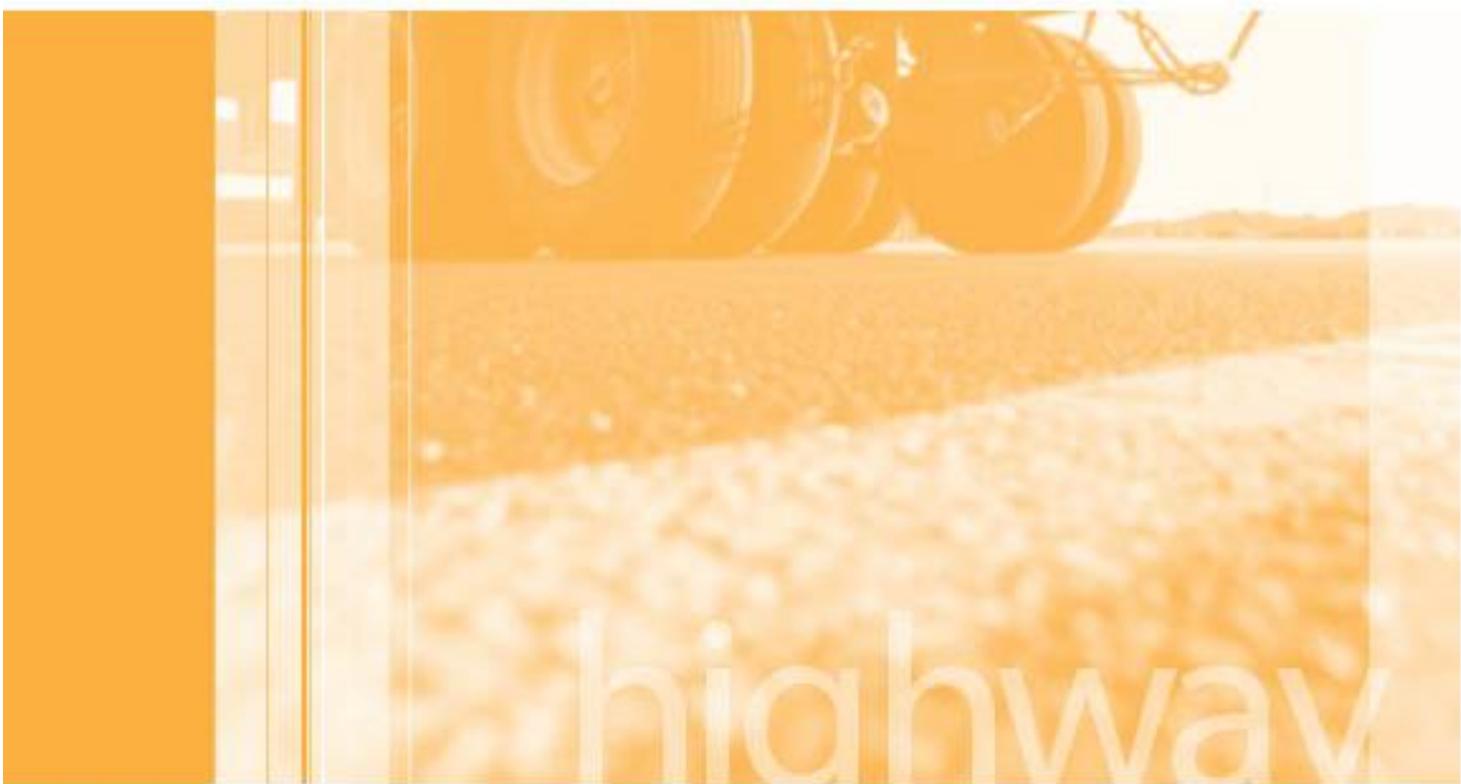


Selective Issues in School Bus Transportation Safety: Crashes in Baltimore, Maryland, and Chattanooga, Tennessee



Special Investigation Report

NTSB/SIR-18/02
PB2018-100932



**National
Transportation
Safety Board**

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Adopted May 22, 2018

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and Chattanooga, Tennessee



**National
Transportation
Safety Board**

490 L'Enfant Plaza SW
Washington, DC 20594

National Transportation Safety Board. 2018. *Selective Issues in School Bus Transportation Safety: Crashes in Baltimore, Maryland, and Chattanooga, Tennessee. Special Investigation Report NTSB/SIR-18/02. Washington, DC.*

Abstract: In November 2016, the NTSB began the investigation of two crashes involving school buses. Each crash was initiated when the driver lost control of the bus. In the November 1 crash in Baltimore, Maryland, the driver was epileptic and suffered a seizure. In the November 21 crash in Chattanooga, Tennessee, the driver was speeding while using a cell phone and ran off the road. In both cases, the school bus operators were private for-hire motor carriers. Although the specific safety issues differed, the crashes shared one common factor: poor driver oversight by both the school districts and the contracted motor carriers, which resulted in unsafe operation of the school buses. Between the two crashes, 12 people died and 37 were injured. The crash investigations focused on the following safety issues: school districts' lack of oversight of student transportation providers; poor management of unsafe school bus drivers by the motor carriers and school districts; medically unfit school bus drivers; commercial driver license fraud; occupant protection in large school buses; and the benefits of electronic stability control, automatic emergency braking, and event data recorders. The NTSB made safety recommendations to the Federal Motor Carrier Safety Administration; the National Highway Traffic Safety Administration (NHTSA); the states of Florida, Louisiana, New Jersey, and New York; 42 states, the District of Columbia, and the territory of Puerto Rico—which lack requirements for lap/shoulder belts on large school buses; the state of Maryland; the Maryland Department of Education; the Maryland Motor Vehicle Administration; five school bus transportation associations; National Express LLC; seven school bus manufacturers; five electronic health record companies; and Concentra, Inc. The report also reiterates four recommendations to NHTSA and reclassifies a recommendation to the Baltimore City Public Schools.

The NTSB is an independent federal agency dedicated to promoting aviation, railroad, highway, marine, and pipeline safety. Established in 1967, the agency is mandated by Congress through the Independent Safety Board Act of 1974 to investigate transportation accidents, determine the probable causes of the accidents, issue safety recommendations, study transportation safety issues, and evaluate the safety effectiveness of government agencies involved in transportation. The NTSB makes public its actions and decisions through accident reports, safety studies, special investigation reports, safety recommendations, and statistical reviews.

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Assignment of fault or legal liability is not relevant to the NTSB statutory mission to improve transportation safety by investigating accidents and incidents and issuing safety recommendations. In addition, statutory language prohibits the admission into evidence or use of any part of an NTSB report related to an accident in a civil action for damages resulting from a matter mentioned in the report. 49 *United States Code* Section 1154(b).

