers—is unclear.

10. By including a transportation safety component in the oversight of milk and dairy production and transportation, milk cooperatives and dairy-processing plants can mitigate the risk of fatigued driving.

11. The Commercial Vehicle Safety Alliance, as the operator of the North American Fatigue Management Program, can directly influence all motor carriers in reducing the risk of drivers operating while fatigued, including those that operate under an agricultural hours-of-service exemption.

12. Although the Arizona Department of Transportation Traffic Operations Center classification of the road closure message as low priority deemphasized the safety risk of the ongoing traffic incident, it is unlikely that the low-priority message level affected the truck driver's failure to notice the fully conspicuous traffic queue.

13. The use of lap/shoulder belts by the passenger vehicle occupants would have reduced serious and fatal injuries and the risk of ejection.

14. The use of a lap/shoulder belt without an appropriate child safety restraint system contributed to the injuries of the child occupant.

15. The speed differential in this crash was well outside the parameters of the National Highway Traffic Safety Administration's research test protocols for forward collision avoidance systems in heavy vehicles.

16. Had the truck-tractor and at least one of the vehicles in the traffic queue been equipped with vehicle-to-everything capabilities, the truck driver would have been alerted of the stopped traffic queue well in advance to take necessary action to prevent the crash from occurring or at least mitigate its severity.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of the Phoenix, Arizona, multivehicle crash was the truck driver's failure to respond to the fully conspicuous traffic queue, likely as the result of fatigue. Contributing to the crash was Arizona Milk Transport's (1) poor oversight of its drivers, (2) lack of fatigue management program, and (3) failure to enforce its own policies, such as those regarding on-duty hours—all a consequence of its inadequate safety culture. Contributing to the severity of injuries to several passenger vehicle occupants was their lack of or improper lap/shoulder belt use.

4. Recommendations

4.1 New Recommendations

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

To the US Department of Transportation:

Develop and implement a program to determine the prevalence of for-hire motor carriers operating under an agricultural hours-of-service exemption and study their safety performance, including but not limited to (1) fatigue-related crashes, (2) risk of fatigued operation, and (3) adherence to fatigue management principles. Report the findings and any recommendations to improve safety to Congress, as expected in the National Highway System Designation Act, and make them publicly available. (H-23-4)

Require interstate motor carriers operating under an agricultural hours-of-service exemption to implement a fatigue management program or, if necessary, seek authority from Congress to do so. (H-23-5)

To the Arizona Department of Transportation:

Revise your dynamic message sign operational policies to classify single-direction road closures as high-priority messages. (H-23-6)

To Arizona Milk Transport:

Implement an improved coaching program as part of your fleet management and driving monitoring system that would improve driving behavior and reduce instances of violations of carrier safety policies. (H-23-7)

Implement a process to improve adherence to carrier policies and regularly verify the accuracy of drivers' reported hours of operation, such as by reviewing the drivers' records of duty status and cross-referencing other available information. (H-23-8)

Develop and implement a fatigue management program based on the North American Fatigue Management Program. (H-23-9)

To the Commercial Vehicle Safety Alliance:

> As part of your promotion of the North American Fatigue Management Program, develop a dedicated outreach plan that focuses on motor carriers that operate under an agricultural hours-of-service exemption. (H-23-10)

To the International Dairy Foods Association and the National Conference for Interstate Milk Shipments:

> Inform your members of the circumstances of this crash and encourage those members that contract with motor carriers to request that the carriers implement a fatigue management program based on the North American Fatigue Management Program. (H-23-11)

To the International Milk Haulers Association:

> Inform your members of the circumstances of this crash and encourage them to implement a fatigue management program based on the North American Fatigue Management Program. (H-23-12)

4.2 Previously Issued Recommendations Reiterated in This Report

The National Transportation Safety Board reiterates the following safety recommendations.

To the National Highway Traffic Safety Administration:

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

This recommendation is reiterated in section 2.7.1 of this report.

> Develop minimum performance standards for connected vehicle technology for all highway vehicles. (H-13-30)

> Once minimum performance standards for connected vehicle technology are developed, require this technology to be installed on all newly manufactured highway vehicles. (H-13-31)

These recommendations are reiterated in section 2.7.2.1 of this report.

