
September 3, 2025 Highway Investigation Report HIR-25-05

# Multivehicle Collision and Postcrash Fire on Interstate 70

Etna, Ohio
November 14, 2023

Abstract: On Tuesday, November 14, 2023, about 8:47 a.m. eastern standard time, a combination vehicle, operated by Mid-State Systems Inc., was traveling west in the right lane of Interstate 70 near Etna, Ohio. As the combination vehicle approached a traffic queue that had formed due to an earlier minor crash, the driver did not slow and crashed into the rear of the traffic queue. The resulting chain-reaction collision and postcrash fire involved five vehicles, including two passenger vehicles, a motorcoach, and a second combination vehicle. Immediately before the crash, the combination vehicle was traveling about 72 mph, and the other four vehicles were traveling between 3 and 15 mph. As a result of the crash, 6 occupants were fatally injured, 4 were seriously injured, and 37 sustained minor injuries. Fifteen occupants were uninjured. Safety issues identified in this investigation include inadequate guidance for traffic incident management to reduce the incidence of secondary crashes, driver inattention and lack of standards for collision avoidance technology for heavy vehicles, and inadequate standards for postcrash fire protection on motorcoaches and insufficient school district processes for chartering motorcoach transportation. The National Transportation Safety Board (NTSB) issues new safety recommendations to the Federal Highway Administration, National Highway Traffic Safety Administration (NHTSA), Ohio Department of Transportation, American Trucking Associations, Owner-Operator Independent Drivers Association, American Bus Association, United Motorcoach Association, Amalgamated Transit Union, International Brotherhood of Teamsters, Transport Workers Union of America, and Tuscarawas Valley Local School District. The NTSB also reiterates two recommendations to NHTSA and classifies one of these recommendations.

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# Acronyms and Abbreviations

| | |
|---|---|
| AASHTO | American Association of State Highway and Transportation Officials |
| ABS | antilock braking system |
| ACM | airbag control module |
| ADAS | advanced driver assistance systems |
| AEB | automatic emergency braking |
| BASIC | Behavior Analysis and Safety Improvement Category |
| CDL | commercial driver's license |
| CDLIS | Commercial Driver's License Information System |
| *CFR* | *Code of Federal Regulations* |
| CMV | commercial motor vehicle |
| CR | compliance review |
| CSA | Compliance, Safety, Accountability |
| CVSA | Commercial Vehicle Safety Alliance |
| Daimler | Daimler Trucks North America |
| DMS | driver monitoring system |
| DOT | Department of Transportation |
| ECM | engine control module |
| EDR | event data recorder |
| ELD | electronic logging device |
| EMS | emergency medical services |
| Euro NCAP | European New Car Assessment Programme |
| FCW | forward collision warning |
| FHWA | Federal Highway Administration |
| FMCSA | Federal Motor Carrier Safety Administration |
| FMVSS | Federal Motor Vehicle Safety Standard |
| GPD | Gahanna Police Department |
| HOS | hours of service |
| I-70 | Interstate 70 |

| | |
|---|---|
| IPM | intelligent powertrain management |
| mg/dL | milligrams per deciliter |
| MUTCD | *Manual on Uniform Traffic Control Devices for Streets and Highways* |
| NHTSA | National Highway Traffic Safety Administration |
| NIST | National Institute of Standards and Technology |
| NTSB | National Transportation Safety Board |
| ODOT | Ohio Department of Transportation |
| OSHP | Ohio State Highway Patrol |
| Pioneer | Pioneer Trails, Incorporated |
| PUCO | Public Utilities Commission of Ohio |
| RPM | revolutions per minute |
| SMS | Safety Measurement System |
| TIM | traffic incident management |
| TMC | Transportation Management Center |
| TVLSD | Tuscarawas Valley Local School District |
| USDOT | US Department of Transportation |
| V2X | vehicle-to-everything |
| VSL | variable speed limit |
| WLJFD | West Licking Joint Fire District |

# Executive Summary

## What Happened

On Tuesday, November 14, 2023, about 8:47 a.m. eastern standard time, a 2019 Freightliner Cascadia truck-tractor in combination with a 2017 Strickland semitrailer (Freightliner combination vehicle), operated by Mid-State Systems Inc., was traveling west in the right lane of Interstate 70 (I-70) near Etna, Ohio. Near milepost 118.8, the Freightliner combination vehicle approached a traffic queue that had formed due to an earlier minor crash that occurred 1.6 miles west. The speed limit for I-70 near the crash was 70 mph. The Freightliner combination vehicle did not slow and crashed into the rear of the traffic queue, causing a chain-reaction collision and postcrash fire that involved five vehicles, including two passenger vehicles, a motorcoach, and a second combination vehicle. Immediately before the crash, the Freightliner combination vehicle was traveling about 72 mph and the other four vehicles were traveling between 3 and 15 mph, consistent with the slow-moving traffic queue.

As a result of the crash, three motorcoach passengers and three passenger vehicle occupants were fatally injured. The driver and two passengers of the motorcoach, as well as the driver of a passenger vehicle, were seriously injured. The driver of the Freightliner combination vehicle (truck driver) and 36 motorcoach passengers sustained minor injuries. Fourteen motorcoach passengers and the Volvo combination vehicle driver were uninjured in the crash.

## What We Found

We found that salient cues, in the form of slowing traffic in both lanes and illuminated brake lights, were present at the end of the traffic queue to inform the truck driver of the need to slow his vehicle. The truck driver's lack of evasive action was consistent with being inattentive to the forward roadway, but the reason for his inattention was unknown. Further, we found that the speed differential between the combination vehicle and the slow-moving traffic queue contributed to the severity of the crash and injuries.

We found that Ohio's policies, training, and procedures for traffic incident management did not require or advise communication between responders and the Ohio Department of Transportation (ODOT) after minor incidents when vehicles are quickly removed from the travel lane, even if a queue forms, which led to a missed opportunity to warn drivers approaching the traffic queue after the initial incident.

Catastrophic crashes can result when traffic queues form after minor roadway incidents, and the current guidance in the Federal Highway Administration's (FHWA) *Manual on Uniform Traffic Control Devices for Streets and Highways* (MUTCD) for safely managing these incidents, which focuses on the duration of lane closures instead of the overall effect on traffic, may create conditions that enable potentially dangerous queues to form. The initial crash and traffic queue created dangerous conditions similar to those that ODOT addresses effectively with variable speed limits (VSL) elsewhere in the state, but the crash area on I-70 was not equipped with VSL signage. In addition, motor carriers, such as the carrier in this crash, may be unaware of the availability and potential safety benefits of in-cab alert technology that warns commercial drivers of impending congestion or traffic queues.

We found that the FHWA plays an active role in disseminating information about successful state strategies and advanced technologies to warn drivers about upcoming traffic queues—such as in-cab alerts, queue warning trucks, and dynamic message signs—but most of this information is absent from its Proven Safety Countermeasures publication, which may limit the opportunity for states and other stakeholders to adopt these strategies and technologies. We also found that if the Freightliner combination vehicle had been equipped with a driver monitoring system designed to return a driver's attention to the roadway, it could have alerted the inattentive truck driver to the traffic queue and increased the likelihood that the crash would have been avoided or mitigated. In addition, collision avoidance technology can help prevent or mitigate rear-end crashes into slow-moving traffic queues, as in the Etna, Ohio, crash, by alerting drivers to slowed traffic ahead or automatically applying brakes to reduce crash severity. We found that the postcrash fire and smoke that spread into the motorcoach prevented two passengers from being extricated and contributed to the severity of injuries for at least one passenger. Finally, we found that selecting transportation operators that provide motorcoaches and other large buses equipped with passenger lap/shoulder belts in all seating positions and requiring the use of those belts enables school districts, such as the Tuscarawas Valley Local School District, to provide the maximum safety benefit to students.

We determined that the probable cause of the Etna, Ohio, crash was the truck driver's inattention and failure to respond, for unknown reasons, to the visibly slow-moving vehicles, including a motorcoach, at the end of a traffic queue caused by an earlier minor crash. Contributing to the crash was the lack of adequate strategies to monitor the development of the traffic queue on I-70 after a minor incident and to inform travelers of the traffic conditions ahead. Also contributing to the crash was the lack of an in-vehicle driver monitoring system to return the truck driver's attention to the forward roadway. Contributing to the severity of the crash and occupant injuries were the speed differential between the combination vehicle and the slow-moving traffic queue and the postcrash fire.

## What We Recommended

As a result of this crash, we issued eight new safety recommendations and reiterated two recommendations. We recommended that the FHWA issue guidance to states on ensuring that incident classification accounts for all affected roadway conditions and that communications occur between responding and transportation agencies for all incidents in which a queue has formed or is likely to form, and also that the FHWA revise the MUTCD to reflect this guidance. We further recommended that the FHWA update its Proven Safety Countermeasures publication to incorporate end-of-queue protections and effective communication strategies to provide advance warning to drivers approaching traffic queues. We recommended that the National Highway Traffic Safety Administration (NHTSA) require driver monitoring systems in all commercial vehicles greater than 10,000 pounds to detect driver inattention and bring attention back to the driving task through multimodal signaling. We also recommended that ODOT implement a statewide strategy for the use of VSLs.

We recommended that the American Trucking Associations, Owner-Operator Independent Drivers Association, American Bus Association, United Motorcoach Association, Amalgamated Transit Union, International Brotherhood of Teamsters, and Transport Workers Union of America promote to their members the potential safety benefits of in-cab alert technology to encourage owner-operators and carriers to use these systems. We also recommended that these associations inform their members about the safety benefits of collision avoidance technologies including forward collision warning, automatic emergency braking, and driver monitoring systems as well as the safety risks involved in opting out of purchasing advanced driver assistance systems, including forward collision warning and automatic emergency braking, offered by heavy vehicle manufacturers.

We also recommended that the Tuscarawas Valley Local School District update its process for chartering motorcoach or other large bus transportation to prioritize the selection of operators that provide and require the use of lap/shoulder belts for all seating positions.

We reiterated Safety Recommendation H-15-5 to NHTSA to complete the development and application of performance standards for forward collision avoidance systems in commercial vehicles. Finally, we reiterated Safety Recommendation H-15-12 to NHTSA to adopt more rigorous interior flammability standards that are already in use for commercial aviation and rail passenger transportation, and we changed the classification of this recommendation from Open—Acceptable Response to Open—Unacceptable Response.

# 1 Factual Information

## 1.1 Crash Narrative

On Tuesday, November 14, 2023, about 8:47 a.m. eastern standard time, a 2019 Freightliner Cascadia truck-tractor in combination with a 2017 Strickland semitrailer (Freightliner combination vehicle), operated by Mid-State Systems Inc., was traveling west in the right lane of Interstate 70 (I-70) near Etna, Licking County, Ohio.[1] Near milepost 118.8, the Freightliner combination vehicle approached a traffic queue that had formed due to an earlier minor crash that occurred near milepost 117.2. The posted regulatory speed limit for I-70 in the vicinity of the crash was 70 mph. The Freightliner combination vehicle did not slow and crashed into the rear of the traffic queue, causing a chain-reaction collision that involved five vehicles, including two passenger vehicles, a motorcoach, and another combination vehicle. Immediately before the crash, the Freightliner combination vehicle was traveling about 72 mph and the other four vehicles were traveling between 3 and 15 mph, consistent with the slow-moving traffic queue.[2] The crash occurred during daylight hours. The weather was clear and the roadway was dry.

### 1.1.1 Video Evidence

Video from a witness vehicle traveling behind the Freightliner combination vehicle provided insight into the motions of the Freightliner leading up to the crash.[3] The video began 33.2 seconds before the Freightliner combination vehicle crashed into a 2015 Nissan Murano passenger vehicle (Nissan) at the rear of the traffic queue.[4] At the beginning of the video, the Freightliner was traveling in the right lane of westbound I-70 and no other westbound vehicles were visible in the camera's view. The combination vehicle remained in the right lane of I-70 until the collision with the Nissan. At 27.0 seconds before the collision, an unidentified vehicle became visible in the left lane of westbound I-70, in front of the combination vehicle. At 17.7 seconds

[1] Visit ntsb.gov to find additional information in the public docket for this NTSB accident investigation (case number HWY24MH001). Use the CAROL Query to search safety recommendations and investigations.

[2] See sections 1.4.2.4, 1.4.3.2, and 1.4.4 for more details on how the vehicle speeds were determined.

[3] The timing provided in this section is based on the reported frame rate of 30 frames per second. See section 1.4.4 for more information.

[4] Times described in this section indicate time before the collision between the Freightliner combination vehicle and the Nissan. All times reported have an uncertainty of ± 0.4 seconds.

before the collision, the combination vehicle's right-side trailer tires briefly crossed onto the solid white edge line on the right side of the travel lane, but the combination vehicle then moved back fully into the lane.

At 9.0 seconds before the collision, a white van, which had initially been traveling in the right lane ahead of the Freightliner combination vehicle, changed lanes into the left lane. The van was not involved in the collision. When interviewed, the van driver told OSHP investigators that he had observed brake lights and vehicles slowing ahead of him and had decided to move to the left lane because traffic there was lighter. The van fully occupied the left lane at 6.9 seconds before the collision (see figure 1). At 2.7 seconds before the collision, the Freightliner moved slightly to the right and its right-side trailer tires appeared to be on the (right) solid white highway edge line when the crash occurred. The video depicted no clear indications of evasive steering or rapid slowing by the Freightliner combination vehicle consistent with emergency braking before the collision. Two seconds after the initial impact, fire was visible underneath and on the left of the Freightliner combination vehicle (see figure 2). About 2 seconds later, the Freightliner began to move onto the right shoulder.

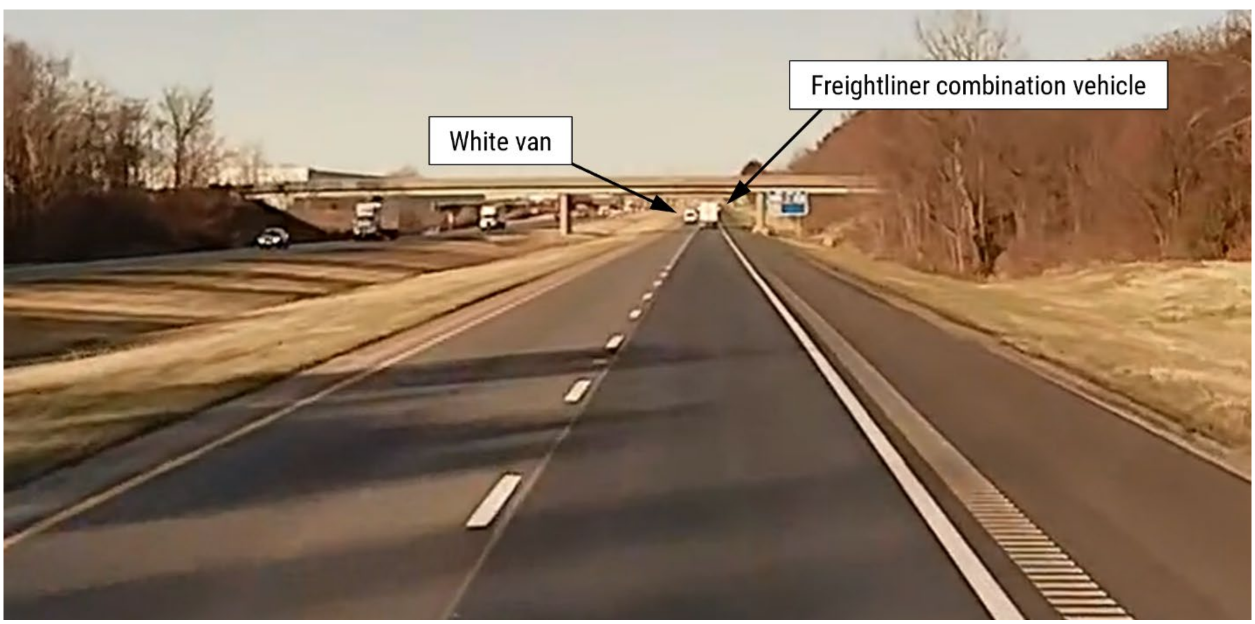


**Figure 1.** Video still from witness vehicle's forward-facing camera (annotated by NTSB), showing the Freightliner combination vehicle and the white van that moved from the right lane into the left lane, ahead of the Freightliner, about 7 seconds before the crash.

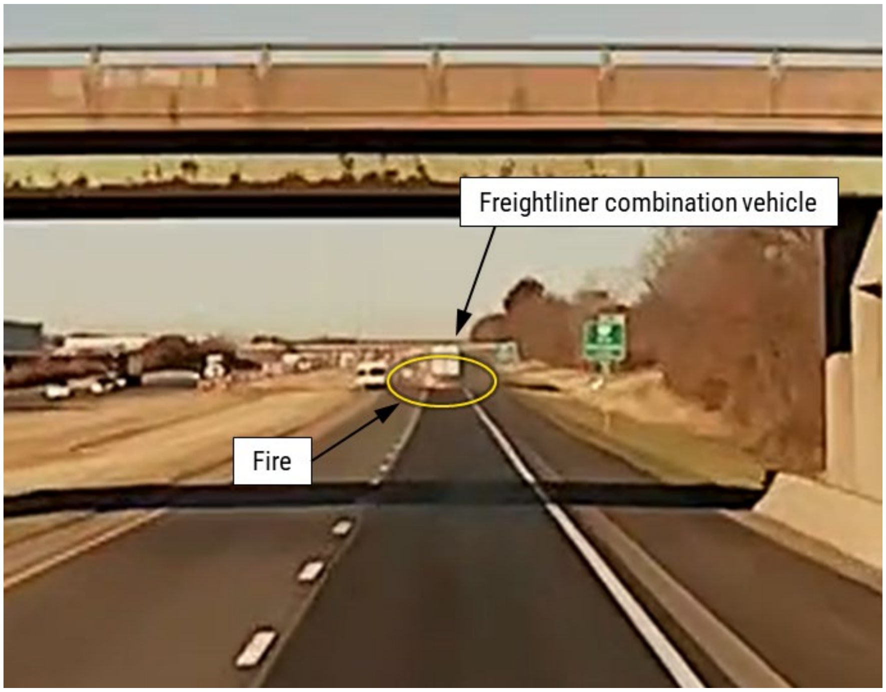


**Figure 2.** Video still from the witness vehicle's forward-facing camera (annotated by NTSB), showing the fire under the Freightliner combination vehicle.

### 1.1.2 Roadway Evidence

As discussed, the crash sequence began when the Freightliner combination vehicle struck the rear of the Nissan, which was also traveling west in the right lane. The Freightliner was occupied solely by the driver (truck driver), and the Nissan was occupied by the driver and two passengers, who were traveling with the motorcoach on a school trip. Roadway evidence consisting of pavement scrapes and gouges was present and indicative of the Freightliner colliding with the rear of the Nissan. There were no tire friction marks in advance of the area of initial contact.

The Freightliner combination vehicle forced the Nissan into the rear of a 2009 Van Hool motorcoach (motorcoach), which was also traveling west in the right lane. Roadway evidence consisting of a second area of pavement scars, about 39 feet west of the initial onset of roadway evidence, marked this second impact. The Freightliner combination vehicle then overrode the Nissan and impacted the rear of the motorcoach. The motorcoach was occupied by the driver and 55 passengers who were being transported on a school trip. The passengers included 52 students and 3 faculty members.

The front of the motorcoach struck the rear of a 2006 Toyota Highlander passenger vehicle (Toyota), which rotated counterclockwise while traveling forward and struck the left side of a 2014 Volvo combination vehicle that was traveling west in the right lane before coming to rest in the left westbound lane. The motorcoach continued traveling forward and struck the rear of the semitrailer of the Volvo combination vehicle. The Toyota and Volvo were each occupied only by their respective drivers. Excluding the Toyota, which remained in the travel lane, the crash-involved vehicles progressed or were moved to the right shoulder.

At final rest, the Freightliner combination vehicle was facing west on the right shoulder about 274 feet west of the initial onset of roadway evidence. Scene photographs showed that nearly the entire vehicle occupied the shoulder except for the left wheels of the semitrailer, which were atop the highway edge line. The front of the combination vehicle remained in contact with, and partially intruded into, the rear of the motorcoach. Figure 3 shows the sequence of impacts and figure 4 shows the final rest positions of the vehicles.