For more detailed background information on this report, visit the [NTSB investigations website](#) and search for NTSB accident numbers HWY17MH007 and HWY17MH009. Recent publications are available in their entirety at the [NTSB website](#). Other publications information may be obtained from the website or by contacting: **National Transportation Safety Board, Records Management Division, CIO-40, 490 L’Enfant Plaza SW, Washington, DC 20594, (800) 877-6799 or (202) 314-6551**

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Acronyms and Abbreviations

AAMVA	American Association of Motor Vehicle Administrators
AASHTO	American Association of State Highway and Transportation Officials
ACM	air bag control module
AEB	automatic emergency braking
BASIC	behavior analysis and safety improvement category [FMCSA]
BCPS	Baltimore City Public Schools
BFD	Baltimore City Fire Department
BPD	Baltimore Police Department
CAS	collision avoidance system
CDL	commercial driver's license
CFD	Chattanooga Fire Department
CFR	<i>Code of Federal Regulations</i>
CME	certified medical examiner [FMCSA]
CMV	commercial motor vehicle
COMAR	<i>Code of Maryland Regulations</i>
CPD	Chattanooga Police Department
CR	compliance review
DMV	Department of Motor Vehicles
DOT	US Department of Transportation
ECM	engine control module
EHR	electronic health record
EMS	emergency medical services
ESC	electronic stability control
FAA	Federal Aviation Administration
FMCSA	Federal Motor Carrier Safety Administration
FMCSRs	<i>Federal Motor Carrier Safety Regulations</i>

FMVSS	<i>Federal Motor Vehicle Safety Standard</i>
FR	<i>Federal Register</i>
FSA	Farm Service Agency [United States]
g	acceleration due to gravity
GPS	global positioning system
GVWR	gross vehicle weight rating
HCDE	Hamilton County Department of Education
HVEDR	heavy vehicle event data recorder
LOC	loss of consciousness
µg/dL	microgram per deciliter
µg/mL	microgram per milliliter
mg	milligram
mg/dL	milligram per deciliter
MAB	Medical Advisory Board
MSDE	Maryland State Department of Education
MTA	Maryland Transit Administration
MVA	Motor Vehicle Administration [Maryland]
NAIP	National Agricultural Imagery Program [United States]
NAPT	National Association for Pupil Transportation
NASDPTS	National Association of State Directors of Pupil Transportation Services
NCSL	National Conference of State Legislatures
NHTSA	National Highway Traffic Safety Administration
NSTA	National School Transportation Association
NTSB	National Transportation Safety Board
SIR	special investigation report
USDA	US Department of Agriculture
USDOT	US Department of Transportation

Executive Summary

School bus travel is one of the safest forms of transportation in the United States. Every day, nearly 600,000 buses carry more than 25 million students to and from school and activities. Children are safer traveling in school buses than in any other vehicle.

Although school buses are extremely safe, the National Transportation Safety Board (NTSB) continues to investigate school bus crashes in which fatalities and injuries occur. Improved oversight of school bus drivers and enhancements to school bus design—such as installation of passenger lap/shoulder belts, electronic stability control, and automatic emergency braking—could prevent or mitigate such crash outcomes.

In November 2016, the NTSB began the investigation of two multifatality crashes involving school buses. Each crash was initiated when the driver lost control of the school bus. In the November 1 crash in Baltimore, Maryland, the driver was epileptic and suffered a seizure. In the November 21 crash in Chattanooga, Tennessee, the driver was speeding while using a cell phone and ran off the road. In both cases, the school bus operators were private for-hire motor carriers performing contracted student transportation services. Although the specific safety issues differed, the crashes shared one common factor: poor driver oversight by both the school districts and the contracted motor carriers, which resulted in unsafe operation of the school buses.

This special investigation report focuses on:

- School districts' lack of oversight of student transportation service providers (Baltimore, Chattanooga).
- Poor management of unsafe school bus drivers by motor carriers and school districts (Baltimore, Chattanooga).
- Medically unfit school bus drivers (Baltimore).
- Commercial driver license fraud in Maryland (Baltimore).
- Large school bus occupant protection (Chattanooga).
- Electronic stability control, automatic emergency braking, and event data recorders (Baltimore, Chattanooga).

Probable Causes

The National Transportation Safety Board determines that the probable cause of the *Baltimore, Maryland*, school bus crash was (1) the loss of vehicle control due to incapacitation of the bus driver because of a seizure stemming from a long-standing seizure disorder; (2) the bus driver's continued operation of a school bus with a disqualifying medical condition and a fraudulently obtained commercial driver's license; and (3) the failure of AAAfordable Transportation and the Baltimore City Public Schools to provide adequate bus driver oversight,

allowing the medically unfit driver to drive a commercial vehicle with a medical condition that they knew, or should have known, could lead to the unsafe operation of the school bus. Contributing to the severity of the crash was the lack of a collision avoidance system with automatic emergency braking on the school bus.

The National Transportation Safety Board determines that the probable cause of the *Chattanooga, Tennessee*, crash was (1) the school bus driver's excessive speed and cell phone use, which led to the loss of vehicle control; (2) Durham School Services' failure to provide adequate bus driver oversight, allowing an inexperienced driver to operate a commercial vehicle with escalating risky driving behaviors that it knew, or should have known, could lead to the unsafe operation of the school bus; and (3) the Hamilton County Department of Education's lack of followup to ensure that Durham had addressed a known driver safety issue. Contributing to the severity of the crash was the lack of passenger lap/shoulder belts on the school bus.

Recommendations

As a result of this special investigation report, the NTSB makes safety recommendations to the Federal Motor Carrier Safety Administration; the National Highway Traffic Safety Administration (NHTSA); the states of Florida, Louisiana, New Jersey, and New York; 42 states, the District of Columbia, and the territory of Puerto Rico—which lack requirements for lap/shoulder belts on large school buses; the state of Maryland; the Maryland Department of Education; the Maryland Motor Vehicle Administration; the National Association of State Directors of Pupil Transportation Services, National Association for Pupil Transportation, National School Transportation Association, American School Bus Council, and Maryland School Bus Contractors Association; National Express LLC; school bus manufacturers Blue Bird Corporation, Collins Industries, Inc., IC Bus, Starcraft Bus, Thomas Built Buses, Inc., Trans Tech, and Van-Con, Inc.; electronic health record companies Epic, Cerner Corporation, eClinicalWorks, MEDITECH, and NextGen Healthcare; and Concentra, Inc. The report also reiterates four recommendations to NHTSA and reclassifies a recommendation to the Baltimore City Public Schools.

1 Introduction

In the United States, nearly 600,000 buses carry 25 million students to and from school and activities every day. Children are much safer traveling in school buses than in any other vehicle, whether they are going to or from school, a field trip, or a sporting event.¹ Although school bus travel is one of the safest forms of transportation, the National Highway Traffic Safety Administration (NHTSA) reports that between 2007 and 2016, 58 school-age children were killed in school transportation vehicles (NHTSA 2018).²

Despite the overall safety of large school buses, the National Transportation Safety Board (NTSB) continues to investigate school bus crashes in which fatalities and injuries occur.³ We have issued many probable cause determinations in which the cause of the crash was driver related, and the lack of comprehensive occupant protection contributed to the severity of the crash. These investigations have resulted in numerous recommendations for improving driver and vehicle safety (NTSB 2016a; 2016b; 2016c; 2015a; 2013; 2011a; 2009b; 2008a; 2008b; 2002a; 2001a; 2000).⁴

The NTSB developed this special investigation report (SIR) on selective issues in school bus transportation safety because—in both the Baltimore, Maryland, and the Chattanooga, Tennessee, crashes—we found that a lack of driver oversight among the school districts and contracted motor carriers resulted in the unsafe operation of their school buses.