To the states of Alabama, Arizona, Arkansas, Colorado, Connecticut, Florida, Georgia, Hawaii, Idaho, Iowa, Kansas, Kentucky, Louisiana,

Maryland, Massachusetts, Michigan, Mississippi, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Vermont, Virginia, West Virginia, and Wyoming, and to the District of Columbia:

> Enact legislation that provides for primary enforcement of a mandatory seat belt use law for all vehicle seating positions equipped with a passenger restraint system. (H-15-42)

This recommendation is reiterated in section 2.6 of this report.

4.3 Previously Issued Recommendations Reiterated and Classified in This Report

The National Transportation Safety Board reiterates and classifies the following safety recommendations.

To the US Department of Transportation:

> Implement a plan for nationwide connected vehicle technology deployment that (1) resolves issues related to interference from unlicensed devices, such as those that use wi-fi; (2) ensures sufficient spectrum necessary for advanced connected vehicle applications; and (3) defines communication protocols to be used in future connected vehicle deployment. (H-22-1)

This recommendation is reiterated in section 2.7.2.2 of this report. Its classification is changed from Open—Await Response to Open—Unacceptable Response.

To the Federal Communications Commission:

> Implement appropriate safeguards to protect vehicle-to-everything communications from harmful interference from unlicensed devices, such as those that use wi-fi. (H-22-6)

This recommendation is reiterated in section 2.7.2.2 of this report. Its classification is changed from Open—Await Response to Open—Unacceptable Response.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

JENNIFER HOMENDY
Chair

MICHAEL GRAHAM
Member

BRUCE LANDSBERG
Vice Chairman

THOMAS CHAPMAN
Member

Report Date: March 28, 2023

Appendixes

Appendix A: Investigation

The National Transportation Safety Board (NTSB) received notification of the Phoenix, Arizona, crash on June 10, 2021, and launched investigators on the same day from the Office of Highway Safety to address highway and vehicle factors, motor carrier operations, human performance, survival factors, and technical reconstruction. The NTSB's Transportation Disaster Assistance Division and Office of Research and Engineering participated in the investigation.

The Federal Motor Carrier Safety Administration, the Arizona Department of Public Safety, Daimler Trucks North America LLC, and United Dairymen of Arizona were parties to the investigation.

Appendix B: Consolidated Recommendation Information

Title 49 *United States Code* 1117(b) requires the following information on the recommendations in this report.

For each recommendation–

(1) a brief summary of the Board's collection and analysis of the specific accident investigation information most relevant to the recommendation;

(2) a description of the Board's use of external information, including studies, reports, and experts, other than the findings of a specific accident investigation, if any were used to inform or support the recommendation, including a brief summary of the specific safety benefits and other effects identified by each study, report, or expert; and

(3) a brief summary of any examples of actions taken by regulated entities before the publication of the safety recommendation, to the extent such actions are known to the Board, that were consistent with the recommendation.

To the US Department of Transportation:

H-23-4

Develop and implement a program to determine the prevalence of for-hire motor carriers operating under an agricultural hours-of-service exemption and study their safety performance, including but not limited to (1) fatigue-related crashes, (2) risk of fatigued operation, and (3) adherence to fatigue management principles. Report the findings and any recommendations to improve safety to Congress, as expected in the National Highway System Designation Act, and make them publicly available.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.4.1 Broader Oversight. Information supporting (b)(1) and (b)(2) can be found on pages 51-56; (b)(3) is not applicable.

H-23-5

Require interstate motor carriers operating under an agricultural hours-of-service exemption to implement a fatigue management program or, if necessary, seek authority from Congress to do so.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.4.1 Broader Oversight. Information supporting (b)(1) and (b)(2) can be found on pages 51-56; (b)(3) is not applicable.

To the Arizona Department of Transportation:

H-23-6

Revise your dynamic message sign operational policies to classify single-direction road closures as high-priority messages.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.5 Prioritization of DMS Messages. Information supporting (b)(1) can be found on pages 59-60; (b)(2) and (b)(3) are not applicable.

To Arizona Milk Transport:

H-23-7

Implement an improved coaching program as part of your fleet management and driving monitoring system that would improve driving behavior and reduce instances of violations of carrier safety policies.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.3.1 Driver Performance Monitoring. Information supporting (b)(1) can be found on pages 45-46; (b)(2) and (b)(3) are not applicable.