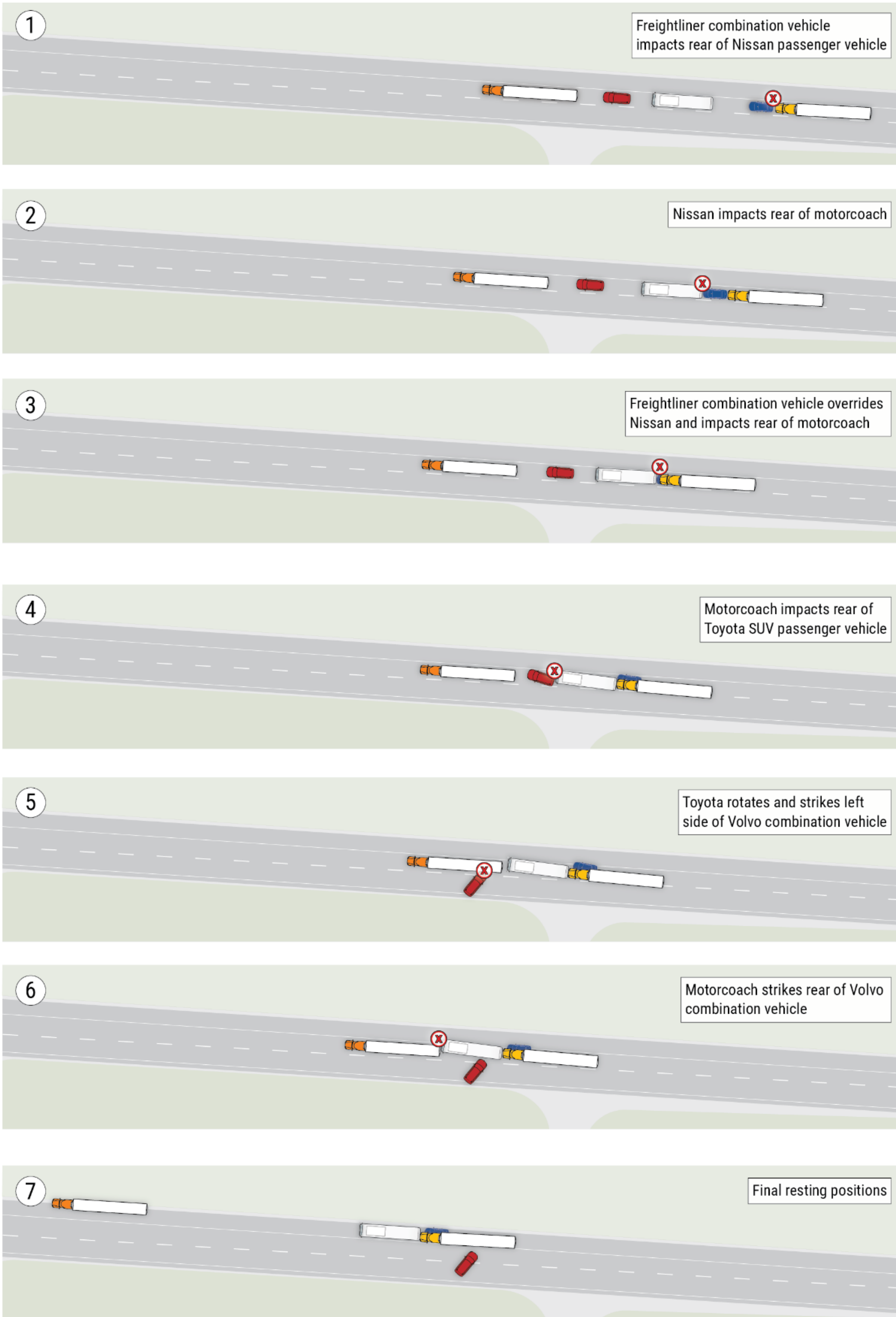


**Figure 3.** Sequence of impacts.

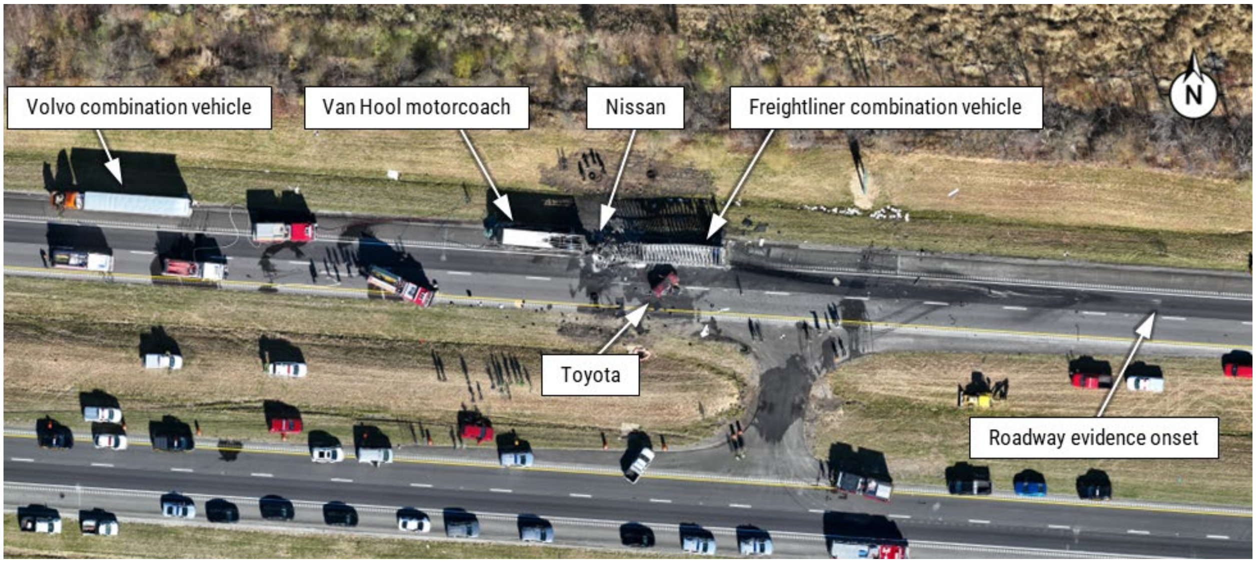


**Figure 4.** Overhead view of crash scene, vehicular positions of rest, and roadway evidence. (Source: Ohio State Highway Patrol; annotated by NTSB)

The fire began shortly after the Freightliner struck the Nissan and before the vehicles came to final rest. The fire progressed postcrash and engulfed the Nissan and Freightliner. It then spread to the rear of the motorcoach. Figure 5 shows the postcrash fire shortly after the crash; at the time the photograph was taken, the fire had not yet spread to the motorcoach.


**Figure 5.** Postcrash fire initially involving Nissan and Freightliner combination vehicle before spreading to motorcoach. (Source: motorcoach occupant)

## 1.2 Injuries, Occupant Protection, Egress, and Emergency Response

### 1.2.1 Injury Outcome

As a result of the crash, the three occupants of the Nissan and three motorcoach passengers were fatally injured. The driver and two passengers of the motorcoach, as well as the driver of the Toyota, were seriously injured. Thirty-six motorcoach passengers and the truck driver sustained minor injuries. Fourteen motorcoach passengers and the Volvo combination vehicle driver were uninjured. The table below summarizes the distribution of injury severity for all involved vehicles, and figure 6 shows the occupant seating chart and injury severity for the motorcoach.[5]

**Table.** Injury severity distribution.

| Vehicle | Fatal | Serious | Minor | None | Total |
|---|---|---|---|---|---|
| Freightliner combination vehicle | | | 1 | | 1 |
| Nissan Murano | 3 | | | | 3 |
| Van Hool motorcoach | 3 | 3 | 36 | 14 | 56 |
| Toyota Highlander | | 1 | | | 1 |
| Volvo combination vehicle | | | | 1 | 1 |
| Total | 6 | 4 | 37 | 15 | 62 |

[a] Although 49 *Code of Federal Regulations* 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 the injury was received; (2) results in a fracture of any bone (except simple fractures of fingers, toes, or nose); (3) causes severe hemorrhages, nerve, muscle, or tendon damage; (4) involves any internal organ; or (5) involves second- or third-degree burns, or any burns affecting more than 5% of the body surface.

[5] Refer to figure 6 for additional context when specific rows or seating positions on the motorcoach are mentioned elsewhere in this report.

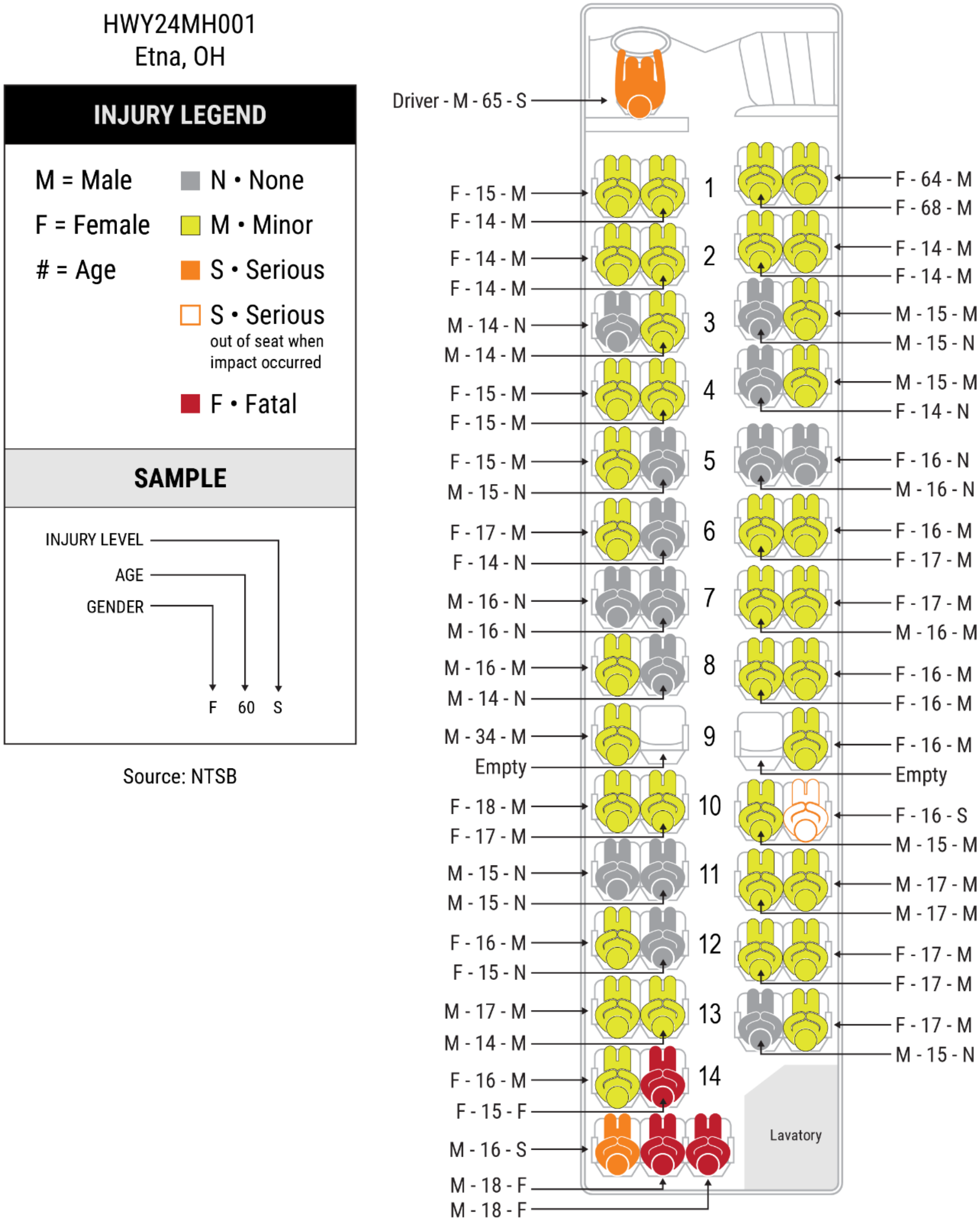


**Figure 6.** Motorcoach seating chart showing occupant injury severity.

One of the fatally injured motorcoach passengers, who was seated in the middle seat of row 15, sustained blunt force trauma to the torso and head. He was extricated from the motorcoach and given CPR. The other two fatally injured occupants, seated in rows 14 and 15, sustained blunt force trauma injuries to their head and neck but were not able to be extricated until the fire was fully extinguished. Autopsy reports documented that both had severe cerebral edema and evidence of soot and smoke inhalation with carboxyhemoglobin levels of 8% and 12%.[6]

One surviving motorcoach occupant was initially seated in row 10 on the right side but was walking to the lavatory and attempting to open the door when the impact occurred. She sustained first-degree burns. Several students were evaluated but were determined not to have smoke inhalation injuries.

The three fatally injured occupants of the Nissan sustained blunt force trauma injuries to their head and neck, along with other skeletal fractures. These occupants had postmortem burns, but no soot or smoke inhalation was noted on the autopsy reports.

### 1.2.2 Occupant Protection

Seat belt use for all vehicle occupants was investigated using vehicle data recording systems, driver and occupant interviews, and examination of seat belt mechanisms and webbing. When interviewed by the Ohio State Highway Patrol (OSHP), the Freightliner truck driver stated that he was wearing his seat belt. There was no physical evidence confirming seat belt use due to extensive thermal damage to the Freightliner combination vehicle.

In the Nissan, airbag control module (ACM) data showed that both front seat occupants were belted.[7] The seat belt status for the rear occupant of the Nissan was unknown because thermal damage consumed physical evidence that would have been used to determine seat belt use.

In the motorcoach, the driver's seating area was equipped with a lap-only belt. The motorcoach driver told the National Transportation Safety Board (NTSB) that he was wearing his seat belt during the crash. There was insufficient physical evidence on the seat belt mechanism or webbing to confirm use. No seat belts were installed

[6] Carboxyhemoglobin is formed when carbon monoxide binds to hemoglobin in blood, impairing the blood's ability to deliver oxygen to body tissues. Carbon monoxide is produced by fire; smoke inhalation is a common cause of elevated carboxyhemoglobin.

[7] The Nissan's ACM was not capable of recording, or was not configured to record, rear seat belt status.

or available for use in any of the seating positions of the motorcoach's occupant compartment.[8]

In the Toyota, the seat belt examination showed no physical evidence that the driver was belted during the crash. The ACM recorded the driver's buckle switch status as unbuckled.

The Volvo combination vehicle was not available for examination by the NTSB; therefore, the driver's seat belt usage was not determined.

### 1.2.3 Emergency Response

Beginning at 8:48 a.m., the Licking County Regional Communications Center received eight 911 notifications regarding the 8:47 a.m. collision.[9] Police, fire/rescue, and emergency medical services (EMS) were dispatched within 1 minute of the first 911 notification and were en route less than 1 minute after being dispatched. The first law enforcement agency to arrive, the Gahanna Police Department (GPD), self-dispatched after observing smoke in the distance, about 8:51 a.m. The first agency to dispatch after the 911 notifications, the Licking County Sheriff's Office, arrived at 8:53 a.m. The OSHP arrived about 1 minute later. In total, four police agencies responded to the crash.

Nineteen fire/rescue and EMS agencies responded to the crash. The first agency that arrived on scene was the West Licking Joint Fire District (WLJFD), which was also the primary fire/rescue and EMS agency, at 8:57 a.m. The WLJFD was dispatched within 1 minute of the initial 911 notification, was en route within 1 minute of being dispatched, and arrived within about 8 minutes of being dispatched. At that

[8] At the time the motorcoach was manufactured, in 2009, Federal Motor Vehicle Safety Standard No. 208 required a lap belt in the driver's position and did not require passenger seat belts in the occupant compartment. In 2016, the regulation was amended to require lap/shoulder belts in all seating positions on all newly manufactured over-the-road buses and other buses with a gross vehicle weight rating greater than 26,000 pounds, excluding school buses and several other bus types. If the crash-involved motorcoach had been manufactured after the regulation was amended in 2016, it would have been required to have lap/shoulder belts in all seating positions.

[9] One of these was an Apple Watch notification that consisted of a recorded message containing the unique latitude and longitude of the location of the watch, and therefore the location of the collision. The dispatcher did not use the information provided in the notification and terminated the call. Due to several 911 notifications being received, the missed Apple Watch notification did not cause a delay in response to this crash. Licking County Regional Communications Center supervisors were contacted by the NTSB regarding the missed Apple Watch notification and subsequently performed training with their staff to ensure that Apple Watch and Apple iPhone notifications are properly used in future incidents.

time, the WLJFD assistant fire chief established incident command. Supporting agencies were assigned to patient triage or fire suppression by the WLJFD incident commander. Fire suppression concluded about 9:07 a.m. By the time the fire was extinguished by first responders, it had spread forward to row 8 of the motorcoach.

Eighteen injured vehicle occupants were transported from the crash scene to seven local hospitals, including two Level 1 trauma centers. The first injured patient departed the scene at 9:13 a.m., and the last transported patient departed at 9:54 a.m. At least seven additional individuals sought medical treatment later after departing the crash scene and self-transported to local hospitals. The remaining injured occupants self-reported minor injuries during interviews with the NTSB.

### 1.2.4 Motorcoach Egress

According to witnesses, immediately after the collision occurred, faculty members seated in rows 1 and 9 of the motorcoach told students to stay seated while they determined what had happened. A student seated in row 10 of the motorcoach yelled "fire!" and the faculty immediately directed everyone to evacuate. The motorcoach driver, who was injured and unable to stand, pressed the driver's control to open the front door. Students entered the aisle and began exiting through the front of the motorcoach. According to interview statements, as the students exited, some encountered a visibility issue from the smoke and fire. Students seated in the middle and rear noted that it was "foggy," "cloudy," "dusty," and "smoky." One student reported, "I had trouble seeing the front doors."

After all students able to self-evacuate had exited the motorcoach, a faculty member and at least one passerby entered the motorcoach to assist students who were unable to exit on their own. One student (row 15, middle seat) who was unconscious was carried off the motorcoach and was being given CPR when emergency responders arrived. This passenger was triaged as deceased at the crash scene. When the GPD arrived at the crash scene about 4 minutes after the crash occurred, officers observed that all persons who were able to exit the motorcoach on their own had done so. GPD officers described the inside of the motorcoach as filled with black smoke. One student (row 15, left window seat) was still inside the motorcoach and was caught in vehicle debris. One of the faculty members, who had exited the motorcoach, helped to pull the student out through its rear-left, non-emergency window, which had been broken out. A passerby captured this part of the motorcoach evacuation on video. While the student was being helped through the non-emergency exit window, the front-left tire of the Freightliner combination vehicle exploded, causing a momentary delay in the evacuation. At this time, smoke rising from the roofline was visible along the length of the motorcoach, and the fire was visible at the back of the motorcoach. This was the last occupant to be evacuated.

A head count of students who had evacuated the motorcoach indicated that two students were missing. According to the OSHP incident commander, an OSHP trooper entered the burning motorcoach through the front door to look for survivors. He went as far back as he could, but the flames prevented him from reaching the back. He deployed his fire extinguisher inside the vehicle but did not see any occupants (either deceased or surviving). Both missing students were extricated once the fire was suppressed, and both were deceased. These students had been seated in rows 14 and 15.

## 1.3 Highway Factors

### 1.3.1 General Roadway Description, Traffic Characteristics, and Crash History

I-70, in Licking County, was constructed in 1965 as a four-lane divided highway. The roadway consisted of two westbound and two eastbound travel lanes, each about 12 feet wide, separated by a 76-foot-wide, depressed earthen median. Each direction of travel had a 4-foot-wide left shoulder and a 10-foot-wide right shoulder. At the crash location, the roadway was straight with a 0.32% uphill grade for motorists traveling in the westbound direction. Milled rumble strips were present in the paved shoulders adjacent to the right and left travel lanes.[10] The roadway was last resurfaced on November 12, 2023, 2 days before the crash.[11] The roadway design conformed to the existing guidance that was applicable during its construction and conforms to American Association of State Highway and Transportation Officials (AASHTO) guidance (AASHTO 2018).

As determined by the Ohio Department of Transportation (ODOT) in 2022, the average daily traffic volume in the vicinity of the crash was 51,048 vehicles. About 74% of the vehicular traffic was passenger vehicles and four-tire, single-unit trucks; 26% was larger trucks and buses. Within 1 mile of the crash location, an average of 26 crashes occurred annually over the past 6 years, of which 74% caused property

[10] Rumble strips are intended to alert drivers through noise and vibration that they are leaving the travel lanes.

[11] The resurfacing project was complete, and no residual signage or work was ongoing at the time of the crash.

damage only (no injuries).[12] About 60% of the crashes involved a rear-end or sideswipe collision.