This SIR focuses on the following school transportation safety issues related to school bus drivers: the school districts' lack of oversight of student transportation service providers in both Baltimore and Chattanooga, poor management of unsafe school bus drivers by the motor carriers and school districts, medically unfit school bus drivers (Baltimore), and commercial driver license fraud in Maryland. Further, we discuss occupant protection in large school buses, in the case of Chattanooga; and the benefits of electronic stability control (ESC), automatic emergency braking (AEB), and event data recorders in improving driver and vehicle safety. States, school districts, and student transportation service providers should examine these issues to improve the safety of student transportation.

¹ See the [National Association for Pupil Transportation advocacy webpage](#) and the [NHTSA webpage on school bus safety](#), accessed June 4, 2018.

² NHTSA defines a school-transportation-related crash as a crash that involves, either directly or indirectly, a school bus body vehicle, or a nonschool bus functioning as a school bus, transporting children to or from school or school-related activities.

³ NHTSA defines a “large” school bus as a school bus having a gross vehicle weight rating (GVWR) greater than 10,000 pounds. See [NHTSA Final Rule, 49 CFR Part 571, FMVSS 222](#), accessed June 4, 2018.

⁴ (a) These crashes were located in Knoxville, Tennessee; Houston, Texas; Anaheim, California; Port St. Lucie, Florida; Chesterfield, New Jersey; Gray Summit, Missouri; Milton, Florida; Arlington, Virginia; Atlanta, Georgia; Mountainburg, Arkansas; Conasauga, Tennessee; and Central Bridge, New York, respectively. (b) In 1999, the NTSB issued a special investigation report (SIR) on bus crashworthiness, which analyzed six school bus crashes and collected information from a public hearing held in August 1998 (NTSB 1999). The NTSB also evaluated the *Federal Motor Vehicle Safety Standards* (FMVSS) that govern the design of school buses to determine their effectiveness and issued safety recommendations that have improved school bus safety.

2 School Bus Crash Investigations

2.1 Baltimore, Maryland

2.1.1 Crash Narrative

2.1.1.1 Sequence of Events. Just before 6:30 a.m. (eastern daylight savings time) on Tuesday, November 1, 2016, a 2015 IC Bus 64-passenger school bus was traveling east in the 4000 block of Frederick Avenue in Baltimore, Maryland, when it was involved in two separate crashes.⁵ The school bus, operated by the motor carrier AAAfordable Transportation LLC, under contract to the Baltimore City Public Schools (BCPS), was occupied by the 67-year-old driver and a school bus attendant.⁶ No students were on the bus.

After the school bus traveled through the South Loudon Avenue intersection, it struck the rear of a 2012 Ford Mustang, which was also traveling east on Frederick Avenue.⁷ Upon impact, the car—occupied by a driver only—traveled 74 feet, struck the south curb of Frederick Avenue, collided with a brick wall and metal fence, and continued to a final position across the eastbound lane of Frederick Avenue.⁸

Security camera videos from three locations recorded the school bus movement on Frederick Avenue.⁹ Based on video evidence, the bus was traveling about 57 mph when it crossed the camera fields of view moments before impact with the car. The bus slowed to 47 mph due to the collision. The posted speed limit on Frederick Avenue is 30 mph.

After striking the car, the school bus continued traveling east for about 820 feet, crossed the Frederick Avenue center turn lane, and entered the westbound travel lane. The school bus then struck the front and left side of an oncoming 2005 New Flyer transit bus operated by the Maryland Transit Administration (MTA).¹⁰ The transit bus was occupied by a 33-year-old driver and 13 passengers (see figures 1 through 3).

⁵ The Baltimore school bus had a GVWR of 28,500 pounds.

⁶ (a) AAAfordable was registered with the Federal Motor Carrier Safety Administration (FMCSA) under US Department of Transportation (USDOT) number 1982031 as an authorized for-hire carrier of passengers (intrastate). (b) A BCPS bus attendant (or bus aide) attends to the safety and care of special education students and other student passengers.

⁷ Downloaded data from the air bag control module (ACM) indicated that the car was traveling about 16 mph when it was struck by the school bus.

⁸ The initial impact between the school bus and the car was evidenced by scrapes, collision scrub, and tire friction marks on the pavement.

⁹ Security cameras were located at a convenience store on Frederick Avenue, at a gas station at the intersection of Frederick Avenue and Monastery Avenue, and at the chapel of St. Joseph's Monastery. Video recordings were used to estimate the school bus speed as it traveled 900 feet on Frederick Avenue over a span of 12 seconds.

¹⁰ The MTA is a state-owned mass transit agency that services the greater Baltimore–Washington, DC, metropolitan area under the Maryland Department of Transportation. It includes four divisions: heavy rail, light rail, bus and paratransit (mobility), and operations. The MTA also manages the city taxi system and operates a 150-officer police department.

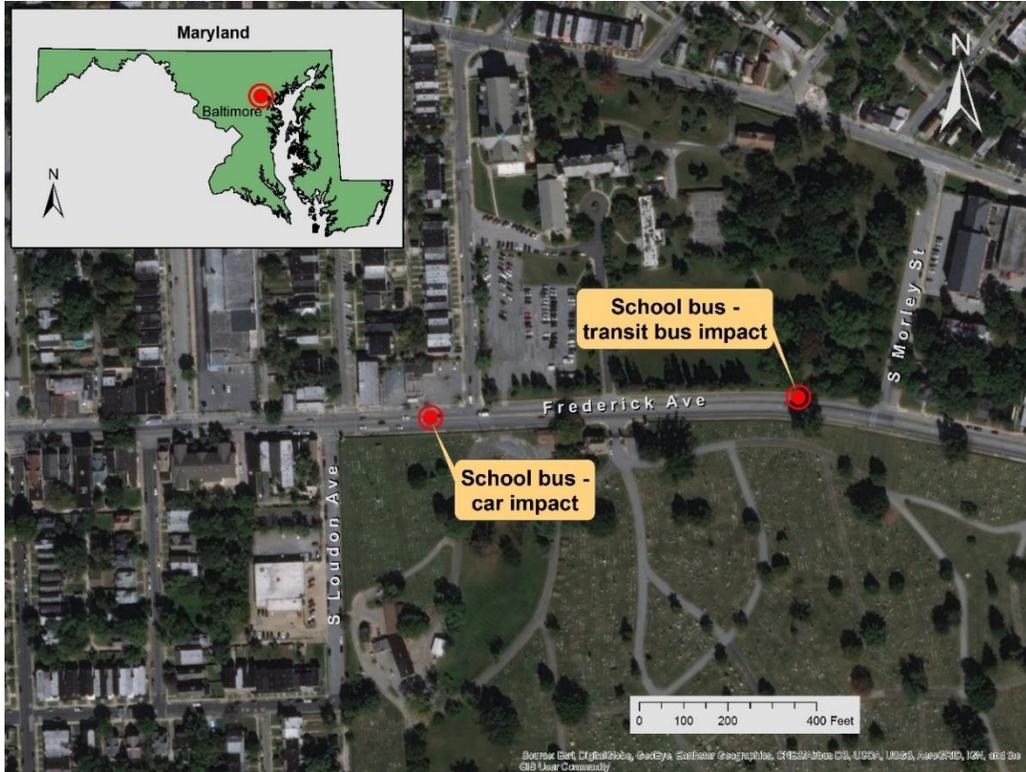


Figure 1. Overhead view of Frederick Avenue crash locations for eastbound school bus and car and for school bus and westbound transit bus. (Source: USDA FSA NAIP 2015, July 24, 2015)