H-23-8

Implement a process to improve adherence to carrier policies and regularly verify the accuracy of drivers' reported hours of operation, such as by reviewing the drivers' records of duty status and cross-referencing other available information.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.3.2 Driver On-Duty Hours. Information supporting (b)(1) can be found on pages 47-48; (b)(2) and (b)(3) are not applicable.

H-23-9

Develop and implement a fatigue management program based on the North American Fatigue Management Program.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.3.3 Fatigue Management. Information supporting (b)(1) and (b)(2) can be found on pages 48-50; (b)(3) is not applicable.

To the Commercial Vehicle Safety Alliance:

H-23-10

As part of your promotion of the North American Fatigue Management Program, develop a dedicated outreach plan that focuses on motor carriers that operate under an agricultural hours-of-service exemption.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.4.2 Role of Associations. Information supporting (b)(1) and (b)(2) can be found on pages 57-59; (b)(3) is not applicable.

To the International Dairy Foods Association and the National Conference for Interstate Milk Shipments:

H-23-11

Inform your members of the circumstances of this crash and encourage those members that contract with motor carriers to request that the carriers implement a fatigue management program based on the North American Fatigue Management Program.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.4.2 Role of Associations. Information supporting (b)(1) and (b)(2) can be found on pages 57-59; (b)(3) is not applicable.

To the International Milk Haulers Association:

H-23-12

Inform your members of the circumstances of this crash and encourage them to implement a fatigue management program based on the North American Fatigue Management Program.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.4.2 Role of Associations. Information supporting (b)(1) and (b)(2) can be found on pages 57-59; (b)(3) is not applicable.

References

Beck, L.F., and B.A. West. 2011. *Vital Signs: Motor Vehicle Occupant Nonfatal Injures (2009) and Seat Belt Use (2008) Among Adults – United States*. Atlanta, Georgia: Centers for Disease Control and Prevention.

CAMP (Crash Avoidance Metrics Partners). 2020. *V2X Performance Assessment Project Task 8: Assessment of Wi-Fi Interference to V2X Communication Based on Proposed FCC 5.9 GHz NPRM*. CAMP–V2X Consortium.

Campbell, T.C. 1960. "Agricultural Exemptions from Motor Carrier Regulation." *Land Economics*, 36, No. 1, (1960):14–25.

Chen, Y.Y. 2015. *Seat Belt Use in 2014, Use Rates in the States and Territories*. (Report No. DOT HS 812 149) Washington, DC: National Highway Traffic Safety Administration.

Dinges, D.F. and N.B. Kribbs. 1991. "Performing While Sleepy: Effects of Experimentally-Induced Sleepiness." In T. H. Monk (Ed.), *Sleep, Sleepiness and Performance*, 97–128. John Wiley & Sons.

Douma, F., and N. Tilahun. 2012. *Impacts of Minnesota's Primary Seat Belt Law*. Minneapolis, Minnesota: Center for Excellence in Rural Safety.

Farmer, C., and A. Williams. 2004. *Effect on Fatality Risk of Changing From Secondary to Primary Seat Belt Enforcement*. Ruckersville, Virginia: Insurance Institute for Highway Safety.

FMCSA (Federal Motor Carrier Safety Administration). 2010. *Agricultural Commodity and Utility Carriers Hours of Service Exemption Analysis.* FMCSA-RRA-10-048 https://ntlrepository.blob.core.windows.net/lib/42000/42700/42776/FMCSA-RRA-10-048.pdf

_____ 2006. *Report to Congress on the Large Truck Crash Causation Study*. USDOT, MR/MRRA.

_____. 2000. "Hours of Service of Drivers; Driver Rest and Sleep for Safe Operations; Proposed Rule." 65 *Federal Register*, no. 85: 25540.

Gaspar, J., C. Schwarz, T. Brown & J. Kang. 2019. "Gaze Position Modulates the Effectiveness of Forward Collision Warnings for Drowsy Drivers." *Accident Analysis & Prevention*, 126, 25–30.

Giambra, L.M. 1995. “A laboratory method for investigating influences on switching attention to task-unrelated imagery and thought.” *Consciousness and Cognition*, 4, 1–21.