### 1.3.2 Precrash Events

The 8:47 a.m. crash occurred at the end of a traffic queue that had formed due to an earlier crash involving only property damage that took place near milepost 117.2 (see figure 7). The initial crash, which occurred almost an hour earlier at 7:51 a.m., was a rear-end crash that involved four vehicles in the left lane, including one combination vehicle. All vehicles had been moved out of the travel lanes when an OSHP trooper arrived on scene at 8:14 a.m. Figure 8 shows the locations of the vehicles from the initial crash occupying the left shoulder and median. The vehicles were nearly on the solid yellow edge line and inches away from traffic traveling in the left lane of westbound I-70. Because all vehicles had moved out of the travel lanes before the OSHP trooper's arrival, the trooper pulled behind the vehicles in the median immediately after arriving at the scene and neither of the westbound lanes were blocked.


**Figure 7.** Locations of initial and secondary crashes on westbound I-70. (Source: Google Earth; annotated by NTSB)

[12] Before this crash, only one fatal crash occurred at this location within the previous 6 years: a single-vehicle motorcycle roadway departure.


**Figure 8.** Trooper body camera images showing locations of vehicles from initial crash after they were moved to the median. The right rear of the trailer involved in the initial crash was nearly on the solid yellow edge line and inches away from traffic traveling in the left lane of westbound I-70. (Source: OSHP)

Although the vehicles involved in the initial crash were moved from the travel lanes in less than 30 minutes, a traffic queue formed. ODOT provided the NTSB with camera footage showing I-70 at the State Highway 310 interchange from 7:00 a.m. until 10:00 a.m. on November 14, 2023. (Figure 7 shows a map indicating the I-70–State Highway 310 interchange.) Figure 9 shows a still image of the camera footage at 8:47 a.m., looking west toward the location of the initial crash, which occurred about 1 mile west of State Highway 310. The 8:47 a.m. crash occurred about 0.6 miles east of State Highway 310.

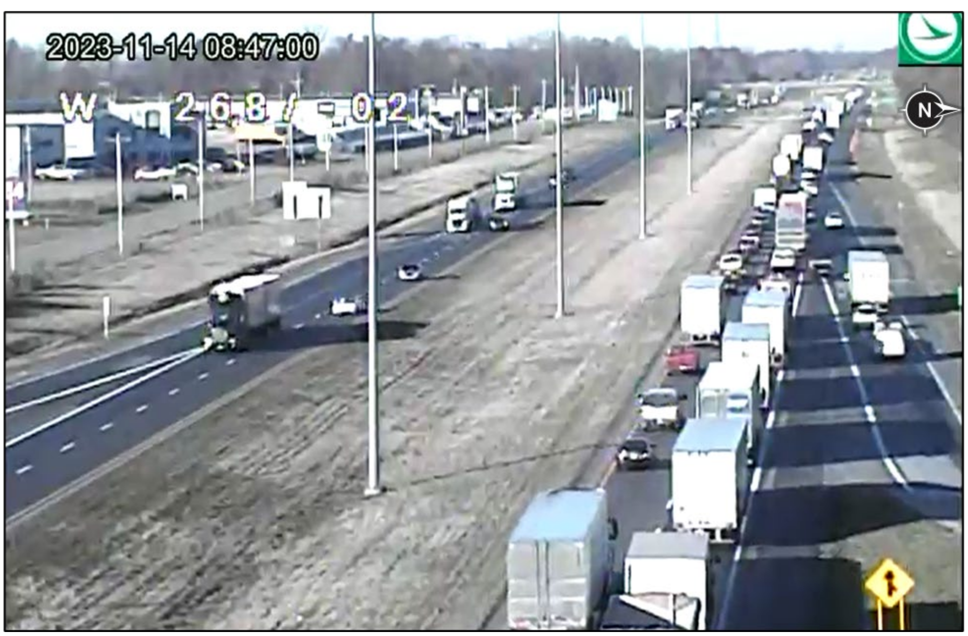


**Figure 9.** Image from ODOT traffic camera footage, looking west and showing the traffic queue on I-70 at the State Highway 310 interchange at 8:47 a.m. on November 14, 2023. (Source: ODOT)

### 1.3.3 Traffic Incident Management

#### 1.3.3.1 Incident Management on Day of Crash

The initial crash occurred at 7:51 a.m. on November 14, 2023, in the left lane of westbound I-70. As a result, the left lane was blocked for about 23 minutes. ODOT was not notified of the initial crash. In an email dated November 20, 2023, ODOT informed the NTSB that the trooper who responded to the initial crash stated that "ODOT was not contacted since all lanes were open." The secondary crash at 8:47 a.m. caused the westbound travel lanes to be closed for about 14 hours. At 8:55 a.m., ODOT was contacted for traffic control, which involved diverting westbound traffic off I-70 onto Exit 122 (State Highway 158), located about 4 miles east of the crash location. When these crashes occurred, I-70 was not equipped with variable speed limit (VSL) signage.

#### 1.3.3.2 Guidance and Training

Federal and state guidance and training related to traffic incident management (TIM) that were in place when the initial and secondary crashes occurred were followed in response to these crashes. According to the Federal Highway Administration (FHWA), TIM "consists of a planned and coordinated multi-disciplinary process to detect, respond to, and clear traffic incidents so that traffic flow may be restored as safely and quickly as possible."[13] In Ohio, ODOT has overall responsibility for actively monitoring and managing the flow of traffic during and after an incident, depending on the incident's severity, in coordination with the police, fire/rescue, and EMS personnel. ODOT relies on the FHWA's *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]

The MUTCD provides guidance for controlling traffic through traffic incident management scenes. A *traffic incident* is defined as an "emergency road user occurrence, a natural disaster, or other unplanned event that affects or impedes the

[13] Traffic Incident Management (TIM) | FHWA.

[14] The FHWA published the most recent version of the MUTCD in 2023 (FHWA 2023). The states have 2 years from the effective date of the final rule—January 18, 2024—to be in substantial conformance with the 2023 MUTCD. ODOT indicated to the NTSB that it plans to adopt the 2023 MUTCD in its entirety with Ohio supplements by January 2026.

normal flow of traffic" and is categorized into three types—minor, intermediate, and major—depending on incident duration and travel lane closures (FHWA 2023).[15]

Minor incidents typically include disabled vehicles and minor crashes that result in lane closures of less than 30 minutes. According to the MUTCD, for minor incidents, "traffic control is the responsibility of on-scene responders." The initial crash—which resulted in the left lane of I-70 being closed for about 23 minutes—was considered a minor incident according to this guidance; therefore, the on-scene responder was responsible for controlling traffic, and queue development was not monitored. Intermediate incidents "typically affect travel lanes for a time period between 30 minutes and 2 hours, and usually require traffic control on the scene to divert road users past the blockage." Intermediate incidents typically involve multiple lane closures. 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 (FHWA 2023). Consistent with this guidance, the secondary crash at 8:47 a.m.—which involved multiple vehicles and fatalities and which resulted in both westbound lanes being closed for about 14 hours—was considered a major incident by the on-scene responders, who then coordinated with ODOT.

General guidance in the MUTCD advises that responders arriving at a traffic incident should estimate its magnitude, its expected duration, and the expected vehicle queue length, and then set up the appropriate temporary traffic controls based on these estimates. Although the MUTCD notes generally that responders should pay attention to the upstream end of the traffic queue, the guidance also states that traffic control devices—including upstream warning devices to alert traffic approaching the queue—should be "available so that they can be readily deployed for all *major* traffic incidents" (FHWA 2023; emphasis added).

Further, with respect to coordination and communication with other highway agencies, the FHWA provides a TIM handbook which notes that "effective communication among responder agencies is essential, even for minor incidents" (FHWA 2010). However, the MUTCD states that when events are deemed as probable *major* incidents that could generate prolonged lane or road closures, notification of all affected agencies should be initiated as part of the initial incident report that is provided to the emergency communications center, which would then be

[15] The three categories for traffic incident duration in the 2023 MUTCD are unchanged from prior versions dated 2009 and 2003.

responsible for making notifications to appropriate state, regional, and local agencies (FHWA 2023).

The FHWA also maintains a national TIM responder training program.[16] In addition, ODOT operates a TIM training program with specific content on ODOT procedures and Ohio motor vehicle laws.[17] The TIM training program also covers ODOT's Transportation Management Center (TMC) procedures, which provide key information and specific contact details for responders.[18] This includes information on the ODOT Freeway Safety Patrol and availability of cameras and message boards for situational awareness and advanced warning.[19] The training indicates that communication with ODOT is advisable for intermediate incidents and required for major incidents but is neither required nor suggested for minor incidents.

The Ohio TIM training program is offered to any agency that responds to highway incident scenes, including ODOT, OSHP, fire/rescue, EMS, and towing/recovery personnel. The program includes a set of Ohio-specific incident videos to ensure that responders review incidents that have happened in Ohio and their accompanying lessons learned.

#### 1.3.3.3 ODOT Digital Alert Program

ODOT provides real-time alerts to drivers for sudden slowdowns, congestion, and travel delays via traveler information systems using probe-based, real-time traffic speed data.[20] The probe-based speed data are obtained through a contract with a third-party provider. The data collected by the third-party provider are presented on Ohio's cost-free, public-facing website and mobile application, OHGO. Users receive real-time traffic updates, personalized route notifications, live traffic camera feeds, and accurate delay times for all of Ohio's highways. The use of cell phones while driving can lead to driver distraction and present significant safety risks. It is important

[16] National TIM Responder Training | FHWA.

[17] Ohio Traffic Incident Management | Ohio Department of Transportation.

[18] The TMC is an office within ODOT that provides real-time traveler information, actively manages and monitors the flow of traffic through various roadside devices, and facilitates interagency communication and coordination.

[19] The ODOT Freeway Safety Patrol is a Good Samaritan program that assists stranded motorists on Ohio's interstates, performing services such as changing flat tires.

[20] Probe data are data generated by monitoring the position of individual vehicles (that is, probes) over space and time. Probe speed data are obtained from multiple sources such as commercial fleets, delivery and taxi vehicles, and consumer vehicles.

that drivers consult these resources for planning purposes in advance of their trip and not while they are driving.

When the crash occurred, ODOT also had an active contract with a third-party company that provides services such as weigh station bypass, in-cab safety alerts, and other safety and coaching services for commercial fleets.[21] In-cab safety alerts are a type of connected vehicle technology—including congestion and dangerous slowdown alerts, road hazard alerts such as low bridges or roads unsuitable for trucks, work zone alerts, service vehicle alerts, and temporary alerts for emergency road closures—that is provided to devices designed for use while driving. Dangerous slowdown alerts are sent when there is a speed differential of 35 mph or more between the section of a roadway that the vehicle is traveling on and a nearby section of the same roadway. The alerts include both a visual display and an auditory chime.[22] For commercial drivers, these alerts are provided free to any truck driver who has both (1) an electronic logging device (ELD) or a connected phone logged in with a US Department of Transportation (USDOT) number, and (2) the free third-party application. The third-party company informed the NTSB that most ELDs are compatible with the application.

Although the slowdown on I-70 resulting from the initial crash met the company's criterion for sending a dangerous slowdown alert through its connected vehicle system, the system did not send an alert. The company later determined that this was due to a technical issue that has since been corrected. The Freightliner combination vehicle involved in this crash had an ELD but did not have the third-party application, and the ELD was not compatible with the application.

[21] Ohio's contract with Drivewyze provided in-cab safety alerts as a free service. Other services, such as weigh station bypass, require fees for use. Other third-party companies provide comparable services, but Ohio used this particular service.

[22] Congestion and dangerous slowdown alerts are designed to be sent automatically based on probe vehicle speed data. Work zone alerts, emergency road closures, road hazards, and public awareness campaign sign locations are manually determined and configured by third-party company staff.

## 1.4 Vehicle Factors

### 1.4.1 Freightliner Combination Vehicle

#### 1.4.1.1 General Description

The combination vehicle consisted of a 2019 Freightliner Cascadia truck-tractor and a 2017 Strick semitrailer. The truck-tractor was equipped with a Detroit Diesel DD15 475-horsepower engine, a DT12 Detroit 12-speed automatic transmission, and air-operated drum brakes with an antilock braking system (ABS). The truck-tractor had two 120-gallon aluminum fuel tanks mounted on each side below the sleeper berth.

The semitrailer included a 53-foot-long enclosed shipping container with air-operated drum brakes and ABS. At the time of the crash, the semitrailer was loaded with 24,633 pounds of 12-volt automotive batteries. The total loaded weight at the time of the crash was 56,652 pounds, and the vehicle had a registered maximum weight of 80,000 pounds.

The truck-tractor was equipped with standard electronic cruise control with intelligent powertrain management (IPM) and an electronic accelerator control pedal. An IPM system is standard on vehicles equipped with the DT12 transmission. The function of an IPM is to aid in fuel efficiency by predicting the proper vehicle speed and gear selection for upcoming road grades.[23] According to the build sheet and officials from the motor carrier operating the Freightliner combination vehicle, Mid-State Systems Inc., the truck-tractor's speed was limited by a governor to 70 mph; however, this could not be confirmed by examination due to the fire damage to the engine and engine control module (ECM).[24]

[23] IPM works by using a 3D digital map database and GPS. Cruise control must be engaged for IPM to be active. IPM will automatically activate the engine brake if the vehicle exceeds the set cruise speed. When the vehicle is being operated on a roadway that is not included in the 3D map database, the system reverts to a conventional cruise control system.

[24] A governor on a heavy vehicle diesel engine does not provide active speed control. When the threshold speed, which is calculated within the ECM based on various parameters, is reached, the ECM restricts fuel to the engine with the objective of maintaining a consistent speed balanced with throttle input and engine revolutions per minute (RPM). In situations where engine RPM can drop, such as the vehicle traveling downhill or even on level terrain, the governor will not restrict speed until certain parameters that factor into a speed calculation are met. Because the ECM was destroyed in the crash and the data were inaccessible, the NTSB could not identify the programmed parameters or validate the reported governed speed of 70 mph.

The truck-tractor was not equipped with advanced driver assistance systems (ADAS) or collision avoidance systems, nor did federal regulations require it to be.[25] However, ADAS features, including collision avoidance systems, were available for this truck-tractor model. Since 2015, Daimler Trucks North America (Daimler) has provided the Detroit Assurance® Safety Suite as an optional feature on all new Freightliner Cascadias and, since 2018, has marketed it as a standard feature. The Detroit Assurance® Safety Suite included forward collision warning (FCW), automatic emergency braking (AEB), and adaptive cruise control, among other features.

Mid-State Systems leased its vehicles from a leasing company, Maplewood Leasing LLC, which was owned by the same individual who owns Mid-State Systems. Maplewood Leasing ordered new vehicles annually using the same two dealerships and the same specification order sheets. Although the Freightliner truck-tractor was equipped with the latest engine and transmission configurations, the order sheets had not been updated or modified to include any of the latest collision avoidance technologies. Because the specification order sheet did not include the Detroit Assurance® Safety Suite, Freightliner provided the 2019 truck-tractors without the safety system for a cost discount.

The Freightliner combination vehicle was also not equipped with a driver monitoring system (DMS), nor was such a system available as original equipment at the time the truck-tractor was manufactured.[26] A spokesperson from Daimler informed the NTSB that DMSs are being researched for inclusion in future Detroit Assurance® Safety Suites.

#### 1.4.1.2 Damage

The NTSB examined the Freightliner truck-tractor and documented that it was completely burned in the postcrash fire (see figure 10). All combustible materials from the front bumper to rear of the last drive axle—such as the electrical wiring,

[25] *Advanced driver assistance systems* are technologies designed to increase the safety of driving a vehicle. These include, but are not limited to, forward collision avoidance systems, lane-keeping systems, driver monitoring systems, and adaptive cruise control. In 2023, the National Highway Traffic Safety Administration and Federal Motor Carrier Safety Administration announced a joint notice of proposed rulemaking to require certain collision avoidance systems in heavy vehicles. See Section 2.4.2 for more information.

[26] A *driver monitoring system* is an advanced safety feature that uses a driver-facing camera to detect signs of driver inattention, distraction, and/or fatigue. When these conditions are detected, the system issues warnings or alerts to redirect the driver's attention back to the task of driving. These systems are discussed in greater detail in section 2.4.1.

rubber and plastic air hoses and lines, all driver controls, and vehicle body parts—were damaged.

**Figure 10.** Damage to Freightliner truck-tractor.

Despite the extensive fire damage, crash-induced damage was apparent as well. The front frame horns and rails were bowed upward and rearward. The right-side frame rail was bowed outward above the steering axle, and the left-side frame rail was buckled outward and bowed upward above the steering axle. The right-side frame rail was bowed upward beneath the sleeper berth. The cab was separated from the front and rear mounts. The two fuel tanks, which were no longer mounted to the truck-tractor, were found with the crash debris. The fuel tanks had been torn open and crushed.

The semitrailer also sustained damage from the crash and postcrash fire. All that remained at the front of the semitrailer were the vertical ribs and roof rails, which are the supports for the semitrailer sidewalls and roof. The vertical ribs were bowed forward, and pieces of the semitrailer were located on the deck of the truck-tractor. The exterior siding of the semitrailer was consumed by the fire. Remnants of the automotive batteries carried in the semitrailer were observed at the tow yard.

#### 1.4.1.3 Examination

The NTSB conducted a postcrash examination of the truck-tractor's steering, brakes, tires, wheels, suspension, and electrical systems. The steering system was intact but not functional due to the crash damage inside the steering gear box. The NTSB observed the steering gear box as engineers from ZF North America, Inc., removed it from the truck-tractor and subsequently disassembled and examined it.

Component damage uncovered during the steering gear examination revealed that the steering gear was oriented in a straight-forward direction at impact.

The postcrash fire consumed the combustible materials of the braking system on the truck-tractor, which prevented any brake adjustment or operational checks from being conducted. The NTSB examined the remaining brake components. The brake lining thicknesses were above the minimum allowable lining thickness of one-quarter inch, and the drum measurement was within manufacturer specifications.

The postcrash fire consumed all ten tires except for some tread on the drive axles. Three tires had small tread patches that were measured to estimate the precrash tire conditions. The tread depth measurements were greater than the minimum allowable tread depth of 2/32 inch. All wheels were inspected for cracks, welds, and elongated lug nut holes, and no non-crash-related defects were discovered.

The suspension system sustained fire damage, but no pre-existing damage was found. The postcrash fire consumed the electrical system, including wiring, lighting components, and batteries.

#### 1.4.1.3.1 Semitrailer Hazardous Material Examination

Federal regulations require batteries to be prepared and packaged for transport in a manner that prevents damage and short-circuits in transit.[27] Due to the damage to the trailer and the fact that part of the load had been thrown from the trailer, the NTSB examined the remainder of the load in the tow yard. The NTSB acquired several exemplar batteries and packed them onto the plastic skids that the original batteries had been shipped with to confirm that the batteries were properly held in place by the ridges on the skids. Each skid would have contained 15 12-volt batteries. They stacked on top of each other, locking the lower batteries into similar ridges.

#### 1.4.1.4 Maintenance

The motor carrier operating the Freightliner combination vehicle, Mid-State Systems, regularly conducted maintenance on its truck-tractors, including the crash-

[27] 49 *Code of Federal Regulations* 173.159(e) is known as "The Wet Battery Exception." If batteries are loaded or braced to prevent damage and short-circuits, and any other non-hazardous material loaded in the vehicle is blocked, braced, or otherwise secured to prevent contact or damage to the batteries, then the load of batteries is not subject to the remaining requirements, such as placarding and shipping papers.

involved vehicle. The most recent annual inspection for this truck-tractor was conducted in May 2023, and the record listed no defects. There were three recalls for this vehicle. The recalls were related to replacement of the aluminum battery cables (dated February 2022), replacement of the exhaust pipe (dated May 2022), and potential corrosion of the brake modulator valve (issued February 2023). At the time of the crash, these recalls were either incomplete or their completion status was unknown.

#### 1.4.1.5 Electronic Data

The truck-tractor was equipped with multiple control modules for engine management and vehicle operation. The ECM, which was mounted to the left rear of the engine, and other control modules, which were mounted inside the cab, were consumed by the postcrash fire and no data could be downloaded.

The truck-tractor also contained an ELD that was destroyed in the fire. The motor carrier provided the NTSB with a printout of an ELD record, which reported date, time, location, mileage, speed, and vehicle unit number information. The record pertaining to the crash date contained five lines of data that began at 7:49 a.m. and were reported at 11- to 17-minute intervals. The earliest three records reported a vehicle speed of 0 mph. At 8:32 a.m. the reported vehicle speed was 71.6 mph with the location identified as I-70. The final data sample, 16 minutes later at 8:48 a.m., recorded a vehicle speed of 0 mph with a location of I-70.