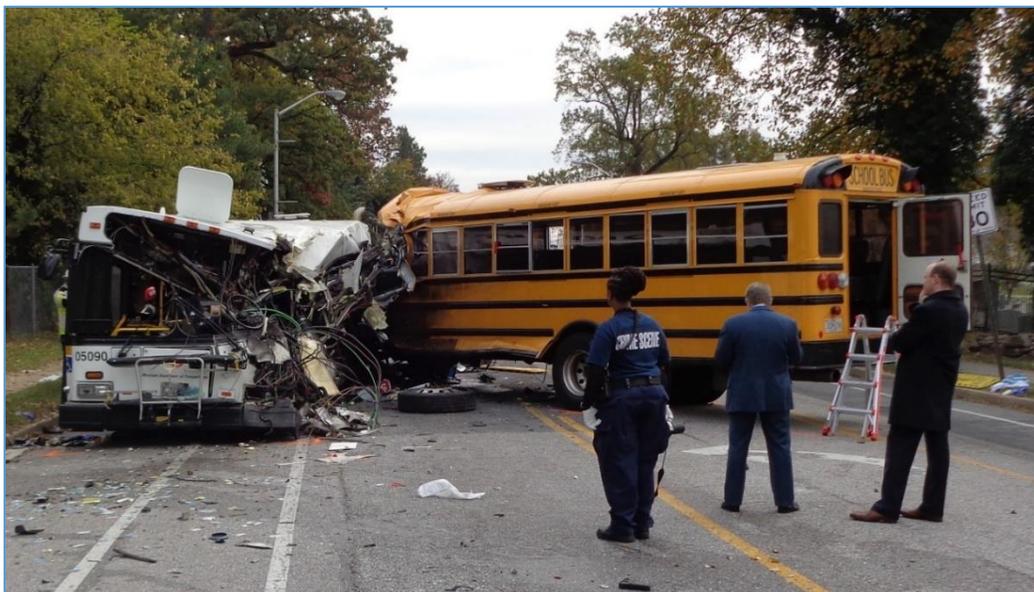


Figure 2. Crash scene on Frederick Avenue. (Source: Maryland Transit Administration)

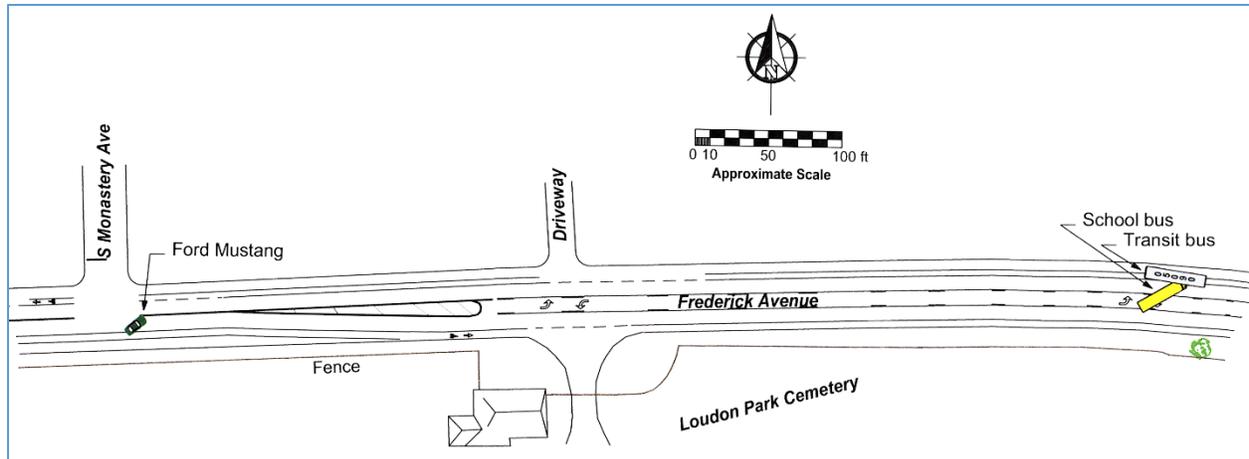


Figure 3. Crash scene diagram, Frederick Avenue, Baltimore.

The transit bus was equipped with video surveillance cameras that continuously recorded the exterior and interior of the bus. The recorded videos were used to estimate the speed of each vehicle before impact.¹¹ As the westbound transit bus approached the 3800 block of Frederick Avenue, its forward-facing video shows the eastbound school bus crossing into the center turn lane and then entering the path of the oncoming transit bus. The school bus was traveling 45 mph several seconds before impact, and the transit bus was traveling 39 mph at impact.¹²

2.1.1.2 Roadway Information. Frederick Avenue is functionally classified as a principal arterial roadway with one eastbound and one westbound lane. Each lane is bordered by a bicycle lane and has paved shoulders, for a total paved roadway width of 45 feet.¹³ A double yellow centerline separates the travel lanes; 204 feet east of South Loudon Avenue, the centerline begins to diverge into two double yellow centerlines to form an 11-foot-wide center turn lane.¹⁴ The straight roadway transitions to a 200-foot-long, 3-degree curve to the right in the eastbound direction.¹⁵

¹¹ The transit bus was equipped with a March Networks 10-camera video surveillance system. Video from one of the cameras, camera 8—curbside view, was used to estimate the speed of the bus during the 8 seconds before impact, based on pavement markings. Video from camera 9—front view was used to estimate the speed of the transit bus and the speed of the school bus during the last half second before impact and to also estimate the impact location on the road.

¹² The impact location of the school bus–transit bus collision was evidenced by radiator splatter located 15 feet forward of where the transit bus came to its final rest position and partially in the center turn lane and the westbound lane of Frederick Avenue.

¹³ Each travel lane is 11 feet wide, with the shoulders varying in width from 7.5 to 8.5 feet and the bicycle lanes varying in width from 4 to 4.5 feet.

¹⁴ A solid yellow pavement stripe with dashed lines inside the solid markings at 30-foot intervals delineates the full-width turn lane from the travel lanes. Each dashed line is 10 feet long.