Hamblin, P. 1987. “Lorry Driver’s Time Habits in Work and Their Involvement in Traffic Accidents.” *Ergonomics*, 30, 1323–33.

Ho, C., N. Reed & C. Spence. 2007. “Multisensory In-Car Warning Signals for Collision Avoidance.” *Human Factors*, 49, 1107–1114.

IIHS (Insurance Institute for Highway Safety). 1987. Jones, I. & S. Howard. *Effect of driver hours of service on tractor-trailer crash involvement*. 355 (iihs.org)

Kahane, C. 2015. *Lives Saved by Vehicle Safety Technologies and Associated Federal Motor Vehicle Safety Standards, 1960 to 2012, Passenger Cars and LTVs.* (Report No. DOT HS 812 069) Evaluation Program Plan (dot.gov)

Kaneko T. & P. Jovanis. 1992. “Multi-Day Driving Patterns and Motor Carrier Accident Risk: A Disaggregate Analysis.” *Accident Analysis and Prevention*, 24, 437–456.

Kiefer, R.J., LeBlanc, D.J., and Flannagan, C.A. 2005. “Developing an Inverse Time-to-Collision Crash Alert Timing Approach Based on Drivers’ Last-Second Braking and Steering Judgments.” *Accident Analysis and Prevention*, 37, 295–303.

Lewis B.A., B.N. Penaranda, D.M. Roberts & C.L. Baldwin. 2013. “Effectiveness of Bimodal versus Unimodal Alerts for Distracted Drivers.” *Proceedings of the 7th International Driving Symposium on Human Factors in Driver Assessment, Training, and Vehicle Design*. Bolton Landing, New York.

Mack, A. 2003. “Inattentional Blindness: Looking Without Seeing.” *Current Directions in Psychological Science*, 12, 180–184.

Mollicone, D., K. Kan, C. Mott, R. Bartels, S. Bruneau, M. van Wollen, A. Sparrow and H. Van Dongen. 2019. “Predicting Performance and Safety Based on Driver Fatigue.” *Accident Analysis & Prevention*, 126, 142–145.

NHTSA (National Highway Traffic Safety Administration). 2022. “Seat Belt Use in 2021–Use Rates in States and Territories,” Traffic Safety Facts. (Report No. DOT HS 813 307) Washington, DC: NHTSA.

______. 2019. VanSickle, S., F. Ahmed-Zaid, H. Krishnan, T. Khatchatrian, S. Mahmud, E. Moradi-Pari, N. Probert, S. Ahmad, S. Kamthan, B. Gallagher, and J. McNew. *Vehicle-to-Vehicle Communications Research Project (V2V-CR)*. (Pre-final version). Washington, DC: NHTSA.

______. 2011. CAMP. *Crash Avoidance Vehicle Safety Communications –Applications (VSA) Final Report*. (Report No. DOT HS 811 492A) Washington, DC: NHTSA.

______. 2010. Wassim, N.G., J. Koopman, J.D. Smith & J. Brewer. *Frequency of Target Crashes for IntelliDrive Safety Systems* (bts.gov). (Report No. DOT HS 811 381) Washington, DC: USDOT/Volpe Center.

______. 2009. "Occupant Protection," Traffic Safety Facts. (Report No. DOT HS 811 160) Washington, DC: NHTSA.

______. 1984. Final Regulatory Impact Analysis Amendment to Federal Motor Vehicle Safety Standard 208, Passenger Car Front Seat Occupant Protection. (Report No. DOT HS 806 572) Washington, DC: NHTSA.

NTSB (National Transportation Safety Board). 2022a. *Multivehicle Crash Near Mt. Pleasant Township, Pennsylvania, January 5, 2020*. NTSB/HIR-22/01 (Washington, DC: National Transportation Safety Board, 2022).

______. 2022b. *Multivehicle Crash Near the Township of Arlington, Wisconsin, June 12, 2020*. NTSB/HIR-22/03 (Washington, DC: National Transportation Safety Board, 2022).

______. 2017. *Motorcoach Collision With Crash Attenuator in Gore Area, US Highway 101, San Jose, California, January 19, 2016*. NTSB/HAR-17/01 (Washington, DC: National Transportation Safety Board, 2017).