Later, the OSHP provided the NTSB with an ELD report for November 14, 2023, that contained odometer values, vehicle speeds, engine speeds, and approximate locations for 17 additional records not present in the ELD telematics data provided to the NTSB by the carrier. These data, reported about every 2 minutes, showed the Freightliner combination vehicle traveling at speeds varying between 62.8 mph and 75.2 mph for 35 miles.[28] The last speed before impact was reported as 74.7 mph, at a location 1.8 miles east of the crash site, at 8:46 a.m. The Freightliner's calculated speed at impact was about 72 mph. (Refer to section 1.4.4 for additional information on the speed calculation.)

[28] The carrier, Mid-State Systems, confirmed that the Freightliner combination vehicle was governed to a speed of 70 mph. However, as noted previously, a vehicle may briefly exceed its electronically governed speed, for example when traveling downhill. Although generally flat, I-70 had minor ascending and descending grades leading to the crash area. In addition, the speed and location data from the ELD had elements of uncertainty. The NTSB did not receive any information about data sample rate, data filtering, or reporting lag. Therefore, it could not be determined whether the speed and position data were sampled synchronously or at different points during the ELD's 2-minute reporting interval.

## 1.4.2 Van Hool Motorcoach

### 1.4.2.1 General Description

The 2009 Van Hool C2045 motorcoach, owned and operated by Pioneer Trails, Incorporated (Pioneer), had a seating capacity of 57 passengers and a driver. The motorcoach was 8 feet, 5 inches wide and 11 feet, 1 inch high.

### 1.4.2.2 Damage

The motorcoach exhibited impact damage at both the front and rear, in addition to fire damage in the rear half of the vehicle and its interior passenger compartment. At the rear, all exterior panels (including the engine cover, upper panel, and lights) were displaced during the crash, though the rear body framing appeared to remain in place (see figure 11). The engine, located in the rear, exhibited evidence of both impact and fire damage. The rear of the motorcoach sustained intrusion from the Freightliner truck-tractor, and the seats in row 15 were displaced upwards and pushed toward the front of the motorcoach.

**Figure 11.** Damage to right rear of motorcoach.

At the front of the motorcoach, both windshield glass panes were missing, the left front was torn open exposing the driver's compartment and fuse panel, the steering wheel and dashboard were displaced forward toward the outside of the vehicle, and the forward portion of the left-front wheel well was displaced rearward into the steer tire. The front-loading door was intact and accessible from the motorcoach interior. The interior fire damage was consistent with the fire having progressed forward from the rear of the vehicle inside the vehicle body up to about row 8.

#### 1.4.2.3 Interior Examination

The motorcoach was equipped with multiple options for egress and evacuation, including the front-loading door, seven emergency exit windows (three on the left side and four on the right side), and an emergency roof hatch. The aisle floor that divided the left- and right-side seating was about 19 inches wide.

The motorcoach windows were equipped with emergency signage including instructions for how to open them. Federal standards for motorcoaches require emergency signage to assist passengers to quickly exit the vehicle in the event of an emergency.[29] Eight of the motorcoach's 14 total windows (4 on each side of the vehicle) were undamaged in the crash. All of these windows contained signage with the words "Emergency Exit" and a graphic that displayed a window, a latch, and an arrow that pointed left or right, even though not all were emergency exits (see figure 12, left image).[30] The Commercial Vehicle Safety Alliance's (CVSA) 2022-04 *Passenger Carrier Vehicle Emergency Exit Inspection* document (CVSA 2025, p. 12) states that:

> If a manufacturer or motor carrier chooses to provide additional marking (for non-emergency/non-opening windows) to indicate the location of the nearest emergency exit, the marking must differ from those used to identify an emergency exit. The use of markings placed on non-opening/non-emergency windows may not be identical to markings used to satisfy the requirements in the [federal regulations].

Therefore, the emergency exit signage on the non-emergency windows constituted an out-of-service condition for the motorcoach, per 49 *Code of Federal Regulations* (*CFR*) 393.62. Although Public Utilities Commission of Ohio (PUCO) safety investigators inspected the motorcoach multiple times between 2017 and 2022, no violations had been documented.[31] When PUCO safety investigators

[29] Federal Motor Vehicle Safety Standard 217 establishes requirements for windows and emergency exits on buses. For more information, see 49 *CFR* 571.217.

[30] The precrash signage present for the windows that were damaged in the crash was unknown.

[31] PUCO is the primary agency in the state of Ohio for the enforcement of commercial vehicle and hazardous material regulations. PUCO investigators conduct compliance reviews, new entrant audits, and roadside inspections within the state.

inspected the motorcoach after the crash on November 16, 2023, it was cited for improper exit markings.

The examination of the motorcoach's windows also revealed that the emergency exit window latch instructions were inaccurate (see figure 12, right image). The instructions directed passengers to turn the handle to the right, but in fact, the handles on the emergency windows needed to be turned to the left for the windows to then be pushed open.


**Figure 12.** Emergency exit signage located on all emergency window exits as well as all non-emergency windows (left) and emergency exit window latch instructions (right).

### 1.4.2.4 Electronic Data

The motorcoach was powered by a Detroit Diesel Corporation diesel engine that was electronically managed by multiple ECMs. The NTSB transported the ECMs to Detroit Diesel Corporation to facilitate the retrieval of any stored data. The data included engine ECM configuration and programming as well as certain engine and transmission usage and events related to a last-stop record, hard-brake record, and diagnostic or fault code records. Two hard-brake records and one last-stop record were identified, but none were related to the crash event. The last-stop record was identified as having occurred at the school complex where the student trip had begun.

After the crash, OSHP investigators recovered a personal navigation device from the motorcoach.[32] Later, the OSHP Computer Crimes Unit obtained the data stored on the device. OSHP investigators provided the NTSB with a copy of a

[32] The motorcoach driver stated in an interview with the NTSB that the navigation device was on a suction mount on the driver's-side window. He had entered his destination address that morning for navigation.

retrieved data file and a summary of time and position data covering the final 9 minutes, 46 seconds of recorded data. The OSHP summarized the time and position data and presented them as 48 data samples that featured intervals ranging from 1 to 23 seconds and covering about 10.8 miles on I-70 between 8:38 a.m. and 8:47 a.m. Vehicle speed was also reported with the position and time data. The data were consistent with the motorcoach's approach to the traffic queue on I-70. At 8:47 a.m., the speed data indicated a reduction in vehicle speed from an initial speed of 71 mph. At this position, the motorcoach was west of the Route 152 overpass and nearing the crash site (refer to figure 7). Its speed decreased from 71 mph (at 8:47:19 a.m.) to 25 mph (8:47:33), followed by an increase to 43 mph (8:47:42) consistent with the acceleration from a rear impact. The motorcoach then continued to decrease in speed to 3 mph (at 8:47:52 a.m.). There was no indication of a sudden braking event.

## 1.4.3 Other Vehicles

### 1.4.3.1 Damage

Three other vehicles were involved in the crash. The 2015 Nissan Murano passenger vehicle sustained catastrophic impact damage and comprehensive fire damage.[33] It was crushed between the front of the Freightliner combination vehicle and the rear of the motorcoach and was found in multiple pieces (see figure 13).

**Figure 13.** Postcrash view of Nissan, which sustained catastrophic crash damage and comprehensive fire damage.

[33] Specifications indicated that the Nissan had an overall width of 6.2 feet and an overall height of 5.5 feet.

The 2006 Toyota Highlander passenger vehicle, which was traveling in front of the motorcoach, was struck at its right-rear corner by the left front of the motorcoach. The rear lift gate, bumper, and right-rear corner panel were crushed forward (see figure 14). The exterior door panel for the right-side rear passenger door was missing and the door was crushed. The Toyota also sustained minor fire damage.

**Figure 14.** Damage to rear of Toyota.

The Volvo combination vehicle—consisting of a 2014 Volvo truck-tractor coupled with a 2022 Vanguard semitrailer—sustained minor damage to the rear of the semitrailer from the front of the motorcoach but was not involved in the postcrash fire (see figure 15).[34] The OSHP released the Volvo combination vehicle from the crash scene, and the NTSB did not examine it.

[34] The Volvo combination vehicle was operated by G.A. Wintzer & Son Company.

**Figure 15.** Damage to rear of Volvo combination vehicle Vanguard semitrailer. (Source: OSHP)

#### 1.4.3.2 Electronic Data

##### 1.4.3.2.1 Nissan

The Nissan was equipped with an event data recorder (EDR) contained within the ACM. The ACM exhibited external fire damage when recovered from the vehicle. The NTSB performed a memory chip transplant and was subsequently able to access relevant crash data. System status data indicated that the driver and right-front passenger seat belts were fastened.[35] Two events were recorded on the same ignition cycle.[36] The first event record indicated a maximum longitudinal change in velocity of 57 mph, consistent with a forward acceleration characteristic of a rear impact.[37] No airbag or seat belt pretensioner deployments were recorded. The second event record indicated a maximum longitudinal change in velocity of -37 mph, consistent with a rearward acceleration from a frontal impact, and recorded that deployment commands were sent by the ACM to the frontal, side, and side curtain airbags as well as the front seat belt pretensioners.

Five seconds of precrash data were also retrieved. The precrash data indicated that the Nissan was steadily decreasing speed from about 24 mph to 15 mph. The

[35] Although there was a rear passenger in the Nissan, the EDR did not record seat belt status for rear-seated occupants.

[36] *Ignition cycle* refers to the process of starting an internal combustion engine by initiating the combustion process.

[37] Where polarity is reported, positive values in the longitudinal direction indicate a forward speed change/acceleration that is characteristic of a rear impact. Negative values indicate a longitudinal speed reduction indicative of a frontal impact.

brake was engaged during the 5 seconds of the first event record captured by the ACM.

#### 1.4.3.2.2 Toyota

The Toyota was also equipped with an EDR contained within the ACM. System data indicated that the driver's seat belt was unbuckled and the front passenger seat was unoccupied. The record conveyed precrash data that were reported at 1-second intervals for a period of just under 5 seconds before the crash. In general, the data indicated that the speed of the Toyota decreased from about 16 mph to 9 mph in the 4.4 seconds leading up to the crash.

A maximum longitudinal change in velocity of 32 mph was recorded during the crash, consistent with a forward acceleration from a rear impact.

#### 1.4.3.2.3 Volvo Combination Vehicle

The NTSB obtained a 50-second-long, forward-facing exterior video segment from the Volvo combination vehicle. Additional data including date, time, vehicle speed, and highway speed limit information were displayed in the video. The displayed timestamp at the beginning of the segment was 8:47:28 a.m. with a vehicle speed of 51 mph. The Volvo combination vehicle visibly began to slow about 15 seconds before it reached a red sedan ahead of it at the end of the traffic queue. The video depicted the Volvo slowing to the traffic flow with no hard braking or evasive maneuver. At a timestamp of 8:47:43 a.m., the displayed speed was 10 mph, and a noticeable jolt could be observed in the video.[38] Immediately after the jolt, the vehicle moved onto the right shoulder and continued for a short distance before coming to a stop straddling the pavement edge. When this stop occurred, the timestamp was 8:48:01 a.m.

ELD data from the Volvo also provided information on time, vehicle position, and vehicle speed at 1-minute intervals. For the initial 6 minutes before the jolt, the Volvo was traveling just over 72 mph. By 8:47 a.m., the data indicated that the vehicle had stopped. The geographic position of the last ELD data output was consistent with the position of rest documented by the OSHP.

[38] The duration of the delay or latency between the vehicle's change in speed and the data displayed in the video was unknown.

### 1.4.4 Speed Calculation

Due to the postcrash fire, no electronic data related to the speed of the Freightliner combination vehicle at impact were available. Using the velocity change data recorded by the Nissan's ACM during the impact with the Freightliner and the Nissan's known precrash speed, the NTSB determined the Freightliner's speed at impact. Due to the significant weight difference between the two vehicles, the velocity change experienced by the Freightliner would have been very small relative to the velocity change experienced by the Nissan. Based on the Nissan's 57-mph change in velocity and assuming the velocity change of the Freightliner to be zero (a conservative assumption), the Freightliner's calculated speed at impact was about 72 mph.

OSHP investigators acquired a forward-facing, exterior-view video segment from a commercial vehicle traveling behind the Freightliner combination vehicle.[39] (See section 1.1.1 for a discussion of precrash- and crash-related events shown in this video.) The video, which is about 1 minute long, shows the Freightliner traveling in the right lane approaching the State Highway 310 interchange (as indicated by roadside signage). Analysis of the video using the reported frame rate of 30 frames per second indicated that the speed of the Freightliner over the final 5 seconds before the collision was about 70 ± 5.0 mph.[40] This was consistent with the Freightliner's speed as calculated using EDR data from the Nissan, and with the Freightliner's ELD data, which indicated a speed of 74 mph about 2 minutes before the crash.

## 1.5 Truck Driver

### 1.5.1 Licensing, Experience, and Driving Record

The Freightliner combination vehicle was being driven by a 60-year-old male with a Class A commercial driver's license (CDL) issued in July 2020 and expiring in July 2024. The license was not restricted and had endorsements for tank vehicles and hazardous materials. The truck driver had worked as a commercial vehicle driver since 2006 and had been employed with Mid-State Systems since 2020.

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[39] The witness vehicle was operated by the commercial motor carrier McKesson Medical-Surgical, Inc.

[40] Because the video was transcoded, it could not be determined whether the reported frame rate of 30 frames per second was accurate. To verify the frame rate, vehicle speeds were estimated using the video and video tracking software and compared to other known information on vehicle speeds.

According to the Commercial Driver's License Information System (CDLIS), the truck driver had nine traffic violations (involving both commercial and non-commercial vehicles) between 2003 and 2022, which included speeding, following too closely, and failing to obey traffic signs.[41] The truck driver had no history of license suspensions or withdrawals. Although no crashes were listed in the driver's CDLIS report, a non-reportable crash in 2017 was documented in pre-employment records obtained from Mid-State Systems. The driver self-reported that he had been involved in a non-injury crash involving a pickup truck and the side of the truck-tractor he was driving.

The truck driver had been subject to three roadside inspections while employed with Mid-State Systems. On March 3, 2021, the driver was stopped in Ohio for a roadside commercial vehicle inspection. The inspector found no driver violations but cited numerous issues with the combination vehicle's brake system and placed the vehicle out of service. In March 2022, the truck driver was stopped for driving 75 mph in a 60-mph zone. The inspection report noted that the driver had his mobile phone open and that a video game was loaded and visible. The driver denied that he was using the game application while driving. In May 2022, an inspection report noted that the driver's combination vehicle was observed swerving left and right out of its lane. The inspection discovered that 3 days before the swerving incident, the driver had exceeded the 14-hour hours-of-service (HOS) rule by 1 hour.[42]

### 1.5.2 Health and Toxicology

The truck driver's most recent USDOT medical exam took place in July 2023, about 4 months before the crash. The exam resulted in the issuance of a 1-year medical certificate with an expiration date of July 2024. The medical examiner who conducted the exam was a medical doctor listed in the Federal Motor Carrier Safety Administration's (FMCSA) National Registry of Certified Medical Examiners. The driver's most recent medical examination form indicated that he was being treated for diabetes, high blood pressure, and high cholesterol.[43] The driver's resting heart rate, blood pressure, visual acuity, and peripheral vision were within regulatory

[41] The CDLIS is a nationwide computer system, administered by the Federal Motor Carrier Safety Administration, that enables state driver licensing agencies to ensure that each commercial driver has only one driver license and one complete driver record.

[42] Per 49 *CFR* 395.3, the 14-hour rule states that "a driver may not drive after a period of 14 consecutive hours after coming on-duty following 10 consecutive hours off duty."

[43] None of his reported medications were generally considered impairing.

limits.[44] His hemoglobin A1c (a measure of long-term blood sugar control) was noted to be normal at the time of the exam.

OSHP investigators who contacted the truck driver at the hospital about 3 hours after the crash did not observe signs of drug or alcohol impairment. Postcrash laboratory tests showed a glucose level of 179 milligrams per deciliter (mg/dL) with no associated major metabolic abnormalities.[45] At the OSHP's direction, a blood specimen was collected from the truck driver in the emergency department and sent for hospital ethanol testing. No ethanol was detected. In addition, urine and blood specimens were collected on the day of the crash at 11:41 a.m. and 1:42 p.m., respectively, for toxicological testing by the OSHP. No alcohol or other tested-for substances were detected in the driver's urine or blood.[46] At the request of the NTSB, the Federal Aviation Administration Forensic Sciences Laboratory performed toxicological testing of the driver's blood sample, which did not detect any substances that are generally considered impairing.

In accordance with 49 *CFR* 382.303, Mid-State Systems was responsible for testing the truck driver for alcohol and drugs as soon as practicable after the crash. The truck driver was discharged from the hospital on the afternoon of November 14, 2024, but due to his ongoing medical treatment, he did not submit to postcrash tests for alcohol (breath) and other substances (urine) until November 15, 2023. Results of both postcrash tests were negative for alcohol and drugs of abuse.

### 1.5.3 Route History and Precrash Activities

#### 1.5.3.1 Route History

The truck driver's primary duty was transporting pre-loaded trailers carrying automotive batteries from facilities in Topton, Pennsylvania, and Laureldale, Pennsylvania, to manufacturing facilities in East Liberty, Ohio, and Marysville, Ohio. The driver would transport packaging materials to the battery companies in Pennsylvania during return trips. A typical week consisted of two or three round trips,

[44] See 49 *CFR* 391.41.

[45] Generally, a person's blood sugar varies throughout the day in response to multiple factors (for example, it may increase from eating a meal or being under stress). In many adults with diabetes, target peak blood sugar after eating is less than 180 mg/dL. Blood sugar typically is considered low if below 70 mg/dL.

[46] The Ohio Department of Public Safety Highway Patrol crime lab tested blood and urine samples for the presence of alcohol, amphetamines, cannabinoids, benzodiazepines, cocaine, barbiturates, opiates/opioids, carisoprodol, dextromethorphan, citalopram, meprobamate, cyclobenzaprine, phencyclidine, zolpidem, and gabapentin.

which included stops in Zanesville, Ohio, or Hebron, Ohio. The crash-involved combination vehicle had been assigned as the truck driver's primary vehicle for about 1 year. The driver had made four previous trips to the manufacturing facilities since October 31, 2023, and on each occasion had driven past the crash location around the same time of day that the crash occurred.

ODOT provided the NTSB with traffic speed data for a range of dates, including the morning of the crash and the four westbound trips the truck driver made since October 31, 2024. Data showed that for each of the four recent westbound trips, traffic had been flowing normally at the crash location when the truck driver traveled through the area.

The truck driver had a flexible work schedule. In the 15-day period leading up to the crash, he primarily worked between 8:00 a.m. and 6:00 p.m. As an exception to his normal work hours, four of his five trips to eastern Pennsylvania ended between 9:00 p.m. and 11:00 p.m., and the trip to eastern Pennsylvania starting on November 12 ended at 1:28 a.m. on November 13. The driver generally had at least 10 hours off duty each night. Additionally, he had a 71-hour off-duty period between November 3 and November 6, and a 52-hour off-duty period between November 10 and November 12.

#### 1.5.3.2 Precrash Activities

To determine the truck driver's activities before the crash, the NTSB used data from the truck's ELD, his cell phone records, his interview with the OSHP, and the video from the commercial vehicle traveling behind the Freightliner combination vehicle.[47] The driver was off duty from 1:58 p.m. on November 10 until 6:53 p.m. on November 12 (a total of 52 hours and 54 minutes). The driver then went on duty at the Mid-State Systems yard in Hebron, Ohio, at 6:53 p.m. on November 12, and drove to Topton, Pennsylvania, arriving at 1:24 a.m. on November 13. He parked the Freightliner combination vehicle in a dirt lot west of the main facility and entered sleeper berth status at 1:28 a.m.

Although the driver's log indicated that he had remained in the sleeper berth until 11:38 a.m., he moved the Freightliner from the dirt lot to the vicinity of the loading docks at 9:29 a.m. At 11:38 a.m. on November 13, the driver began his return trip to Zanesville, Ohio. He went off duty at 6:03 p.m., parked the combination vehicle overnight about 3 miles from his residence in Zanesville, and slept at his residence. The driver told OSHP investigators that he went to bed between 10:30 p.m. and

[47] The truck driver did not consent to an interview with the NTSB.

11:00 p.m. and slept until about 7:30 a.m. on November 14. He stated that he did not feel tired when he started his day and that he drank some water but did not eat anything before starting his trip. Although the driver was prescribed Metformin for diabetes, he did not remember taking it on the morning of the crash.