¹⁵ In this area, the pavement also begins transitioning from level to an approximate 0.035 percent downgrade in the eastbound direction. Baltimore City Transportation Department crash statistics for a 1-mile section of Frederick Avenue in a 5-year-period (2010–2014) showed 26 nonincapacitating injury, four incapacitating injury, and no fatal crashes. In a 1-mile-long area encompassing the crash location, statistics showed 12 property-damage-only transit bus crashes from November 1, 2014, to November 1, 2016.

2.1.1.3 Injuries. As a result of these two crashes, the school bus driver, the transit bus driver, and four transit bus passengers died. Five transit bus passengers were seriously injured; and the school bus attendant, four transit bus passengers, and the driver of the car sustained minor injuries. (See table 1 for injuries, appendix B for injury details, and figure 4 for transit bus occupant seating locations and injury classifications. NTSB investigators developed the seating chart based on video evidence and interviews with bus passengers.)

Table 1. Injury levels for occupants of Baltimore school bus, transit bus, and car.

Injury Severity ^{a,b}	Fatal	Serious	Minor	TOTAL
School bus				
Driver	1	0	0	1
Attendant	0	0	1	1
Transit bus				
Driver	1	0	0	1
Passengers	4	5	4	13
Car				
Driver	0	0	1	1
TOTAL	6	5	6	17

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

^b Among the 17 occupants of the three vehicles, no one was uninjured.

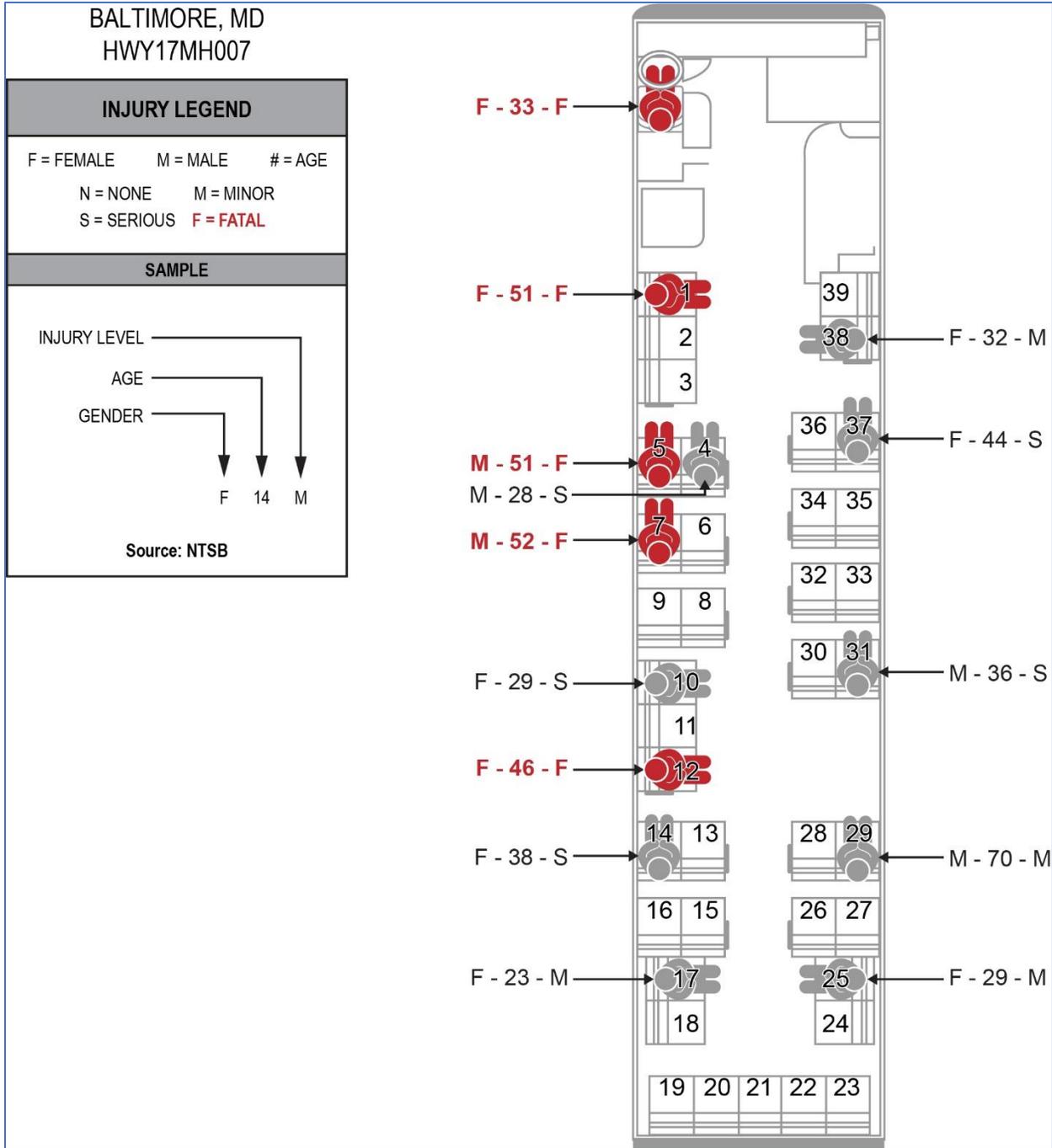


Figure 4. Transit bus occupant seating chart with injury and demographic information.

2.1.1.4 Other Information. The crash occurred at 6:30 a.m. in darkness, before dawn or sunrise. Overhead roadway safety lighting was installed and operational at the crash location. Weather conditions were clear, there was no precipitation, and the temperature was 46°F.¹⁶

The 2015 IC Bus school bus was equipped with a 2015 International engine with an International engine control module (ECM). The ECM had no event recording features (sudden deceleration or last stop events) and, therefore, did not capture the crash.¹⁷

An ECM also controlled the Cummins ISM engine of the 2005 New Flyer transit bus. The ECM was examined by an NTSB recorder specialist, and no crash-pertinent diagnostic data or trouble codes were found.

2.1.2 School Bus Driver

2.1.2.1 Licensing. The school bus driver held a Maryland class A commercial driver's license (CDL) with an expiration date in June 2018.¹⁸ The license held endorsements for triple and double trailers, tank vehicles, school buses, and passengers. Section 3 discusses commercial driver licensing in Maryland, as applicable to the bus driver.

2.1.2.2 Records Review. NTSB investigators gathered information on the school bus driver's activities leading up to the crash from cell phone, medical, and employment records. Police recovered the driver's cell phone postcrash from his personal vehicle; no cell phone activity was recorded.

Medical records from the bus driver's primary care physician (beginning November 2010) document a history of seizures since childhood. The driver was prescribed carbamazepine in December 2010 (200 milligrams [mg] to be taken three times a day) to treat the condition. Carbamazepine is an antiseizure medication that requires routine dosing at regular intervals to maintain effective medication levels and prevent seizures.¹⁹ The driver's physician noted in

¹⁶ According to the US Naval Observatory, for November 1, 2016, morning civil twilight (civil dawn) occurred at 7:07 a.m., and sunrise occurred at 7:35 a.m. Morning civil twilight begins when the geometric center of the sun is 6 degrees below the horizon.