______. 2015a. *Multivehicle Work Zone Crash on Interstate 95, Cranbury, New Jersey, June 7, 2014*. NTSB/HAR-15/02 (Washington, DC: National Transportation Safety Board, 2015).

______. 2015b.*Truck-Tractor Semitrailer Median Crossover Collision With Medium-Size Bus on Interstate 35, Davis, Oklahoma, September 26, 2014*. NTSB/HAR-15/03 (Washington, DC: National Transportation Safety Board, 2015).

______. 2015c. *The Use of Forward Collision Avoidance Systems to Prevent and Mitigate Rear-End Crashes*. NTSB/SIR-15/01 (Washington, DC; National Transportation Safety Board, 2015).

______. 2012a. *Motorcoach Run-Off-the-Road and Collision With Vertical Highway Signpost, Interstate 95 Southbound, New York City, New York, March 12, 2011*. NTSB/HAR-12/01 (Washington, DC: National Transportation Safety Board, 2012).

_____. 2012b. *Motorcoach Roadway Departure and Overturn on Interstate 95 Near Doswell, Virginia, May 31, 2011*. NTSB/HAR-12/02 (Washington, DC: National Transportation Safety Board, 2012).

_____. 2010. *Truck-Tractor Semitrailer Rear-End Collision Into Passenger Vehicles on Interstate 44, Near Miami, Oklahoma, June 26, 2009*. NTSB/HAR-10/02 (Washington, DC: National Transportation Safety Board, 2010).

_____. 2000. *Greyhound Motorcoach Run-Off-the-Road Accident, Burnt Cabins, Pennsylvania, June 20, 1998*. NTSB/HAR-00/01 (Washington, DC: National Transportation Safety Board, 2000).

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

_____. 1990. *Fatigue, Alcohol, Other Drugs, and Medical Factors in Fatal-To-The-Driver Heavy Truck Crashes* (Volume 1), Safety Study NTSB/SS-90/01 (Washington, DC: National Transportation Safety Board, 1990).

_____. 1988. *Safety Study – Performance of Lap/Shoulder Belts in 167 Motor Vehicle Crashes*. NTSB/SS-88/02 (Washington, DC: National Transportation Safety Board, 1988).

_____. 1968. *Interstate Bus/Automobile Collision, Interstate Route 15, Baker, California, March 7, 1968*. NTSB/HAR-SS-H-3 (Washington, DC: National Transportation Safety Board, 1988). [030768CA.pdf (ntsb.gov)](030768CA.pdf)

Park, S.W. and P. Jovanis. 2010. "Hours of Service and Truck Crash Risk: Findings from Three National U.S. Carriers During 2004." *Transportation Research Record*, 2194, 3–10.

Robertson, I., T. Manly, J. Andrade, B. Baddeley, and J. Yiend, 1997. " 'Oops!' Performance Correlates of Everyday Attentional Failures in Traumatic Brain Injured and Normal Subjects." *Neuropsychologia*, 35, 747–758.

Rosa R.R. and M.J. Colligan. *Plain Language About Shiftwork*. US Department of Health and Human Services, Publication No. 97–145, 1997.

Schleicher R., N. Galley, S. Briest, and L. Galley. 2008. "Blinks and saccades as indicators of fatigue in sleepiness warnings: looking tired?" *Ergonomics*, 51, 982–1010.

Smallwood, J., M. McSpadden, and J. Schooler. 2007. "The lights are on but no one's home: Meta-awareness and the decoupling of attention when the mind wanders." *Psychonomic Bulletin & Review*, 14, 527–533.

Smallwood, J. and J. Schooler. 2006. "The Restless Mind." *Psychological Bulletin*, 132, 946–958.

Smiley, A. and others. 2010. *Summary Report Phase III: Effects of a Fatigue Management Program on Fatigue in the Commercial Motor Carrier Industry*. Transportation Development Centre, Montreal, QC, Canada.

Sprajcer, M., M. Thomas, C. Sargent, M. Crowther, D. Boivin, I. Wong, A. Smiley, and D. Dawson. 2022. "How Effective are Fatigue Risk Management Systems (FRMS)? A Review." *Accident Analysis & Prevention*, 165, 106398. doi:10.1016/j.aap.2021.106398

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