On the morning of the crash, the driver returned to the combination vehicle at 7:49 a.m. and began driving at 8:17 a.m. He drove onto I-70 about 35 miles east of the crash location and was traveling to the manufacturing facilities in Marysville, Ohio, to drop off the batteries. The truck driver told OSHP investigators that he remembered leaving his house and everything was normal, and that the next thing he remembered was waking up and seeing the fire outside his truck. The driver also told OSHP investigators that traffic had been lighter than usual on the morning of the crash and that it usually would increase past "that exit."[48] He would usually activate cruise control and "had it set earlier." According to the truck driver, the maximum cruise control speed was 70 mph, but the vehicle could reach 75 mph without cruise control.

#### 1.5.3.3 Sleep Opportunity and Cell Phone Records

The driver's flexible work schedule enabled him to rest at his residence on most nights, including the night before the crash, and in the sleeper berth of the Freightliner combination vehicle on trips to eastern Pennsylvania. The NTSB estimated the truck driver's sleep opportunities in the 3 days before the crash. Sleep opportunities were determined based on when the driver was logged off duty or in the sleeper berth and had no cell phone activity.[49] In the 3 days before the crash, the driver had 11, 7.75, and 11.25 hours available for sleep, respectively.

Cell phone records showed that the driver was not using native calling or regular text messages at the time of the crash.[50] However, around the time of the crash, the records showed a spike in data activity, reaching 39.8 megabytes per minute at 8:37 a.m. on November 14.[51] Because the driver's phone was destroyed in

[48] The truck driver had earlier referenced exit 126, but this exit reference was not clarified during the interview.

[49] Sleep opportunity is not identical to sleep; it indicates the windows of time that the driver could have slept based on the absence of evidence that he was performing other activities, such as being on duty or using his cell phone.

[50] Regular text messages are text messages sent or received via mobile carriers using Short Message Service or Multimedia Messaging Service protocols, and do not include any text messages sent or received via software applications, which use mobile data via the internet.

[51] For comparison, AT&T advises its customers that streaming high-definition video uses 41.7 megabytes of data per minute. For more information, see AT&T's Internet Data Calculator.

the postcrash fire, data could not be downloaded directly from the cell phone. Thus, the NTSB could not determine if the data activity indicated active use of the cell phone by the driver.

## 1.6 Motor Carrier Factors

### 1.6.1 Mid-State Systems Inc.

The Freightliner combination vehicle was owned and operated by Mid-State Systems. The carrier was first incorporated in 1979, obtained operating authority in 1980, and has had the same single owner since its inception. According to the latest paperwork filed by the carrier, Mid-State Systems owned 33 truck-tractors and 57 semitrailers and employed 21 drivers. The carrier reported carrying general freight, paper products, and hazardous materials.

#### 1.6.1.1 Carrier Policies

Mid-State Systems had many policies and procedures in effect at the time of the crash. It had an established hiring process with minimum driver requirements including age and possession of a CDL with a hazardous materials endorsement, among other factors. The carrier provided its drivers with a driver's manual, guidance on HOS and safe operation, and a drug and alcohol policy, and required them to read and acknowledge receipt of the driver's manual and acknowledge understanding of and adherence to the policies.

Mid-State Systems had a policy prohibiting the use of handheld cellular devices. The policy stated, "No driver may hold a cell phone while driving, if we call you do no[t] answer until you are not driving." This policy did not prohibit the use of devices in combination with a headset, speaker, or wireless configuration. The carrier did not have a formal fatigue management policy but took several steps to monitor HOS compliance and reduce driver fatigue, including requiring the company equipment to be parked at the terminal on weekends to ensure a 34-hour reset and scheduling trips to be within HOS regulations.

Mid-State Systems had an established controlled substance and alcohol testing program. The controlled substance testing program met the regulatory requirements under 49 *CFR* 382.305. The carrier provided the NTSB with copies of its annual drug and alcohol testing for the past four quarters. The crash-involved driver was entered into the carrier's random drug testing pool as required. The carrier also had a record of an inquiry into the FMCSA's Drug and Alcohol Clearinghouse for the crash-involved driver that it issued before hiring him; the results showed no positive drug tests.

The FMCSA requires motor carriers to install and maintain an ELD that automatically records a driver's driving time.[52] The ELD facilitates the accurate recording of a driver's HOS. At the time of the crash, Mid-State Systems used J.J. Keller as its ELD provider. J.J. Keller was self-certified and its ELD appeared on the FMCSA's list of registered electronic devices. For the crash-involved driver, ELD records showed no HOS violations in the 7 days before the crash.

Although the carrier maintained disciplinary records, the crash-involved driver's file contained no documentation on violations during roadside inspections. When asked about this by the NTSB, the carrier first stated that the driver had no violations. Later, carrier officials clarified that the driver had previously been counseled for speeding.

With respect to the crash-involved driver's March 2022 roadside inspection that involved speeding and possible use of a gaming application on his phone, Mid-State Systems informed the NTSB that its safety personnel met with the driver on April 4, 2022, to review and counsel him on the speeding violation. The driver denied speeding but was given a verbal warning by the carrier and counseled on the importance of driving at a safe speed. Carrier officials stated that they were not aware of the issue with the driver's phone being opened to a video game until the NTSB asked about driver coaching.

With respect to the May 2022 roadside inspection involving an HOS violation, Mid-State Systems told the NTSB that the violation was reviewed by the safety director and that the driver was counseled. This counseling was not formally documented. After the violation, the company indicated that the driver's logs were closely monitored, and no other HOS issues involving the driver were identified.

#### 1.6.1.2 Federal Oversight

The FMCSA has oversight responsibility for interstate motor carriers that provide transportation services across state borders. The agency operates the Compliance, Safety, Accountability (CSA) program, a data-driven safety compliance and enforcement program designed to improve the safety of large trucks and buses.[53] As part of the CSA program, the Safety Measurement System (SMS) is the

[52] See 49 *CFR* 395.

[53] For more information, see [What is CSA? Factsheet (dot.gov)].

FMCSA's workload prioritization tool to identify carriers with potential safety problems for interventions. The SMS uses a motor carrier's data from roadside inspections, state-reported crashes, and the Federal Motor Carrier Census to quantify performance in seven Behavior Analysis and Safety Improvement Categories (BASIC).[54]

At the time of the crash, Mid-State Systems displayed an alert in the HOS Compliance BASIC at 63% and had been in alert status for the 8 months preceding the crash. The alert threshold for hazardous material carriers for this BASIC is 60%. The SMS profile also showed that at the time of the crash, the carrier's driver out-of-service rate was 2.6% and its vehicle out-of-service rate was 17.9%. These rates were in comparison to the national averages of 6.0% and 21.4%, respectively.

Since becoming a carrier, Mid-State Systems had been subjected to 10 compliance reviews (CR), including a CR that was conducted as a result of this crash. As a result of the postcrash CR, the FMCSA documented several violations, though none were related to the crash-involved driver.[55] The FMCSA determined Mid-State Systems to have a "Satisfactory" safety rating.[56] In addition to the CRs, at the time of the crash, Mid-State Systems had been subjected to 39 roadside inspections since October 28, 2021, resulting in 27 violations.

[54] There are currently seven safety categories, BASICs, reflecting types of regulatory violations: (1) Unsafe Driving, (2) HOS Compliance, (3) Driver Fitness, (4) Controlled Substances and Alcohol, (5) Vehicle Maintenance, (6) Hazardous Materials Compliance (if applicable), and (7) Crash Indicator. A carrier's rating for each BASIC depends on its number of adverse safety events, the severity of its violations or crashes, and when the adverse safety events occurred. Carriers are compared to a peer group of other carriers with a similar number of inspections using a percentile rating of 0 to 100, with the 100th percentile indicating the worst performance. Intervention threshold levels for each BASIC depend on the inherent risk of the category as well as the carrier type. When a carrier is above a threshold level in a BASIC, it is considered to be in an "alert" status. For more information, see Safety Measurement System (dot.gov).

[55] These violations included HOS and record-of-duty status violations, a driver qualification file violation, failure to provide recurrent training, and using a CMV that was not periodically inspected.

[56] A Satisfactory safety rating means that a motor carrier has functional and adequate safety management controls to meet the safety fitness standard prescribed in 49 *CFR* 385.5. Safety management controls are adequate if they are appropriate for the size and type of operation of the carrier.

## 1.6.2 Pioneer Trails, Incorporated, and Tuscarawas Valley Local School District

The motorcoach was owned and operated by Pioneer and chartered by the Tuscarawas Valley Local School District (TVLSD) to transport passengers from Zoarville, Ohio, to Columbus, Ohio.

### 1.6.2.1 Pioneer Trails, Incorporated

Pioneer is a family-owned business that had been in operation for 38 years at the time of the crash. The carrier entered the motor carrier industry on August 7, 1985. According to the carrier's most recent paperwork, it had 31 motorcoaches and employed about 50 drivers between its primary location in Ohio and a secondary location in Parkersburg, West Virginia. The carrier is registered as a for-hire interstate carrier of passengers.

Pioneer had a series of policies, procedures, and memorandums to provide guidance to drivers. These included a driver's handbook; guidance on HOS, safe operation, and cell phone use; and a drug and alcohol policy. The carrier did not have a formal fatigue management policy. Pioneer electronically governed its motorcoaches so that they could not travel faster than 68 mph. Pioneer used Verizon's Connect Reveal as its ELD provider. The device and provider were self-certified and appeared on the FMCSA's list of registered electronic devices.

Pioneer had a drug and alcohol testing program and provided copies of its annual testing for the past four quarters. The program met the regulatory requirements under 49 *CFR* 382.305. The crash-involved driver was enrolled in the carrier's random testing pool when he began employment with Pioneer. He was subjected to postcrash drug and alcohol tests, with negative results.

Pioneer's driver handbook instructed drivers to provide a pretrip briefing reviewing safety practices with passengers including operation of passenger seats, operation of emergency roof and window exits, and use of onboard restrooms. According to interviews with the motorcoach driver and occupants, the driver had not conducted a pretrip safety briefing as required by the driver handbook. As a result, motorcoach occupants were not provided with information regarding emergency exits or what to do in the event of an emergency.

The motorcoach driver was a 65-year-old male with an Ohio Class A CDL issued in September 2020 and due to expire in December 2024. The license contained endorsements for motorcycles, school buses, and passenger vehicles. The driver had held a CDL since December 2001 and had been employed driving motorcoaches since that time. He also had a 2-year medical certificate with an expiration date of August 2025.

#### 1.6.2.2 Tuscarawas Valley Local School District

The TVLSD had about 1,300 students and covered 95 square miles. Historically, the TVLSD has hired transportation services for any trip for which school buses are not available due to normal school operations. In this case, the TVLSD chartered the motorcoach operated by Pioneer for round-trip travel from the school in Zoarville, Ohio, to a school band performance in Columbus, Ohio.

School officials stated after the crash that they had no policies, procedures, or guidelines for contracting transportation services with outside entities. They relied on word of mouth and previous leasing experiences. The transportation director had heard of the FMCSA's Bus Safety Search website but had never used it.[57]

In August 2023 (before the crash), the Ohio School Bus Safety Working Group had met to develop strategies to reduce risk to students in school transportation. In January 2024, the group published a report with 17 safety recommendations.[58] Recommendation 17, which was developed in response to the Etna crash, states that, "School districts should adopt policies that require a thorough evaluation of contracted commercial bus services." The Ohio Department of Education and Workforce subsequently published a guide to provide recommendations to district leaders and transportation professionals regarding the selection of commercial carriers.[59]

## 1.7 Postcrash Actions

### 1.7.1 Ohio Department of Transportation

After the crash, ODOT made several upgrades along I-70 in the vicinity of the crash site to improve detection of traffic queues and warn approaching drivers. Several new cameras providing views in four directions were added between December 2023 and February 2024, with real-time video feeds available through the

[57] This website is an online resource that allows the public to research the safety history of bus companies before chartering a bus company or booking a bus trip. For more information, see Bus Safety Search | FMCSA (dot.gov).

[58] Ohio School Bus Safety Working Group Report (2024).

[59] Considerations for Selecting Commercial Charter Bus Services (2025).

OHGO website and phone application.[60] Additional fixed cameras with video analytics were installed to detect slow or stopped traffic.[61] These cameras are configured to send alarms to ODOT's video management system to automatically notify TMC operators when such conditions are detected.

ODOT identified sites for the deployment of queue warning message signs and fixed cameras with analytics in and around major urban centers in Ohio using factors such as traffic congestion and the number and severity of rear-end crashes. One site was located on westbound I-70, about 1.5 miles east of the State Highway 310 interchange, where ODOT installed a new 15-foot-by-8-foot, ground-mounted queue warning message sign on January 29, 2024. The statewide TMC plans to use the queue warning message signs to display incident management, maintenance, and construction messages.

Finally, ODOT updated its TIM training course as a result of the initial and secondary crashes on November 14, 2023. The 2024 version of the training uses these crashes as examples of how the TIM process could have been better implemented to reduce the risk of secondary crashes. In addition, the TIM training course now includes a lesson devoted to deploying early warnings to drivers upstream of a traffic queue, emphasizing the rationale that early warnings give drivers a chance to stop and avoid secondary crashes.

### 1.7.2 Ohio State Highway Patrol and Van Hool Motorcoach

During the investigation, the NTSB, along with OSHP and PUCO safety investigators, identified that the emergency exit window signage on the motorcoach did not meet the guidance in the Ohio Bus Inspection Program standards or Federal Motor Vehicle Safety Standard (FMVSS) 217.[62] Specifically, the signage on the emergency exit windows provided instructions for opening that were contrary to their actual operation, and the same emergency exit markings were present on non-emergency exit windows as on emergency exit windows. The OSHP updated its Ohio Bus Inspection Program standards in May of 2024 to address these shortcomings, which had not been identified during its annual inspections of the motorcoach.[63] The

[60] OHGO Camera: I-70 at SR-310.

[61] Video analytics is a technology that leverages existing video surveillance networks to derive searchable, actionable, and quantifiable intelligence from live or recorded video content.

[62] (a) For more information, see Ohio Bus Inspection Program standards. (b) See again 49 *CFR* 571.217.

[63] Commercial Bus Inspections | Ohio State Highway Patrol.

OSHP also included the CVSA's 2022-04 Inspection Bulletin, which gives step-by-step guidance on the proper inspection of passenger-carrying vehicle emergency exits, in the updated standards.[64] In addition, the OSHP conducted a 100% refresher training for its inspection personnel.

As a result of the NTSB's investigation, on January 8, 2024, Van Hool issued Service Bulletin SB2372 to all its fleet owners to remove any incorrect signage that may be present.[65]

### 1.7.3 Mid-State Systems Inc.

As of October 1, 2024, Mid-State Systems has made several postcrash changes to its safety programs. It now keeps records of all driver notices such as inspections, traffic violations, and/or outside communications in the individual driver's file as well as in a company-wide file of all such documents. Drivers are interviewed, coached, and informed of policy breach ramifications. All notices are documented, and the driver signs and dates receipt of the documentation. In addition, Mid-State Systems updated its Drivers Safety Meetings and Driver Safety Training and now includes periodic safety updates and company-related issues in drivers' pay envelopes. Finally, Mid-State Systems installed forward-facing cameras in its trucks.

### 1.7.4 Pioneer Trails, Incorporated

Since the crash, Pioneer changed its pretrip safety briefing policy to require the driver to show a video produced by the American Bus Association covering safety belt usage, use of handrails entering and exiting the bus, and how to use the emergency exits and fire extinguisher.[66]

### 1.7.5 Tuscarawas Valley Local School District

As of April 2024, the TVLSD confirmed that it would use the information provided in the Ohio School Bus Safety Working Group report to properly screen

[64] Inspection Bulletins - CVSA – Commercial Vehicle Safety Alliance.

[65] Van Hool Service Bulletin SB2372.

[66] Not all of Pioneer's motorcoaches are equipped with passenger lap/shoulder belts. FMVSS No. 208 requires motorcoaches manufactured after 2016 to have lap/shoulder belts in all seating positions. Refer to footnote 8 for more information.

outside contract transportation companies and only select those that have safe systems in place.

# 2 Analysis

## 2.1 Introduction

On Tuesday, November 14, 2023, a Freightliner combination vehicle was traveling west on I-70, near Etna, Ohio, when it crashed into the rear of a slowly moving traffic queue that had formed due to an earlier minor crash. The resulting chain-reaction collision involved five vehicles—two passenger vehicles, two commercial combination vehicles (including the crash vehicle), and one motorcoach. As a result of the crash, six occupants died and four were seriously injured.

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

- Inadequate guidance for traffic incident management to reduce the incidence of secondary crashes (section 2.3)
- Driver inattention and lack of standards for collision avoidance technology for heavy vehicles (section 2.4)
- Inadequate standards for postcrash fire protection on motorcoaches and insufficient school district processes for chartering motorcoach transportation (section 2.5)

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

- ***Weather and visibility:*** The weather was clear and dry and there were no visual obstructions for drivers traveling in the westbound direction.
- ***Mechanical condition of the vehicles:*** The postcrash examination of the Freightliner combination vehicle did not identify any pre-existing conditions that could have contributed to the crash. The open recalls for the truck did not contribute to the crash. The conditions of the other vehicles, which were traveling slowly in the traffic queue, were not a factor.
- ***Truck driver licensing, experience, familiarity with vehicle and route, health, and alcohol or other drug use:*** The truck driver had a CDL with appropriate endorsements and about 17 years of experience driving

commercial motor vehicles (CMV). The driver had driven the same vehicle for about 1 year and drove the same route repeatedly, passing the crash location on westbound I-70 on four previous occasions in the 2 weeks before the crash. Based on police observation and testing that occurred within about 3 hours of the crash, there was no evidence of impairment by alcohol or other drugs or any medical factors, including high or low blood sugar, that contributed to the crash.

- ***Truck driver fatigue:*** In the 3 days before the crash, the truck driver had 11, 7.75, and 11.25 hours available for sleep. He had a flexible schedule that allowed him to rest at his residence on most nights, including the night before the crash, and in the sleeper berth of the Freightliner on trips to eastern Pennsylvania. He primarily worked during the daytime and had been on duty for less than 1 hour at the time of the crash. There was no indication that the driver was fatigued.

- ***Roadway design:*** I-70 where the crash occurred conformed to appropriate roadway design guidance. Although the highway design was not a factor in the crash, traffic incident management is discussed in section 2.3.

The NTSB therefore concludes that none of the following were factors in the crash: (1) weather and visibility; (2) mechanical condition of the vehicles; (3) truck driver licensing, experience, familiarity with vehicle and route, health, and alcohol or other drug use; (4) truck driver fatigue; and (5) roadway design.

The investigation found that the first 911 notification was received at 8:48 a.m. Units were dispatched within 1 minute of the first 911 notification and were en route less than 1 minute after being dispatched. Four law enforcement agencies and 19 fire/rescue and EMS agencies responded to the incident and were appropriately coordinated by the incident commander. The NTSB concludes that the emergency response was timely and adequate.

## 2.2 Truck Driver's Lack of Response

The video from a forward-facing camera on a witness vehicle showed the Freightliner combination vehicle for about 33 seconds before the collision. The video depicted that the driver was able to generally maintain his vehicle's position within the lane during that time.

The NTSB examined the extent to which an alert and attentive driver should have been able to respond to the upcoming traffic queue. To avoid a collision with vehicles moving at lower speeds ahead of the Freightliner combination vehicle, the truck driver would have needed to see the vehicles, including their illuminated brake lights, and understand the closing rate between his vehicle and the slower-moving vehicles. The Nissan and the motorcoach were being driven in the right lane, in front of the Freightliner, within the field of view of any driver approaching the vehicles in the right lane who was visually scanning the forward environment. Both vehicles slowed over time without emergency braking maneuvers. The westbound lanes of I-70 were relatively straight and flat, with no environmental sightline obstructions. A van that was traveling between the Freightliner and the Nissan moved out of the right lane 7–9 seconds before the first impact. The motorcoach (with a width of 8 feet, 5 inches and overall height of 11 feet, 1 inch) was wider and taller than the Nissan (with a width of 6.2 feet and an overall height of 5.5 feet) and the van, and therefore should have been visible to the truck driver despite the presence of the van and Nissan in the right lane between the motorcoach and the Freightliner combination vehicle. Even if the van obstructed the truck driver's view, the Nissan and the motorcoach were detectable and identifiable as vehicles to the truck driver for at least 7–9 seconds before the collision, based on when the van changed lanes. Additionally, traffic in the left lane, which was also slowing, would have been visible to the truck driver.