¹⁷ An ECM is an electronic control system with a primary function of interfacing with many onboard sensors that help monitor and perform vehicle functions. ECMs may also have a secondary function as a data storage system that records vehicle parameters. An ECM may be equipped with the capability of recording trip activity, including daily, monthly, and lifetime engine data—in addition to sudden deceleration or last stop event data. Some recorded parameters include vehicle speed, engine speed (revolutions per minute), throttle usage, cruise control usage, brake pedal application, and clutch pedal application.

¹⁸ In Maryland, a class A CDL allows the driver to operate “any single vehicle or combination of vehicles and any trailer,” and endorsements are required.

¹⁹ (a) Carbamazepine levels of 4–11 micrograms per milliliter (µg/mL) are required for effective dosing. See the [US National Library of Medicine DailyMed webpage on carbamazepine](#), accessed June 4, 2018; and the [FAA Aerospace Medical Research webpage on carbamazepine](#), accessed June 4, 2018. (b) A seizure is the result of an abnormal surge of electrical activity in the brain. Manifestations often include staring, inability to move, jerking motion of limbs, and unconsciousness. A person with recurrent seizures is diagnosed as having a seizure disorder or epilepsy.

medical records that he was noncompliant with his medication regimen.²⁰ For example, on October 17, 2011, the driver visited his physician because he had run out of his seizure medication, and he reported having had seizures. According to employer records and an ambulance report, he had had a seizure 3 days earlier—on October 14—while operating a school bus, and was reported by passengers as being “passed out” when the bus struck a parked car.

As listed in table 2, from 2011 until the day of the crash, the driver had experienced several (documented) incapacitating medical events while on duty as a school bus driver. According to a police report, he also had a crash in a personal vehicle on February 9, 2014, when he was believed to have suffered a medical condition and loss of consciousness (LOC).²¹ On July 28, 2015, law enforcement stopped the driver while he was operating his personal car and rendered medical services.

Table 2. Baltimore school bus driver history of on-duty crashes and medical events, by employer, 2011–2016.

Date	Event	Reporting Source
September 7, 2011	Crash: driver backed into parked vehicle	BCPS
<i>Employed by Reliable Transportation; terminated September 26, 2011</i>		
October 14, 2011	Crash: driver struck three poles and parked car after he was described as having “passed out” while driving school bus with teacher aide (injured) and one student onboard (uninjured)	BCPS
<i>Employed by Barber Transportation (as school bus driver)</i>		
February 7, 2012	Crash: postcrash drug test on file, but no accident report in driver file	BCPS
<i>Employed by C&T Transportation (as school bus driver)</i>		
March 2, 2012	Crash: driver sideswiped car after dropping off student; bus attendant was onboard but no students; no injuries reported	BCPS
<i>Employed by C&T Transportation (as school bus driver)</i>		
April 16, 2012	Crash: postcrash drug test on file, but no accident report in driver file	BCPS
<i>Employed by City Wide Transportation (as school bus driver)</i>		

²⁰ Noncompliant patients fail to regularly take their medication or follow other medical instructions.

²¹ The police report noted that the driver took medication for seizures. He was transferred to Howard County General Hospital.

Date	Event	Reporting Source
October 3, 2013	Crash: driver described as “unresponsive/unconscious”; postcrash drug test on file, but no accident report in driver file	City Wide, Baltimore City Fire Department (BFD), Concentra
<i>Employed by City Wide Transportation; terminated October 15, 2013</i>		
September 23, 2015	Crash: driver sideswiped parked vehicle while operating school bus, left scene, failed to report crash	BCPS
<i>Employed by AAAfordable: driver was issued a 90-day suspension by BCPS for failing to report crash and leaving scene; BCPS lifted suspension after 72 days, in December 2015; driver left company in April 2016</i>		
<i>Employed by First Group (a division of Greyhound): driver was hired April 22, 2016, as transit bus operator; terminated May 5 during first week of training (background check results “did not meet company standards”)</i>		
June 30, 2016	Crash: driver scraped tree while operating school bus; bus attendant witnessed driver having a seizure and called 911; driver taken to hospital	BFD, Reliable
<i>Employed by Reliable Transportation: driver was hired May 23, 2016; Reliable did not report June 30 medical event (seizure) to BCPS; driver returned to work and was dispatched on bus routes until terminated August 26</i>		
July 19, 2016	Crash: driver side-swiped vehicle while making left turn with passengers onboard; postcrash drug test on file, but no accident report in driver file	BCPS, Reliable
<i>Employed by Reliable Transportation</i>		
<i>Rehired by AAAfordable Transportation August 19, 2016</i>		
October 24, 2016	Driver experienced medical event in AAAfordable office, observed by employees Emergency medical services (EMS) responded to AAAfordable business location, driver refused medical treatment and declined hospital transport; company informed driver he had to obtain doctor’s note before returning to work; no BCPS record of event Driver returned to work October 25 without doctor’s medical fitness-for-duty release; completed bus routes for remainder of week (October 26–28)	AAAfordable, BFD
November 1, 2016	Crash occurs	

The Office of Chief Medical Examiner for the state of Maryland identified evidence of heart disease, hypertension, and diabetes during the bus driver's autopsy examination.²² The NTSB obtained blood and urine samples from the driver. Testing of specimens by the Federal Aviation Administration (FAA) Bioaeronautical Sciences Research Laboratory identified low levels of carbamazepine and a significant amount of glucose in the urine.²³

2.1.2.3 Employment. On May 23, 2016, the driver was hired by Reliable Transportation, the motor carrier he had worked for just prior to AAAfordable.²⁴ On June 30, as noted in table 2, he was operating a school bus when he scraped the bus against a tree. The driver and the bus attendant disembarked to look at the damage, and she witnessed him having a seizure on the sidewalk. She called 911 and notified Reliable's owner of the seizure event. The driver returned to work on July 5 and was dispatched on his normal routes. Then, on July 19, while operating a school bus with passengers, he sideswiped a vehicle while making a left turn (it is unknown whether he had a seizure event). According to Reliable, on August 26, the driver was informed that he could not return to work without a note from his doctor stating that he was medically fit, and until he did so, he was terminated.²⁵ In the interim, the driver had applied for employment with AAAfordable.²⁶

On October 24, 2016 (1 week before the crash), the driver had a seizure in front of the AAAfordable dispatcher. The dispatcher and the owner informed him that he needed to obtain a doctor's medical clearance for work. On October 25, he returned to work (without a doctor's clearance) and was dispatched to drive his bus routes for the remainder of the week.

2.1.2.4 Precrash Route and Reported Events. On November 1, the driver checked in for his shift at 5:57 a.m. The driver's "route detail report" scheduled him to pick up 18 students and drop them off at Dallas F. Nicholas Senior Elementary School. The driver and the bus attendant departed the AAAfordable facility and headed to their first student pickup location on Frederick Avenue, waited several minutes, and then departed when the student did not show up. The school bus was continuing east on Frederick Avenue, toward the second student pickup location, when it struck the rear of the car.

²² The cause of death from the November 1, 2016, crash was recorded as "multiple injuries."

²³ Toxicology testing identified 1.858 µg/mL of carbamazepine in the blood sample. Carbamazepine and glucose (at 17,820 milligrams per deciliter [mg/dL]) were found in the urine sample. Toxicological testing included more than 1,300 substances; see the [FAA Forensic Toxicology WebDrugs website for a complete listing](#), accessed June 4, 2018.

²⁴ Reliable Professional Services LLC, doing business as Reliable Transportation, was registered with the FMCSA under USDOT number 2779642 as an authorized for-hire motor carrier of passengers (interstate).

²⁵ Postcrash, NTSB investigators interviewed Reliable managers, who stated that they were unaware the driver had been employed by another bus operator; they confirmed that he had not yet returned to work with his medical clearance. Reliable provided no reason why it had informed the driver of his termination on this specific date.

²⁶ The driver had previously worked for AAAfordable from May 2015 through April 2016. According to company officials, he simply did not return to work after the April spring break. They tried to reach him, were unsuccessful, and assigned a substitute to drive his school bus route. The driver applied for employment again in August 2016.

The bus attendant onboard at the time of the crash stated to NTSB investigators that as the school bus was proceeding east on Frederick Avenue, she felt an “abnormal bump” that was not preceded by braking or swerving of the bus.²⁷ She reported that she turned to her right, looked out the rear emergency door windows, and asked the driver, “Hey, what was that?” She did not see anything when she looked out the window, and the driver did not answer.²⁸ She then felt the bus accelerating, got up from her second-row seat behind the driver, and braced against a seat on the opposite side while trying to observe the driver. She was unable to see him from her position and did not experience any sensations akin to the application of brakes prior to the collision with the transit bus. After the crash, she evacuated through the emergency door at the back of the bus and called 911.

2.1.3 Transit Bus Driver

The 33-year-old MTA bus driver held a class B CDL with passenger endorsement, which was issued in September 2016 and had an expiration date in January 2022. She held a medical examination certificate, which expired in May 2018.²⁹ The bus driver was hired by the MTA in 2006. She had completed 47 training courses since her hire date.³⁰

The bus driver’s route on the day of the crash began at 4:57 a.m. An interior-facing video recording captured the driver’s precrash movements.³¹ Within 1 second before the crash, she reacts to the oncoming school bus by turning the steering wheel to the right and begins to enter the bike lane. She appears to be alert and attentive throughout the video.

Postcrash, the NTSB obtained a sample of the driver’s blood and sent it to the FAA laboratory for further analysis. The results indicate that she had no alcohol or other drugs in her system at the time of the crash.³² (See appendix B for additional information.³³)

²⁷ According to the bus attendant, she was recording on her route sheet that the first student was not picked up when she felt the bump. She added that the roadways are not smooth and being tossed about in one’s seat is a normal occurrence; however, she told interviewers that this “bump” felt different. The bump corresponded to the school bus striking the car.

²⁸ The bus attendant commented that she was still looking to the rear when she asked the question.

²⁹ The transit bus driver was required to wear corrective lenses when behind the wheel. Her US Department of Transportation (DOT) medical certificate and long form from Concentra, dated May 2016, documented a self-reported history of migraines. Her blood pressure was recorded during the examination as 90/60 (normal), and her hearing and corrected vision were normal.

³⁰ New hires must attend a 10-week training program, consisting of both classroom and behind-the-wheel instruction. Upon successful completion of the training, the bus operator reports to a designated terminal for further training and is assigned a route. Bus operators must receive recertification training every 3 years.

³¹ The MTA requires drivers to report to the dispatch office, where the dispatcher manually records clock-in time. The transit bus operator had been off duty for 3 consecutive days prior to the crash.

³² Toxicological testing included more than 1,300 substances; see the [FAA Forensic Toxicology WebDrugs website for a complete listing](#), accessed June 4, 2018.

³³ See also the NTSB public docket for this investigation (HWY17MH007).

2.1.4 Crash Analysis

As noted earlier, the school bus driver was not using a cell phone at the time of the crash. Both the school and the transit bus drivers had been driving for less than 1.5 hours when the crash occurred. Based on the information provided and evidence documented, the school bus driver had not worked the previous day and had had an opportunity for rest.

A reconstruction of the transit bus driver's sleep/wake times suggests that she had less than 6 hours of sleep opportunity the night before the crash; however, video recovered from the transit bus shows that the driver is alert, is not using a cell phone while driving, and immediately conducts a controlled evasive action as the school bus encroaches into the westbound lane. In addition, the video shows that she is not distracted by factors internal or external to the bus prior to the crash.

Postcrash mechanical inspection of the school bus and the transit bus identified no mechanical defects. The weather was clear, roadway lighting was adequate, and there was no precipitation at the time of the crash. No roadway issues were found.

The NTSB concludes that none of the following were primary or contributing factors in the Baltimore crash: (1) distraction, substance impairment, or fatigue for either of the two bus drivers; (2) licensing or experience of the transit bus driver; (3) medical condition of the transit bus driver; (4) mechanical condition of the school bus or transit bus; (5) weather; or (6) roadway lighting or conditions.

The school bus driver had had epilepsy since childhood. He reported this diagnosis to his personal physicians and mentioned that when he ran out of medication, he would have seizures. Physician records indicate that the driver did not routinely fill or take his antiseizure medication. He had been observed to seize or become unresponsive in front of coworkers. In the past 5 years, he had experienced three incidents when he became medically incapacitated while operating a school bus—in addition to two such incidents while driving a noncommercial vehicle.

On November 1, 2016, according to operational information—and the statement from the bus attendant—the bus driver did not brake, slow, stop, or steer the school bus after it collided with the car, but continued on a straight path until colliding with the transit bus at a slight curve in the roadway. Considering the bus driver's history of seizures and his failure to consistently use medication for treatment, witness statements, and crash evidence, it is likely that his medical incapacitation led to both collisions. The NTSB concludes that the Baltimore school bus driver was likely incapacitated by a seizure due to his long-standing seizure disorder, which resulted in collisions with the car and the transit bus.

2.2 Chattanooga, Tennessee

2.2.1 Crash Narrative

2.2.1.1 Sequence of Events. On Monday, November 21, 2016, about 3:20 p.m. (eastern daylight time), a 2008 Thomas Built Buses 84-passenger school bus was traveling south in the 300 block of Talley Road, in Chattanooga, Tennessee, when it departed the roadway, rolled onto its right side, and struck a tree (see figures 5 and 6).³⁴ The school bus, operated by Durham School Services, under contract to the Hamilton County Department of Education (HCDE), was occupied by the 24-year-old driver and 37 students.³⁵



Figure 5. Overhead view of Talley Road crash location. (Source: USDA FSA NAIP June 8, 2016)

³⁴ The Chattanooga school bus had a GVWR of 33,350 pounds.