Videos recorded by the cameras in the Volvo combination vehicle and the witness combination vehicle showed that other drivers had observed and responded to cues of slowing traffic in the same area by slowing to match traffic speed without emergency braking or steering. The Volvo combination vehicle had visibly begun to slow about 15 seconds before it reached a sedan at the end of the traffic queue. In addition, the driver of the van, which was initially in front of the Freightliner combination vehicle, told OSHP investigators that he had observed brake lights and vehicles slowing ahead of him and had decided to move to the left lane because traffic there was lighter. The non-evasive lateral movement of the van and its driver's recollection of traffic conditions suggested that sufficient cues were available to the van driver for him to understand that the van was closing on the slower-moving Nissan.

Even though the slow traffic queue was unexpected, which could have increased the time needed to perceive and respond to the hazard, the non-evasive responses of other commercial and non-commercial drivers reaching the end of the traffic queue suggested that sufficient information was available for the driver to recognize the slowing traffic. The NTSB concludes that salient cues, in the form of slowing traffic in both lanes and illuminated brake lights, were present at the end of the traffic queue to inform the truck driver of the changing traffic conditions and the need to slow his vehicle.

The NTSB did not find evidence to suggest that the truck driver took any evasive action before the crash. No physical evidence suggestive of precrash braking or steering by the truck driver was observed on the roadway at the scene. Although the Freightliner combination vehicle moved slightly to the right before impact, as observed in the video recorded by the witness vehicle, this motion did not appear consistent with an evasive steering response.[67] In addition, analysis of the Freightliner's steering gear indicated a straight-forward orientation at impact.

Although the truck driver told the OSHP that the only thing he remembered about the crash was that he "woke up" and saw the fire outside his truck, he had sufficient sleep opportunity during the previous 3 days and there were no definitive indicators of fatigue. In addition, there was no evidence that the truck driver was impaired. Blood sugar levels postcrash were not indicative of a low or high blood sugar event. Cell phone records showed that the driver was not using native calling or texting applications at the time of the crash. Data use for the truck driver's mobile phone reached high levels just before the crash; however, because the phone was destroyed during the postcrash fire, the NTSB was not able to analyze the contents of the phone's memory to determine if the truck driver had been manipulating the phone to use other applications in the moments before the crash. Therefore, the data from his cell phone were inconclusive regarding driver distraction. However, given the lack of evasive action in response to approaching the recognizable traffic queue, the truck driver was not properly attentive to the forward roadway for several seconds before the crash. The NTSB concludes that the truck driver's lack of evasive action is consistent with being inattentive to the forward roadway, but the reason for his inattention is unknown.

Because the truck driver did not slow his vehicle upon approach to the traffic queue, he struck the last two vehicles in the queue at full highway speed. The slow speed of the traffic queue—3 to 15 mph—compared to that of the Freightliner combination vehicle—about 72 mph—resulted in a considerable speed differential in the collision. Significant differences in mass and bumper height between the Freightliner combination vehicle and the Nissan passenger vehicle were also present. A vehicle moving much faster than the prevailing traffic poses a hazard to other motorists and to the occupants in the slower-moving vehicles, particularly when there

[67] Although illuminated brake lights on the Freightliner combination vehicle were not visible in the video recorded by the witness vehicle, the Freightliner occupied only a small portion of the video frame due to its distance from the witness vehicle; therefore, the observation was inconclusive.

is also a significant weight differential between vehicles. In crashes, the resultant change in velocity of a vehicle and the extremely short time during which that velocity change occurs directly correlates with injury severity. In general, the greater the change in velocity and the shorter the time during which this change in velocity occurs, the greater the injury severity (Parenteau and others 2022). The NTSB concludes that the speed differential between the combination vehicle and the slow-moving traffic queue contributed to the severity of the crash and the resulting injuries.

## 2.3 Traffic Incident Management Guidance

The Etna crash was a secondary crash, meaning that it was an indirect result of another primary crash or incident. The overall prevalence of secondary crashes is unknown, largely due to differences in state crash data collection. A recent FHWA report noted that although the (non-regulatory) Model Minimum Uniform Crash Criteria adopted a new data element and attribute for secondary crashes in 2017, as of 2023 only 18 states had incorporated that attribute into their crash report forms (Pecheux and others 2023).[68] Despite the low reported numbers, secondary crashes are widely acknowledged as a significant safety concern. One study that examined every incident along a 75-mile highway in Virginia over a 1-year period found that a secondary crash occurred on average once every 9.9 crashes and 54 disabled vehicles (Goodall 2017). Another study that examined a 97-mile section of the Florida Turnpike Mainline and a 48-mile Turnpike Extension documented a rate of about 5.7 secondary crashes per mile per year (Alluri and others 2021). The NTSB has investigated numerous secondary crashes caused by commercial vehicles failing to slow in response to an unexpected traffic queue.[69] Specifically, the speed differential between slowed or stopped traffic and a vehicle approaching at highway speed,

[68] (a) The Model Minimum Uniform Crash Criteria (MMUCC) is "a voluntary guideline that represents a minimum, standardized set of data variables to describe motor vehicle traffic crashes, which could be used to identify traffic safety problems and design countermeasures to improve traffic safety…" For more information, see Model Minimum Uniform Crash Criteria | NHTSA. (b) The National Highway Traffic Safety Administration provides financial incentives in the form of grant funding for State Highway Safety Offices to implement state traffic safety information system improvements, including the MMUCC guideline. For more information, see National Highway Traffic Safety Administration: Key Grant Programs | US Department of Transportation.

[69] Relevant NTSB investigations include the following: Greenville, Alabama (HIR-23-05); Phoenix, Arizona (HIR-23-04); Fort Worth, Texas (HIR-23-01); Arlington Township, Wisconsin (HIR-22-03); Elmhurst, Illinois (HAB-20-03); Palm Springs, California (HIR-17-04); Chattanooga, Tennessee (HAR-16-01); Annapolis, Maryland (HAB-14-01); Cranbury, New Jersey (HAR-15-02); Miami, Oklahoma (HAR-10-02); Sulphur Springs, Texas (HAB-08-02); Chelsea, Michigan (HAB-07-01); Hampshire, Illinois (HAR-06-03); Jackson, Tennessee (HAR-02-01); and Sutton, West Virginia (HAR-91-01).

particularly combined with the large mass of a commercial vehicle, can have catastrophic consequences.

### 2.3.1 Incident Classification

As described in section 1.3.3, the FHWA provides significant resources for TIM through the MUTCD, the national TIM responder training program, the TIM handbook, and other websites. Many states, including Ohio, use these resources to develop their own policies, training, and procedures, either directly or with modifications appropriate for their circumstances. Quick and safe clearance of travel lanes is a primary focus of the TIM resources. Clearing an incident as quickly and safely as possible is a critical means of preventing secondary crashes because it reduces the development of traffic queues in response to the initial incident. However, the formation and extent of a queue depends not only on clearance from the travel lane but also on roadway capacity and traffic volume. Even quickly cleared minor incidents can result in extensive traffic queues. In the Etna crash, the initial incident was cleared from the travel lanes within 23 minutes, but the resulting traffic queue lasted well over an hour. In addition, images from the responding officer's body camera showed that the vehicles, including at least one commercial vehicle, although cleared from the travel lanes, were nearly on the solid yellow edge line separating the left lane of travel in the westbound direction from the left paved shoulder, which contributed to queue formation (refer to figure 8). Having the vehicles parked close to the traffic lane is similar to placing construction barriers close to a traffic lane, a strategy often used to slow traffic in work zones. Roadway barriers create the perception that the roadway is narrower and the driving environment more difficult, prompting drivers to increase attention and reduce speed (Shaw and others 2015).

Once a queue forms after an initial incident, informing upstream drivers of the slowdown and reducing upstream travel speed requires coordination from the TMC, which did not occur in the Etna crash. The trooper who responded to the crash indicated that "ODOT was not contacted since all lanes were open." In addition, no end-of-queue protections were deployed. This lack of response was also reflected in Ohio's TIM training, which included guidance that communication with ODOT was advisable for intermediate incidents (duration greater than 30 minutes) and required for major incidents (duration greater than 2 hours) but was neither required nor suggested for minor incidents even if a queue was forming. As demonstrated by the Etna crash, effective communication between responders and transportation agencies is critical for all incidents where a queue has formed, even if the initial incident was minor. This communication enables the TMC to make appropriate traffic control decisions including initiating motorist warnings and/or placing law enforcement or Department of Transportation (DOT) vehicles at the back of the queue to attract oncoming drivers' attention to the end of the queue.

The NTSB concludes that Ohio's policies, training, and procedures for TIM did not require or advise communication between responders and ODOT after minor incidents when vehicles are quickly removed from the travel lane, even if a queue forms; in the Etna, Ohio, crash, this led to a missed opportunity for ODOT to warn drivers approaching the traffic queue after the initial incident.

The TIM procedures implemented in Ohio, based on the definitions provided in the MUTCD, focused on the duration of lane closure as the basis for response magnitude. Per the MUTCD, intermediate traffic incidents "typically *affect* travel lanes for a time period of 30 minutes to 2 hours…" while minor incidents are "typically disabled vehicles and minor crashes that result in lane *closures* of less than 30 minutes" (emphasis added). The distinction between lanes affected and lane closures is important because lanes may be affected for much longer than the actual lane closure or blockage. Even after the original incident is cleared, other factors—such as queue formation, the placement of the disabled vehicles when moved off the roadway, and characteristics of the roadway (such as number of lanes, speed limit, and speed differential)—can affect the traffic.

The NTSB concludes that the Etna, Ohio, crash demonstrates that catastrophic crashes can result when traffic queues form after minor roadway incidents, and the current MUTCD guidance for safely managing minor roadway incidents, which focuses on the duration of lane closures instead of the overall effect on traffic, may create conditions that enable potentially dangerous queues to form. Because the next version of the MUTCD will be subject to a public notice and comment process and will not be published for several years, issuing guidance to the states is critical in the short term. Therefore, the NTSB recommends that the FHWA issue guidance to states to clarify that:

- traffic incident classification (as minor, intermediate, or major) should consider not only the duration of lane closure but also factors such as location of vehicles when moved off the roadway, number of lanes available, queue development, and lanes affected; and

- communications between responding and transportation agencies are critical for all traffic incidents in which a queue has formed or is likely to form.

The NTSB further recommends that the FHWA revise the MUTCD to address traffic queues, including:

- ensuring that all traffic incident classifications (minor, intermediate, and major) are defined using a consistent standard, such as the incident's overall effect on the flow of traffic;
- emphasizing the importance of communications between responding and transportation agencies for all incidents in which a traffic queue has formed or is likely to form; and
- ensuring that traffic queues are monitored and procedures established throughout the TIM to notify road users of the queue.

### 2.3.2 End-of-Queue Protection

In the Etna crash, the truck driver was inattentive for several seconds before the crash and missed salient visual cues that traffic ahead was slowing. However, he was able to generally maintain his vehicle's position within the lane for at least 33 seconds before the collision, based on the video from the witness vehicle traveling behind the Freightliner combination vehicle. This section assesses several types of alerts or warnings that could have been provided to prevent or mitigate the crash at various points between when the traffic queue was forming and when the collision was imminent.

#### 2.3.2.1 Variable Speed Limits

The FHWA promotes the use of VSLs for work zones, inclement weather, congestion, and incident management. When ideal driving conditions are not present, VSLs can incorporate information such as traffic speed, volume, weather, and road surface factors to determine appropriate speeds for improved traffic flow and safety.[70] The FHWA also provides information on implementing intelligent transportation system technologies, including VSLs, in work zones (Schroeder and others 2021). Many of the strategies developed for work zones may also be beneficial for TIM.

For Ohio, the ODOT *Transportation Systems Management and Operations Study Guidebook*, dated April 2020, states that VSLs can be used for congested conditions, including after roadway incidents or hazardous environmental conditions

[70] For more information, see Variable Speed Limits | FHWA.

(ODOT 2020). In September 2024, ODOT informed the NTSB via email that there are three areas in the state where VSLs are implemented. ODOT uses VSLs on Interstate 90 in Lake County during inclement weather, noting that a significant decrease in crashes has occurred in that area after implementing VSLs.[71] ODOT also uses VSLs in conjunction with the opening of an additional lane (the left shoulder) during periods of congestion on Interstate 670 eastbound and Interstate 275 westbound in Cincinnati. However, VSLs were not available in the Etna crash area along I-70. The NTSB concludes that the initial crash and traffic queue formation in Etna, Ohio, created dangerous roadway conditions similar to those that ODOT addresses effectively with VSLs elsewhere in the state, but the crash area on I-70 was not equipped with VSL signage.

Because the truck driver involved in this crash was inattentive, he may not have noticed VSL signage if it had been in place. However, VSLs installed in the crash area could have resulted in the slowing and speed harmonization of approaching traffic as well as an overall reduction in congestion, which could have prevented a significant queue from forming. The witness video suggested that the truck driver was generally following the flow of traffic. Slower speeds of surrounding traffic leading up to the crash location may have influenced him to slow sooner, either preventing the crash or reducing the speed differential that led to its severity.

ODOT has available data about vehicle travel speed and speed differential that could be used to implement a VSL system in the crash area and throughout the state. After the crash, ODOT identified sites for the deployment of queue warning message signs and fixed cameras with analytics in and around major urban centers in Ohio using factors such as traffic congestion and the number and severity of rear-end crashes. In addition, although many states do not currently allow VSLs, Ohio already has the appropriate legislation in place to use them. Therefore, the NTSB recommends that ODOT implement a statewide strategy for the use of VSLs at locations with high congestion, high crash rates, or a high likelihood of queue formation after a traffic incident occurs.

#### 2.3.2.2 In-Cab Digital Alert Technology

Before the crash, ODOT contracted with a third-party company to provide several types of digital alerts, including congestion and dangerous slowdown alerts, to any commercial driver who has both an ELD (or a connected phone logged in with a USDOT number) and the free company application. Although these alerts are

[71] For more information, see ODOT Safety Success: Variable Speed Limits on I-90 in Lake County Produce Significant Decrease in Crashes | Ohio Department of Transportation.

provided free of cost in Ohio (or any state that has a similar contract with the third party), it still requires the driver or fleet manager to install and set up the application to receive the alerts. In addition, although the third-party company informed the NTSB that most ELDs are compatible with its application, the Freightliner combination vehicle in the Etna crash had an ELD that was not compatible. Therefore, the truck driver would not have been able to receive any digital alerts about the earlier crash and upcoming traffic queue, even if these alerts had been sent.

Digital in-cab alerts are considered a type of connected vehicle technology, also known as vehicle-to-everything (V2X). Unlike direct V2X, which relies on direct communication between vehicles as well as between vehicles and infrastructure or other targets, these alerts are sent and received to and from external systems over cellular networks. Because information must pass through an intermediate network before reaching its destination, these systems have an inherent delay but are well-suited to deliver alerts and warnings to drivers about road conditions and hazards that they are likely to encounter in 30–60 seconds.[72] These systems are commercially available today, and because alerts and warnings can be sent to commercial drivers via their ELDs, the technology does not require vehicles to be equipped with native V2X capabilities.[73]

Initial studies have found in-cab alerts to be a viable strategy to inform commercial drivers of upcoming hazards such as unexpected traffic queues. An evaluation of Ohio's in-cab digital alert program used the change in a truck's speed after a driver received the alert as a surrogate for characterizing driver response to alerts, finding that about 20% of trucks lowered their speeds by 5 mph after the alert (Desai and others 2024). Although speed changes were minimal, the results indicate the potential for these technologies to improve driver awareness of an upcoming incident or queue.

In 2023, the FHWA published a fact sheet on in-cab alerts, noting that because of the fairly small sample size obtained to date, the effects of such alerts on driver behavior have been difficult to assess; however, transportation specialists and engineers expect that such alerts will have a positive effect on safety as market penetration of this type of technology increases across different ELD platforms and

[72] See ITS America | Beyond 5.9 Deployment Plan.

[73] The NTSB also advocates for direct V2X technology, which can help prevent rear-end crashes with high speed differentials, such as this crash; however, this technology is not yet widespread. For more details, see NTSB 2023.

commercial fleets.[74] Federal agencies provide resources and funding for states to implement this technology. The FMCSA has a grant program for Innovative Technology Deployment, which can be used by states to deploy work zone and electronic incident notification systems.[75] In addition, federal funding for states to purchase and deploy digital alert technology is included in Section 405(h) of the National Priority Safety Program.[76]

A recent report sponsored by ODOT surveyed 584 commercial drivers in Ohio and 24 large trucking companies, finding that although 88% of the drivers used a commercially available in-cab alert service, only about 50% reported receiving alerts for real-time incidents such as crashes (Kidando and others 2024). Similarly, although 85% of the trucking companies used an alerting service, only about 35% received alerts for real-time incidents. In addition, the NTSB has spoken with multiple motor carriers and has found that many carriers that use compatible ELDs and already contract with the app company for its weigh station bypass service were not aware that in-cab driver alerts were available at no cost through the free company application. Increasing awareness among drivers and motor carriers of in-cab alerts specifically designed to notify drivers of real-time incidents such as dangerous slowdowns and congestion that create upcoming traffic queues would therefore be beneficial. The NTSB concludes that motor carriers, such as the carrier in the Etna, Ohio, crash, may be unaware of the availability and potential safety benefits of in-cab alert technology that warns commercial drivers of impending congestion or traffic queues.

Trade organizations such as the American Trucking Associations, Owner-Operator Independent Drivers Association, American Bus Association, and United Motorcoach Association represent the interests of large and small motor carriers spanning the trucking and bus industries. Along with these organizations, labor associations such as the Amalgamated Transit Union, International Brotherhood of Teamsters, and Transport Workers Union of America can also be instrumental in informing carriers and drivers about in-cab digital alert technology. The NTSB therefore recommends that the American Trucking Associations, Owner-Operator Independent Drivers Association, American Bus Association, United Motorcoach Association, Amalgamated Transit Union, International Brotherhood of Teamsters, and Transport Workers Union of America inform their members about the Etna, Ohio,

[74] Providing In-Cab, Traffic-Related Warning Messages to Commercial Motor Vehicle Drivers | FHWA.

[75] Innovative Technology Deployment Program | FMCSA.

[76] https://www.ecfr.gov/current/title-23/section-1300.27.

crash, and promote the potential safety benefits of in-cab alert technology to encourage owner-operators and carriers to use these systems.

#### 2.3.2.3 Additional Strategies for Widespread Deployment and Communication of End-of-Queue Protections

Comprehensive approaches are essential to effectively provide early warning to drivers approaching traffic queues and reduce the likelihood of secondary crashes. These approaches must include guidance and communication at the federal level that incorporate best practices for states and other stakeholders to deploy VSL signage, digital in-cab alerts, and other proven strategies. The FHWA maintains the Proven Safety Countermeasures, a collection of countermeasures and strategies that are effective in reducing roadway fatalities and serious injuries and that transportation agencies are strongly encouraged to consider for widespread implementation.[77] The Proven Safety Countermeasures promote VSL signage but do not include any other end-of-queue alerting or warning strategies.

Outside of the Proven Safety Countermeasures resource, several innovative approaches are being promoted by the FHWA and individual states. The FHWA disseminates information about new technologies to improve the effectiveness of TIM and promising approaches being used by states through its Every Day Counts initiative and Talking TIM Webinar Series.[78] The FHWA's Next-Generation TIM Technology fact sheet notes that there are a wide range of ways to inform drivers that there is an incident ahead that they should be concerned about—including signs, alerts, and messages that are delivered to drivers visually and audibly, originating from sources inside and outside of the driver's vehicle.[79]

At the state level, Tennessee's "Protect the Queue" program, established in 2013, is a Tennessee DOT initiative that emphasizes the importance of providing advance warning to upstream traffic of a downstream incident to reduce the likelihood of a secondary crash.[80] Indiana has also developed a "Protect the Queue" program in which the state DOT deploys queue warning trucks with message boards, flashers, and digital alerts that can be transmitted to navigation systems such as Waze.[81] An evaluation of the Indiana program found that hard-braking events

[77] For more information, see FHWA | Proven Safety Countermeasures.

[78] (a) Every Day Counts initiative. (b) Talking TIM Webinar Series.

[79] Next-Generation Traffic Incident Management: Technology for Saving Lives (NextGen TIM Tech).

[80] Tennessee | Protect the Queue (tn.gov).

[81] INDOT: Protect the Queue: INDOT's Queue Awareness Program.

decreased about 80% when queue warning trucks were deployed to alert motorists of impending queues (Sakhare and others 2021).

A recent National Academies report summarized the state of the practice for providing drivers with dynamic information that can be frequently updated based on real-time conditions, including deployments such as multipurpose overhead lane use control signs, dynamic speed limits, and dynamic queue warnings (National Academies of Sciences, Engineering, and Medicine 2021). The report also provides guidance on how to use alternative media, such as in-vehicle displays and smartphone applications, to disseminate messages in combination with more traditional infrastructure-based strategies such as roadside signs.

The NTSB concludes that although the FHWA plays an active role in disseminating information about successful state strategies and advanced technologies to warn drivers about upcoming traffic queues—such as in-cab alerts, queue warning trucks, and dynamic message signs—most of this information is absent from its Proven Safety Countermeasures publication, which may limit the opportunity for states and other stakeholders to adopt these strategies and technologies.

The FHWA has an established process for determining how countermeasures are incorporated and presented in its publication. The process would likely include consideration of the projected safety benefits that different end-of-queue warning strategies may provide, such as improvements in driver performance, crash mitigation, or crash prevention. Because of the importance of providing early warning to drivers approaching traffic queues, especially on high-speed, limited-access roadways such as I-70, and because this type of countermeasure is largely absent from the published collection of approaches, the NTSB recommends that the FHWA update its Proven Safety Countermeasures publication to incorporate end-of-queue protections as well as effective communication strategies to provide advance warning to drivers approaching the end of a traffic queue, especially on freeways and highways.

## 2.4 Driver Inattention

In this crash, the NTSB found that the truck driver was inattentive to the forward roadway, as evidenced by the lack of braking or evasive maneuver before impact. (see section 2.2). Driver inattention can be defined as insufficient or no attention to activities critical for safe driving (Regan and others 2011). High rates of data transfer on the truck driver's cell phone suggest the possibility that the phone could have been in use and a distracting factor near the time of the crash, though ultimately this was inconclusive. During a previous roadside inspection, the truck driver had been found with a video game open on his phone. Naturalistic driving data show that drivers who more frequently engage in secondary tasks are more likely to be involved in inattention-related crashes or near-crashes (Klauer and others 2006).

Three distinct periods can be identified as opportunities to correct errant CMV driver behavior before a CMV reaches a hazard that may require an emergency response: (1) the days, weeks, or months before a potential crash event, (2) minutes before a hazard is reached, and (3) when a crash is imminent. The three periods are addressed by different technologies and mitigation strategies. Section 2.3 discussed methods to alert upstream drivers of unexpected slowdowns and traffic queues in the minutes before a potential crash. This section describes vehicle technologies designed to prevent driver distraction and inattention, which can help correct driver behavior in the days, weeks, or months before a potential crash event, as well as ADAS designed to prevent imminent rear-end crashes.

### 2.4.1 Driver Monitoring

DMSs are designed to alert a distracted or inattentive driver to return their attention to the roadway. These systems can use interior cameras to detect if the driver's eyes are off the road and can use vehicle-based sensors to infer distraction or inattention through driving performance metrics such as ride smoothness, lane-keeping, speed, and steering behavior. DMSs are also designed to address fatigue and other impairments (such as from alcohol and other drugs). Although varying in execution, many commonly available DMSs for CMVs provide instantaneous alerts to drivers when the system detects an unsafe behavior and notify carriers when a behavior is repeated to facilitate coaching or other corrective action to improve future driver performance.

DMSs have been studied in commercial vehicles for more than 15 years. In 2009, the FMCSA began a field operational test to determine whether an onboard monitoring system reduced at-risk behavior among CMV drivers and improved driver safety performance.[82] The NTSB subsequently issued Safety Recommendation H-12-14, which asked the FMCSA to determine whether the results of field operational tests for onboard monitoring systems indicated that such systems would

[82] The FMCSA defines onboard monitoring systems as hardware/software suites that allow for (1) online measurement of a set of unsafe driving behaviors, (2) real-time performance feedback to the driver, and (3) "roll-up" reports of driver behaviors for use by motor carriers for a "delayed discussion with the driver." Driving behaviors that may be monitored include top speeds, sharp vehicle decelerations (that is, hard braking), and lateral accelerations (indicative of speed on curves). For more information, see FMCSA 2007.

reduce accidents or injuries, and if so, to require carriers to use these systems. Although the FMCSA reported that the data did not support a cost/benefit analysis, the field operational test did suggest that onboard monitoring helped to reduce critical event rates, and the effectiveness improved with driver coaching. Safety Recommendation H-12-14 was classified Closed–Acceptable Action in 2017.

The NTSB has also found benefits associated with onboard video event recorders that can improve investigative data collection and provide motor carriers with information about risky driver behavior during recorded events to improve driver coaching and discipline. As a result of our investigation of the January 5, 2020, multivehicle collision in Mt. Pleasant Township, Pennsylvania, the NTSB found that if onboard video EDR systems were available on all CMVs, these systems—combined with a driver management or coaching program—could be used proactively by motor carriers to aid in driver training and address driver behaviors that have been associated with crash risks (NTSB 2022). As a result, the NTSB issued Safety Recommendation H-22-3 to the National Highway Traffic Safety Administration (NHTSA) to require onboard video event recorders that record data associated with a crash event, as well as H-22-4 to the FMCSA to provide guidance to motor carriers to proactively use onboard video event recorder information to aid in driver training and ensure driver compliance with regulatory rules essential for safe operation. Safety Recommendation H-22-3 is currently classified Open—Unacceptable Response, due to NHTSA's lack of action. In addition, because the FMCSA's delay in providing guidance on proactive driver coaching using onboard recording systems is unnecessary, given the known benefits of coaching and driver feedback, Safety Recommendation H-22-4 was reiterated and classified Open—Unacceptable Response in 2025, as a result of the NTSB's Highland, Illinois, investigation (NTSB 2025).

Onboard video event recorder systems, although instrumental for driver training, do not necessarily provide real-time feedback to a driver whose attention has been diverted from the driving task, as occurred in the Etna crash. DMSs that provide real-time performance feedback to drivers to return their attention to the roadway are becoming more widespread. Commercially available third-party systems can now be retrofitted into existing vehicles (Michelaraki and others 2023). Studies of the effectiveness of DMSs for CMVs have found that the combination of real-time alerts and timely coaching from a supervisor significantly contributes to a reduction in harsh braking and speeding incidents (Mase and others 2020, Hickman and Hanowski 2011, Bell and others 2017).

As of July 2024, the European Union requires newly manufactured vehicles—including trucks and buses—to be equipped with advanced driver distraction warning systems.[83] These systems cover a specific downward vision area—including the driver's lap, passenger footwell, and center console—and the driver's attention is considered distracted if their gaze is fixed on this area for a prolonged period (more than 6 seconds at speeds between 20 and 50 km/h and more than 3.5 seconds at speeds above 50 km/h). The system must provide a visual warning plus an acoustic and/or haptic warning whenever driver distraction is detected. The European New Car Assessment Programme (Euro NCAP) also evaluates driver monitoring in new vehicles and recently updated its evaluation protocol.[84]

The Freightliner combination vehicle involved in the Etna crash was not equipped with a DMS. The truck driver failed to respond to observable, changing traffic conditions ahead of his vehicle, which suggests that his attention was not directed to the forward roadway when he needed to identify the hazard of a slow-moving traffic queue. A multimodal warning, such as that mandated by the European Union, could have been effective in returning the truck driver's attention to the roadway. Researchers reported faster response times to sudden events when drivers were alerted by multimodal signals, such as auditory/visual or auditory/haptic, rather than a single sensory cue (Ho and others 2007). In addition to instantaneous alerts, timely coaching from the motor carrier based on previously recorded episodes of driver distraction may have addressed a developing behavioral issue long before the truck driver encountered the traffic queue on November 14, 2023.

The NTSB concludes that if the Freightliner combination vehicle had been equipped with a DMS designed to return a driver's attention to the roadway, it could have alerted the inattentive truck driver to the traffic queue and increased the likelihood that the crash would have been avoided or mitigated.

The NTSB therefore recommends that NHTSA, for all commercial vehicles with gross vehicle weight ratings greater than 10,000 pounds, require DMSs that detect risky driving behavior, including but not limited to driver inattention, and that provide instantaneous feedback that communicates to the driver through multimodal signaling the need to bring attention back to the driving task.

### 2.4.2 Forward Collision Avoidance Systems

Forward collision avoidance systems—including forward collision warning (FCW) and automatic emergency braking (AEB)—may also have helped mitigate this

[83] For more information, see the European Union Regulation 2019/2144.

[84] For more information, see Euro NCAP Safe Driving Driver Engagement Protocol.

crash. These systems represent the last opportunity for intervention when a driver faces a situation that would otherwise be crash-imminent. FCW and AEB use radar, cameras, and lidar (light detection and ranging) sensors to monitor the forward environment for potential conflicts that could lead to a crash, such as slow-moving or stopped vehicles. When the system detects a conflict, FCW provides a warning to the driver and AEB applies vehicle braking if the driver does not take appropriate action.

The NTSB has a long history of investigating rear-end collisions that could have been prevented or mitigated by collision avoidance technologies. For more than 24 years, we have issued recommendations to NHTSA related to collision warning systems in commercial trucks and buses to help mitigate or avoid crashes. In 2001, we published a special investigation report examining vehicle- and infrastructure-based technology designed to prevent rear-end collisions (NTSB 2001). In that report, we issued Safety Recommendation H-01-6 to the USDOT to complete rulemaking on adaptive cruise control and collision warning system performance standards for new commercial vehicles. In a 2015 special investigation report, we examined the current state of collision avoidance technologies for preventing rear-end crashes and concluded that these technologies were mature and effective in reducing such crashes (NTSB 2015a). In that report, we 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)

Safety Recommendation H-15-5 has been reiterated six times and is currently classified Open—Unacceptable Response because NHTSA has not required collision avoidance systems in commercial vehicles.[85]

The real-world benefits of these systems in commercial vehicles have been demonstrated. A study by the Insurance Institute for Highway Safety found a 22% reduction in rear-end crashes per mile traveled in trucks equipped with FCW, and this technology provided only a warning when a crash was imminent. An even greater safety improvement of 41% was achieved with AEB, which actively applies braking to avoid rear-end collisions (Teoh 2021). In the European Union, AEB technology is

[85] H-15-5 superseded H-01-6 and has since been reiterated as a result of the following NTSB investigations: Cranbury, New Jersey (HAR-15-02); San Jose, California (HAR-17-01); Palm Springs, California (HAR-17-04); Mount Pleasant, Pennsylvania (HIR-22-01); Phoenix, Arizona (HIR-23-04); and Williamsburg, Virginia (HIR-24-05).

available and, since 2015, required on new trucks. In 2024, Euro NCAP began rating crash avoidance technologies on trucks.[86]

In 2023, NHTSA and the FMCSA announced a joint notice of proposed rulemaking to require AEB in heavy vehicles.[87] The proposal would require complete avoidance of rear-impact crashes at travel speeds up to about 50 mph without concurrent manual brake application by the driver and up to 62 mph with manual braking application. These test speeds were set, in part, due to testing practicability concerns at higher speeds. NHTSA's proposal also includes performance requirements for the system to continue to function at speeds greater than the proposed test speeds. The NTSB supports the proposed rulemaking and urges NHTSA and the FMCSA to expeditiously implement the rule, because only a regulation will ensure that new heavy vehicles are equipped with AEB systems as standard equipment.[88] Although NHTSA recently promulgated a final rule requiring AEB in passenger vehicles, neither NHTSA nor FMCSA have yet completed the rulemaking for trucks and other heavy vehicles.[89]

The combination vehicle in the Etna crash was traveling above NHTSA's proposed test speed for conditions without manual braking (about 70 mph versus 50 mph in the NHTSA test), and the speed differential was also above proposed test conditions (about a 55-mph differential versus 37-mph in the NHTSA test). Thus, an AEB system designed to NHTSA's proposed standards may not have been able to fully prevent the crash. The system would have provided, at minimum, an additional alert (FCW) to the driver that a crash was imminent, affording him another opportunity to return his attention to the roadway and initiate an evasive response. In addition, the AEB may have been able to slow the vehicle and lessen the severity of the crash.

The combination vehicle involved in this crash was not purchased with available collision avoidance systems. Because no federal regulation requires trucks to have collision mitigation systems, manufacturers are voluntarily installing these systems on their vehicles; however, customers can still opt out during the ordering process (even if that technology is offered as "standard" by the manufacturer), as

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[86] For more information, see Euro NCAP | Launch of the brand-new Euro NCAP TRUCK SAFE assessment programme.

[87] For more information, see Automatic Emergency Braking Test Devices: Heavy Vehicle Automatic Emergency Braking.

[88] For more information, see the NTSB's response to the rulemaking.

[89] Federal Motor Vehicle Safety Standards; Automatic Emergency Braking Systems for Light Vehicles.

occurred here. The NTSB examined this issue in our investigations of a 2018 crash that occurred in Boise, Idaho, and a 2022 crash that occurred in Williamsburg, Virginia (NTSB 2020 and 2024). In the Williamsburg investigation, we found that because commercial vehicle customers can choose not to purchase collision avoidance systems even when marketed by manufacturers as standard equipment, federal requirements are necessary to increase widespread deployment of this technology.

In the Etna crash, we similarly identified that the crash-involved truck-tractor was not equipped with ADAS including FCW or AEB despite those systems being marketed by Daimler as standard equipment. Unlike passenger vehicles being purchased at a car lot, commercial vehicles are exclusively sold using a customizable ordering system. Any systems not required by federal regulation (such as collision avoidance technology) could therefore be omitted during the ordering process. The motor carrier in the Etna crash, Mid-State Systems, leased vehicles from a leasing company, Maplewood Leasing, which ordered new vehicles annually using the same two dealerships and the same specification order sheets, which had not been updated or modified to include any of the latest collision avoidance technologies. The Etna crash demonstrates, again, that although some heavy vehicle manufacturers, such as Daimler, are providing these and other ADAS for purchase, only a federal motor vehicle safety standard can guarantee that the systems are installed on all new trucks.

The NTSB concludes that collision avoidance technology, such as forward collision avoidance systems on commercial vehicles, can help prevent or mitigate rear-end crashes into slow-moving traffic queues, as in the Etna, Ohio, crash, by alerting drivers to slowed traffic ahead or automatically applying brakes to reduce crash severity. Because the Etna, Ohio, crash is another example of a rear-end crash that could have been mitigated if collision avoidance systems were required on all commercial vehicles, the NTSB reiterates H-15-5 to NHTSA.

Trucking and bus trade and labor associations can also play a critical role in raising awareness among motor carriers and drivers about the importance of purchasing ADAS, even if the option to forgo these technologies is provided. The NTSB recommends that the American Trucking Associations, Owner-Operator Independent Drivers Association, American Bus Association, United Motorcoach Association, Amalgamated Transit Union, International Brotherhood of Teamsters, and Transport Workers Union of America inform their members about the Etna, Ohio, crash; the safety benefits of collision avoidance technologies including FCW, AEB, and DMSs; and the safety risks associated with opting out of purchasing the ADAS, including FCW and AEB, offered by heavy vehicle manufacturers.

## 2.5 Postcrash Fire and Motorcoach Egress and Safety

The Etna crash involved a postcrash fire that consumed the Freightliner combination vehicle, the Nissan, and the rear of the motorcoach. By the time the fire was extinguished by first responders, it had spread forward from the Freightliner combination vehicle and the Nissan into the rear of the motorcoach and forward to row 8. Two of the fatally injured motorcoach occupants, who were seated in the last two rows, could not be removed from the motorcoach until the fire was extinguished. Responders had entered the front of the motorcoach to search for surviving victims, but the crew only made it to row 9 before being pushed back by a wall of fire and high-heat conditions. Although both deceased occupants had evidence of soot/smoke in their airways, the elevated carboxyhemoglobin levels were below those associated with fatal or serious smoke inhalation injury (Goldstein 2008). These occupants, who were within the impact zone, also sustained blunt force trauma from the crash due to significant impact forces, intrusion, and the displacement of seats in row 15.[90]

Although all surviving occupants were able to be evacuated within about 4 minutes, one student sustained first-degree burns. This student was originally seated in the right window seat of row 10 but was walking to the lavatory and attempting to open the door when the impact occurred. Thus, the NTSB concludes that the postcrash fire and smoke that spread into the interior of the motorcoach prevented two passengers from being extricated and contributed to the severity of injuries for at least one passenger.

Federal Motor Vehicle Safety Standard (FMVSS) 302 addresses the burn resistance requirements for materials in all motor vehicles. The standard also addresses vehicle fires originating in the interior of the vehicle from sources such as matches or cigarettes. The NTSB has been concerned about motorcoach and bus interior material flammability and smoke emission standards for nearly 50 years, and we have issued multiple safety recommendations to NHTSA to improve FMVSS 302. In response to the first of these, Safety Recommendation H-75-13 (which was ultimately classified Closed—Reconsidered), NHTSA stated that the intent of FMVSS 302 was not to fireproof an interior or to be a countermeasure against a fuel-initiated

[90] NHTSA has shown significant safety benefits from the use of passenger lap/shoulder belts in preventing injuries and ejections from vehicles, even in rear-impact collisions such as the motorcoach in this crash, leading to the changes to FMVSS 208 to require such systems. However, there is limited information on the effectiveness of passenger lap/shoulder belts in mitigating injuries for passengers seated within the area of significant intrusion resulting in loss of survival space. For more information, see NHTSA's 2010 notice of proposed rulemaking, Federal Motor Vehicle Safety Standards; Motorcoach Definition; Occupant Crash Protection, and the NTSB's response.

fire, but rather to address small vehicle fires originating in the interior of the vehicle from sources such as matches or cigarettes and require a burn rate low enough to provide occupants with enough time to evacuate the vehicle.

Following a 2005 NTSB investigation of a motorcoach fire in Wilmer, Texas, NHTSA sponsored research by the National Institute of Standards and Technology (NIST) to support NHTSA's effort to improve motorcoach fire safety (NTSB 2007). The flammability testing conducted by NIST on a set of materials taken from used motorcoaches was designed to assess how motorcoach interior materials perform beyond what is normally required by FMVSS 302 (Johnsson and Yang 2012). Representative interior materials were selected from seat, wall, and ceiling constructions because these materials constitute the bulk of the contents in interior compartments of motorcoaches. Testing results showed that except for the interior wall panel, all components (parcel rack doors, seat fronts, and seat backs) failed comparable standards for the same material class established by both the Federal Aviation Administration for aircraft and Federal Railroad Administration for trains.[91]

In the NTSB's investigation of a 2014 crash that occurred in Orland, California, we found that FMVSS 302 does not adequately account for modern vehicle interior components or conditions experienced in real-world vehicle fires, nor does it include specific fire-resistant material standards appropriate for large commercial vehicles with increased passenger capacity (NTSB 2015b). As a result, we issued Safety Recommendation H-15-12 to NHTSA:

> Revise Federal Motor Vehicle Safety Standard 302 to adopt the more rigorous performance standards for interior flammability and smoke emissions characteristics already in use throughout the US Department of Transportation for commercial aviation and rail passenger transportation.

Safety Recommendation H-15-12 was classified Open—Acceptable Response in 2017 based on NHTSA's ongoing efforts to evaluate flammability standards in other transportation modes and research the flammability and smoke emissions characteristics of vehicle interior materials. Although NHTSA has since completed research to develop alternative methodology for evaluating the flammability of materials in vehicles, no changes have been made to existing regulations (Huczek and others 2021). Because the Etna crash is another example of a postcrash fire on a high-occupancy passenger vehicle that demonstrates the need for improvements to flammability requirements for motorcoaches or other vehicle interiors, and because

[91] See 14 *CFR* 25.853 and 49 *CFR* 238.103.

of NHTSA's lack of progress in addressing this safety issue, the NTSB reiterates Safety Recommendation H-15-12 to NHTSA and classifies the recommendation Open—Unacceptable Response.

In addition to lacking protections against interior flammability, the 2009 motorcoach also was not equipped with lap/shoulder belts in its passenger seating positions. The Tuscarawas Valley Local School District (TVLSD) improved its transportation selection process after the crash occurred and plans to consult the Ohio School Bus Safety Working Group report in the future. However, although the Ohio School Bus Safety Working Group report encourages the selection of commercial charter bus services that have a 10-to-12-year average age for their fleets and that have other safety features, it does not direct the hiring of transportation providers that have buses equipped with passenger seat belts.[92] The NTSB has previously emphasized the safety benefits of properly worn lap/shoulder belts for all motorcoach passengers (NTSB 2015b and 1999). The NTSB concludes that selecting transportation operators that provide motorcoaches and other large buses equipped with passenger lap/shoulder belts in all seating positions and requiring the use of those belts enables school districts, such as the TVLSD, to provide the maximum safety benefit to students. Therefore, the NTSB recommends that the TVLSD update its process for chartering motorcoach or other large bus transportation to prioritize the selection of operators that provide and require the use of lap/shoulder belts for all seating positions.

[92] As noted previously, FMVSS No. 208 was amended in 2016 to require lap/shoulder belts in all seating positions on all newly manufactured over-the-road buses and other buses with a gross vehicle weight rating greater than 26,000 pounds, excluding school buses and several other bus types. This report refers to these vehicles when discussing motorcoaches and other large buses. Vehicles that were manufactured before the 2016 amendment, including the crash-involved motorcoach, are not required to have lap/shoulder belts in all seating positions.

# 3 Conclusions

## 3.1 Findings

1. None of the following were factors in the crash: (1) weather and visibility; (2) mechanical condition of the vehicles; (3) truck driver licensing, experience, familiarity with vehicle and route, health, and alcohol or other drug use; (4) truck driver fatigue; and (5) roadway design.

2. The emergency response was timely and adequate.

3. Salient cues, in the form of slowing traffic in both lanes and illuminated brake lights, were present at the end of the traffic queue to inform the truck driver of the changing traffic conditions and the need to slow his vehicle.

4. The truck driver's lack of evasive action is consistent with being inattentive to the forward roadway, but the reason for his inattention is unknown.

5. The speed differential between the combination vehicle and the slow-moving traffic queue contributed to the severity of the crash and the resulting injuries.

6. Ohio's policies, training, and procedures for traffic incident management did not require or advise communication between responders and the Ohio Department of Transportation (ODOT) after minor incidents when vehicles are quickly removed from the travel lane, even if a queue forms; in the Etna, Ohio, crash, this led to a missed opportunity for ODOT to warn drivers approaching the traffic queue after the initial incident.

7. The Etna, Ohio, crash demonstrates that catastrophic crashes can result when traffic queues form after minor roadway incidents, and the current *Manual on Uniform Traffic Control Devices for Streets and Highways* guidance for safely managing minor roadway incidents, which focuses on the duration of lane closures instead of the overall effect on traffic, may create conditions that enable potentially dangerous queues to form.

8. The initial crash and traffic queue formation in Etna, Ohio, created dangerous roadway conditions similar to those that the Ohio Department of Transportation addresses effectively with variable speed limits (VSL) elsewhere in the state, but the crash area on Interstate 70 was not equipped with VSL signage.

9. Motor carriers, such as the carrier in the Etna, Ohio, crash, may be unaware of the availability and potential safety benefits of in-cab alert technology that warns commercial drivers of impending congestion or traffic queues.

10. Although the Federal Highway Administration plays an active role in disseminating information about successful state strategies and advanced technologies to warn drivers about upcoming traffic queues—such as in-cab alerts, queue warning trucks, and dynamic message signs—most of this information is absent from its Proven Safety Countermeasures publication, which may limit the opportunity for states and other stakeholders to adopt these strategies and technologies.

11. If the Freightliner combination vehicle had been equipped with a driver monitoring system designed to return a driver's attention to the roadway, it could have alerted the inattentive truck driver to the traffic queue and increased the likelihood that the crash would have been avoided or mitigated.

12. Collision avoidance technology, such as forward collision avoidance systems on commercial vehicles, can help prevent or mitigate rear-end crashes into slow-moving traffic queues, as in the Etna, Ohio, crash, by alerting drivers to slowed traffic ahead or automatically applying brakes to reduce crash severity.

13. The postcrash fire and smoke that spread into the interior of the motorcoach prevented two passengers from being extricated and contributed to the severity of injuries for at least one passenger.

14. Selecting transportation operators that provide motorcoaches and other large buses equipped with passenger lap/shoulder belts in all seating positions and requiring the use of those belts enables school districts, such as the Tuscarawas Valley Local School District, to provide the maximum safety benefit to students.

## 3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of the Etna, Ohio, crash was the truck driver's inattention and failure to respond, for unknown reasons, to the visibly slow-moving vehicles, including a motorcoach, at the end of a traffic queue caused by an earlier minor crash. Contributing to the crash was the lack of adequate strategies to monitor the development of the traffic queue on Interstate 70 after a minor incident and to inform travelers of the traffic conditions ahead. Also contributing to the crash was the lack of an in-vehicle driver monitoring system to return the truck driver's attention to the forward roadway. Contributing to the severity of the crash and occupant injuries were the speed differential between the combination vehicle and the slow-moving traffic queue and the postcrash fire.

# 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 Federal Highway Administration:**

Issue guidance to states to clarify that:

- traffic incident classification (as minor, intermediate, or major) should consider not only the duration of lane closure but also factors such as location of vehicles when moved off the roadway, number of lanes available, queue development, and lanes affected; and
- communications between responding and transportation agencies are critical for all traffic incidents in which a queue has formed or is likely to form. (H-25-17)

Revise your *Manual on Uniform Traffic Control Devices for Streets and Highways* to address traffic queues, including:

- ensuring that all traffic incident classifications (minor, intermediate, and major) are defined using a consistent standard, such as the incident's overall effect on the flow of traffic;
- emphasizing the importance of communications between responding and transportation agencies for all incidents in which a traffic queue has formed or is likely to form; and
- ensuring that traffic queues are monitored and procedures established throughout the traffic incident management to notify road users of the queue. (H-25-18)

Update your Proven Safety Countermeasures publication to incorporate end-of-queue protections as well as effective communication strategies to provide advance warning to drivers approaching the end of a traffic queue, especially on freeways and highways. (H-25-19)

**To the National Highway Traffic Safety Administration:**

For all commercial vehicles with gross vehicle weight ratings greater than 10,000 pounds, require driver monitoring systems that detect risky driving behavior, including but not limited to driver inattention, and that provide instantaneous feedback that communicates to the driver through multimodal signaling the need to bring attention back to the driving task. (H-25-20)

**To the Ohio Department of Transportation:**

Implement a statewide strategy for the use of variable speed limits at locations with high congestion, high crash rates, or a high likelihood of queue formation after a traffic incident occurs. (H-25-21)

**To the American Trucking Associations, Owner-Operator Independent Drivers Association, American Bus Association, United Motorcoach Association, Amalgamated Transit Union, International Brotherhood of Teamsters, and Transport Workers Union of America:**

Inform your members about the Etna, Ohio, crash, and promote the potential safety benefits of in-cab alert technology to encourage owner-operators and carriers to use these systems. (H-25-22)

Inform your members about the Etna, Ohio, crash; the safety benefits of collision avoidance technologies including forward collision warning (FCW), automatic emergency braking (AEB), and driver monitoring systems; and the safety risks associated with opting out of purchasing the advanced driver assistance systems, including FCW and AEB, offered by heavy vehicle manufacturers. (H-25-23)

**To the Tuscarawas Valley Local School District:**

Update your process for chartering motorcoach or other large bus transportation to prioritize the selection of operators that provide and require the use of lap/shoulder belts for all seating positions. (H-25-24)

## 4.2 Previously Issued Recommendation Reiterated in This Report

The National Transportation Safety Board reiterates the following safety recommendation.

**To 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)
>
> Safety Recommendation H-15-5 is reiterated in section 2.4.2 of this report.

## 4.3 Previously Issued Recommendation Classified and Reiterated in This Report

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

**To National Highway Traffic Safety Administration:**

> Revise Federal Motor Vehicle Safety Standard 302 to adopt the more rigorous performance standards for interior flammability and smoke emissions characteristics already in use throughout the US Department of Transportation for commercial aviation and rail passenger transportation. (H-15-12)

Safety Recommendation H-15-12 is reiterated in section 2.5 of this report. Its classification is changed from Open—Acceptable Response to Open—Unacceptable Response.

**BY THE NATIONAL TRANSPORTATION SAFETY BOARD**

JENNIFER HOMENDY
Chairwoman

MICHAEL GRAHAM
Member

THOMAS CHAPMAN
Member

J. TODD INMAN
Member

**Report Date: September 3, 2025**

# Appendixes

## Appendix A: Investigation

The National Transportation Safety Board (NTSB) received notification of the Etna, Ohio, crash on November 14, 2023, 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 team included staff from the NTSB's Transportation Disaster Assistance Division and the Office of Safety Recommendations and Communications. Chairwoman Jennifer Homendy was the board member on scene. The NTSB's Office of Research and Engineering participated in the investigation.

The Federal Motor Carrier Safety Administration, the Ohio State Highway Patrol, the Ohio Department of Transportation, the Public Utilities Commission of Ohio, and Daimler Trucks North America LLC 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 Federal Highway Administration:**

**H-25-17**

Issue guidance to states to clarify that:

- traffic incident classification (as minor, intermediate, or major) should consider not only the duration of lane closure but also factors such as location of vehicles when moved off the roadway, number of lanes available, queue development, and lanes affected; and
- communications between responding and transportation agencies are critical for all traffic incidents in which a queue has formed or is likely to form.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.3.1, Incident Classification. Information supporting (b)(1) and (b)(2) can be found on pages 49–50; (b)(3) is not applicable.

**H-25-18**

Revise your *Manual on Uniform Traffic Control Devices for Streets and Highways* to address traffic queues, including:

- ensuring that all traffic incident classifications (minor, intermediate, and major) are defined using a consistent standard, such as the incident's overall effect on the flow of traffic;
- emphasizing the importance of communications between responding and transportation agencies for all incidents in which a traffic queue has formed or is likely to form; and
- ensuring that traffic queues are monitored and procedures established throughout the traffic incident management to notify road users of the queue.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.3.1, Incident Classification. Information supporting (b)(1) and (b)(2) can be found on pages 49–50; (b)(3) is not applicable.

**H-25-19**

Update your Proven Safety Countermeasures publication to incorporate end-of-queue protections as well as effective communication strategies to provide advance warning to drivers approaching the end of a traffic queue, especially on freeways and highways.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.3.2.3, Additional Strategies for Widespread Deployment and Communication of End-of-Queue Protections. Information supporting (b)(1) and (b)(2) can be found on pages 55–56; (b)(3) is not applicable.

**To the National Highway Traffic Safety Administration:**

**H-25-20**

For all commercial vehicles with gross vehicle weight ratings greater than 10,000 pounds, require driver monitoring systems that detect risky driving behavior, including but not limited to driver inattention, and that provide instantaneous feedback that communicates to the driver through multimodal signaling the need to bring attention back to the driving task.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.4.1, Driver Monitoring. Information supporting (b)(1) and (b)(2) can be found on pages 57-59; (b)(3) is not applicable.

**To the Ohio Department of Transportation:**

**H-25-21**

Implement a statewide strategy for the use of variable speed limits at locations with high congestion, high crash rates, or a high likelihood of queue formation after a traffic incident occurs.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.3.2.1, Variable Speed Limits. Information supporting (b)(1) and (b)(2) can be found on pages 51–52; (b)(3) is not applicable.

**To the American Trucking Associations, Owner-Operator Independent Drivers Association, American Bus Association, United Motorcoach Association, Amalgamated Transit Union, International Brotherhood of Teamsters, and Transport Workers Union of America:**

**H-25-22**

Inform your members about the Etna, Ohio, crash, and promote the potential safety benefits of in-cab alert technology to encourage owner-operators and carriers to use these systems.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.3.2.2, In-Cab Digital Alert Technology. Information supporting (b)(1) and (b)(2) can be found on pages 52–54; (b)(3) is not applicable.

**H-25-23**

Inform your members about the Etna, Ohio, crash; the safety benefits of collision avoidance technologies including forward collision warning (FCW), automatic emergency braking (AEB), and driver monitoring systems; and the safety risks associated with opting out of purchasing the advanced driver assistance systems, including FCW and AEB, offered by heavy vehicle manufacturers.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.4.2, Forward Collision Avoidance Systems. Information supporting (b)(1) and (b)(2) can be found on pages 59-62; (b)(3) is not applicable.

**To the Tuscarawas Valley Local School District:**

**H-25-24**

Update your process for chartering motorcoach and other large bus transportation to prioritize the selection of operators that provide and require the use of lap/shoulder belts for all seating positions.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.5, Postcrash Fire and Motorcoach Egress and Safety. Information supporting (b)(1) and (b)(2) can be found on page 65; (b)(3) is not applicable.

# References

AASHTO (American Association of State Highway and Transportation Officials). 2018. *A Policy on Geometric Design of Highways and Streets*. 7th Edition. Washington, DC: AASHTO.

Alluri, P., T. Sando, A. Kitali, D. Monyo, and H. Wang. 2021. *Strategies to Identify and Mitigate Secondary Crashes Using Real-Time Traffic Data on Florida's Turnpike System*. Florida Department of Transportation Contract No. BDV29-977-48. May 2021.

Bell, J. L., M. A. Taylor, G. Chen, R. D. Kirk, and E. R. Leatherman. 2017. "Evaluation of an in-vehicle monitoring system (IVMS) to reduce risky driving behaviors in commercial drivers: Comparison of in-cab warning lights and supervisory coaching with videos of driving behavior." *Journal of Safety Research* 60: 125-136.

CVSA (Commercial Vehicle Safety Alliance). 2025. *Inspection Bulletin: North American Standard Inspection Program*. *2022-04 – Passenger Carrier Vehicle Emergency Exit Inspection*. Revised May 2025.

Desai, J., J. K. Mathew, and D. M. Bullock. 2024. "Quantifying the impact of in-cab alerts on truck speed reductions in Ohio." *Journal of Transportation Technologies* 14 (3): 273–288. July 2024.

FHWA (Federal Highway Administration). 2023. *Manual on Uniform Traffic Control Devices for Streets and Highways, 11th Edition*. Washington, DC: FHWA.

_____. 2010. *Traffic Incident Management Handbook*. Report No. FHWA-HOP-10-013. Washington, DC: FHWA.

FMCSA (Federal Motor Carrier Safety Administration). 2007. *Onboard Monitoring and Reporting for Commercial Motor Vehicle Safety*. Publication No. FMCSA-RRR-07-011. Washington, DC: FMCSA.

Goldstein, M. 2008. "Carbon monoxide poisoning." *Journal of Emergency Nursing* 34 (6): 538–542. December 2008.

Goodall, N. J. 2017. "Probability of secondary crash occurrence on freeways with the use of private-sector speed data." *Transportation Research Record: Journal of the Transportation Research Board* 2635 (1): 11–18. January 2017.

Hickman, J. S. and R. J. Hanowski. 2011. "Use of a video monitoring approach to reduce at-risk driving behaviors in commercial vehicle operations." *Transportation Research Part F: Traffic Psychology and Behaviour* 14 (3): 189-198. May 2011.

Ho, C., N. Reed, and C. Spence. 2007. "Multisensory in-car warning signals for collision avoidance." *Human Factors* 49 (6): 1107–1114. December 2007.

Huczek, J., M. Janssens, S. Cabiness, K. Friedman, G. Mattos, and R. Stephenson. 2021. *Potential Alternative Methodology for Evaluating Flammability of Interior Automotive Materials*. Report Number DOT HS 812 091. Washington, DC: NHTSA (National Highway Traffic Safety Administration).

Johnsson, E., and J. Yang. 2012. *Motorcoach Flammability Project Final Report: Tire Fires – Passenger Compartment Penetration, Tenability, Mitigation, and Material Performance*. Technical Note 1705. Gaithersburg, MD: National Institute of Standards and Technology.

Kidando, E., A. Kitali, M. Jalayer, P. Kalambay, J. L'Amoreaux, A. Ibrahim, M. Mihayo, A. Ngereza, D. Patel, and M. S. Islam. 2024. *Determining the Effectiveness of Commercial Vehicle Safety Alerts: Final Report*. Prepared for ODOT (Ohio Department of Transportation) Office of Statewide Planning & Research. Project ID Number: 118084. September 2024.

Klauer, S. G., T. A. Dingus, V. L. Neale, J. D. Sudweeks, and D. J. Ramsey. 2006. *The Impact of Driver Inattention on Near-Crash/Crash Risk: An Analysis Using the 100-car Naturalistic Driving Study Data*. Report Number DOT HS 810 594. Washington, DC: NHTSA.

Mase, J. M., S. Majid, M. Mesgarpour, M. T. Torres, G. P. Figueredo, and P. Chapman. 2020. "Evaluating the impact of Heavy Goods Vehicle driver monitoring and coaching to reduce risky behavior." *Accident Analysis & Prevention* 146: 105754. October 2020.

Michelaraki, E., C. Katrakazas, S. Kaiser, T. Brijs, and G. Yannis. 2023. "Real-time monitoring of driver distraction: State-of-the-art and future insights." *Accident Analysis & Prevention* 192: 107241. November 2023.

National Academies of Sciences, Engineering, and Medicine. 2021. *Principles and Guidance for Presenting Active Traffic Management Information to Drivers*. Washington, DC: The National Academies Press.

NTSB (National Transportation Safety Board). 2025. *Collision of Motorcoach with Combination Vehicles Parked Along Exit Ramp to I 70 Rest Area, Highland, Illinois, July 12, 2023*. NTSB/HIR-25-02. Washington, DC: NTSB.

_____. 2024. *Rear-End Collision Between Combination Vehicle and Medium-Size Bus, Williamsburg, Virginia, December 16, 2022*. NTSB/HIR-24-05. Washington, DC: NTSB.

_____. 2023. *Multivehicle Collision Involving a Milk Tank Combination Vehicle and Stopped Traffic Queue, Phoenix, Arizona, June 9, 2021*. NTSB/HIR-23/04. Washington, DC: NTSB.

_____. 2022. *Multivehicle Crash Near Mt. Pleasant Township, Pennsylvania, January 5, 2020*. NTSB/HIR-22/01. Washington, DC: NTSB.

_____. 2020. *Multivehicle Work Zone Crash on Interstate 84, Boise, Idaho, June 16, 2018*. NTSB/HAB-20/02. Washington, DC: NTSB.

_____. 2015a. *The Use of Forward Collision Avoidance Systems to Prevent and Mitigate Rear-End Crashes*. NTSB/SIR-15/01. Washington, DC: NTSB.

_____. 2015b. *Truck-Tractor Double Trailer Median Crossover Collision with Motorcoach and Postcrash Fire on Interstate 5, Orland, California, April 10, 2014*. NTSB/HAR-15/01. Washington, DC: NTSB.

_____. 2007. *Motorcoach Fire on Interstate 45 During Hurricane Rita Evacuation Near Wilmer, Texas, September 23, 2005*. NTSB/HAR-07/01. Washington, DC: NTSB.

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

_____. 1999. *Bus Crashworthiness Issues*. NTSB/SIR-99/04. Washington, DC: NTSB.

ODOT (Ohio Department of Transportation). 2020. *Transportation Systems Management & Operations Study Guidebook*. Prepared by Gannett Fleming. April 2020.

Parenteau, C., S. White, R. Burnett, G. Stephens, and D. Michalski. 2022. "Rear-end impacts – part 1: Field and test data analysis of crash characteristics." *SAE International Journal of Advances and Current Practices in Mobility* 4 (6): 2106-2119.

Pecheux, K. K., G. Carrick, and B. B. Pecheux. *Secondary Crash Research: A Multistate Analysis*. Report No. FHWA-HOP-23-043. 2023. Washington, DC: FHWA.

Regan, M. A., C. Hallett, and C. P. Gordon. "Driver distraction and driver inattention: Definition, relationship and taxonomy." *Accident Analysis & Prevention* 43 (5): 1771–1781. September 2011.

Sakhare, R. S., J. C. Desai, J. Mahlberg, J. K. Mathew, W. Kim, H. Li, J. D. McGregor, and D. M. Bullock. 2021. "Evaluation of the impact of queue trucks with navigation alerts using connected vehicle data." *Journal of Transportation Technologies* 11 (4), 561–576. October 2021.

Schroeder, B., S. Warchol, S. Laffey, R. Grosso, G. Rowe, A. Pate, R. K. Boyapati, and A. Sanchez-Badillo. 2021. *Work Zone Intelligent Transportation Systems-Technology Supplement*. A supplemental document to the 2014 Work Zone Intelligent Transportation Systems (ITS) Implementation Guide. Report No. FHWA-HOP-21-021. Washington, DC: FHWA Office of Operations.

Shaw, J. W., M. V. Chitturi, W. Bremer, and D. A. Noyce. 2015. *Work Zone Speed Management: A Synthesis of Highway Practice*. National Cooperative Highway Research Program Synthesis 482. Washington, DC: Transportation Research Board.

Teoh, E. R. 2021. "Effectiveness of front crash prevention systems in reducing large truck real-world crash rates." *Traffic Injury Prevention* 22 (4): 284–289. March 2021.

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