³⁵ According to the FMCSA Motor Carrier Management Information System, Durham is registered as an interstate “for-hire” motor carrier. Durham operates from its primary place of business in Warrenville, Illinois.



Figure 6. Crash scene off Talley Road, showing school bus on its passenger (right) side against tree. (Source: Chattanooga Fire Department)

The school bus was transporting 37 students from Woodmore Elementary School to their drop-off locations. According to the vehicle's Zonar global positioning system (GPS) information, the bus left the school parking lot at 3:13:24 p.m.³⁶ The 24-year-old bus driver departed the school 13 minutes late. He then deviated from his scheduled route and headed south on Talley Road (see appendix C for route map and drop-off times). The driver answered a cell phone call at 3:17:20 p.m. (see section 2.2.2 for more information on cell phone data). He had not yet dropped off any students—and the cell phone call was still active—when he lost control of the bus and departed the roadway.

2.2.1.2 Roadway Information. Talley Road has one southbound and one northbound lane. Each travel lane is 11 feet wide, separated by a solid double yellow line. The total pavement width is 22 feet. When the school bus was 0.75 mile southwest of the school, it traveled through a horizontal curve to the left (with an advisory speed of 25 mph), which transitions to a 500-foot-long straight segment that descends a hill before Howard Avenue. The bus then entered a horizontal curve to the right (preceded by a 30-mph speed limit sign) before the downward hill levels out about 83 feet into the rightward curve, prior to the intersection with Sunset Avenue.³⁷ The roadway then remains

³⁶ Durham uses Zonar software technology to assist with GPS tracking, payroll, and pretrip vehicle inspections.

³⁷ The right-of-way width is approximately 50 feet. "Right-of-way" is generally understood to be the area that is publicly owned in which the roadway is typically centered, but it may be offset due to topography, utilities, or limited space. On December 1, 2016, the city of Chattanooga conducted a 24-hour speed study in the 318 block of Talley Road southbound. The average vehicle speed recorded was 26 mph (for 1,588 vehicles), with at least half of the vehicles traveling in the 20–25 mph range or lower. City-provided statistics for the entire length of Talley Road from January 2013 through October 2016 showed no fatal, nine injury, and 43 property-damage-only crashes.

essentially level for 120 feet, at which point it begins to ascend for 150 feet, crests, and remains essentially level again (see figure 7).

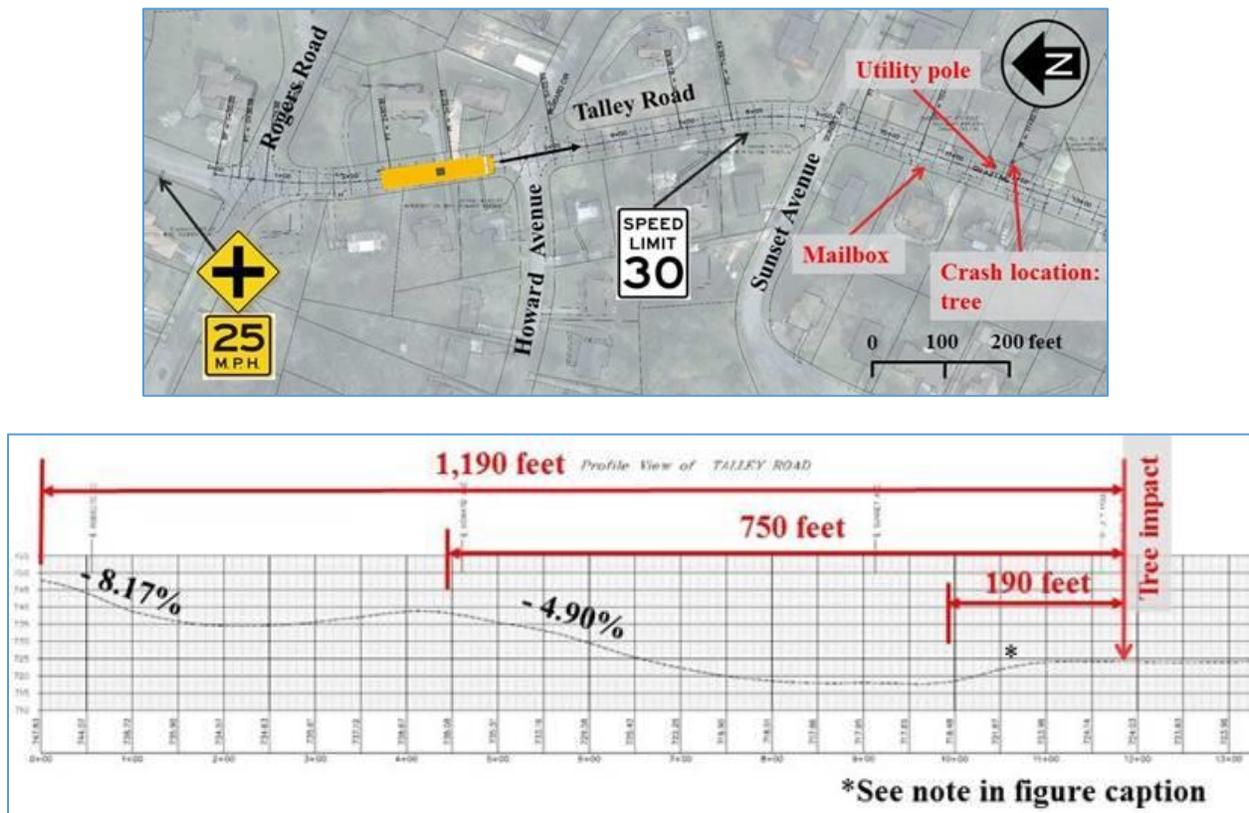


Figure 7. Graphic showing plan view and signage of Talley Road (top) and profile view (bottom). (Source: city of Chattanooga, modified)

Note: 6.9 percent upgrade maximum slope (4.3 percent overall average slope).

2.2.1.3 Reported Precrash Events and Roadway Evidence. NTSB investigators interviewed a witness to the crash, who was at her mailbox when she heard children yelling. She walked to the corner of Howard Circle (at Howard Avenue) and Talley Road, where the 25-mph speed sign is located, and looked north toward Rogers Road. She reported that she observed the school bus coming toward her at a high rate of speed. As the bus passed her, she kept watching because she thought the driver was not going to negotiate the curve. She said he began what is known locally as “mountain driving,” which means that he entered the curve too fast and “cut the corner.” When the driver swerved to correct, the bus “kicked out” to the left (“like fishtailing,” she commented), toward the center of the roadway. She reported that it seemed as if he was fighting for control of the bus—and that she felt the driver lost control because he entered the right curve before Sunset Avenue at too fast a speed. At this time, she reported seeing a white vehicle (a car, pickup truck, or van) approach from the opposite direction, but its driver managed to pass the bus; the witness believed that the bus was already out of control at this point. She saw the bus roll onto its right

side and come to rest in a yard alongside Talley Road. Figure 8 presents a diagram of the crash scene.³⁸

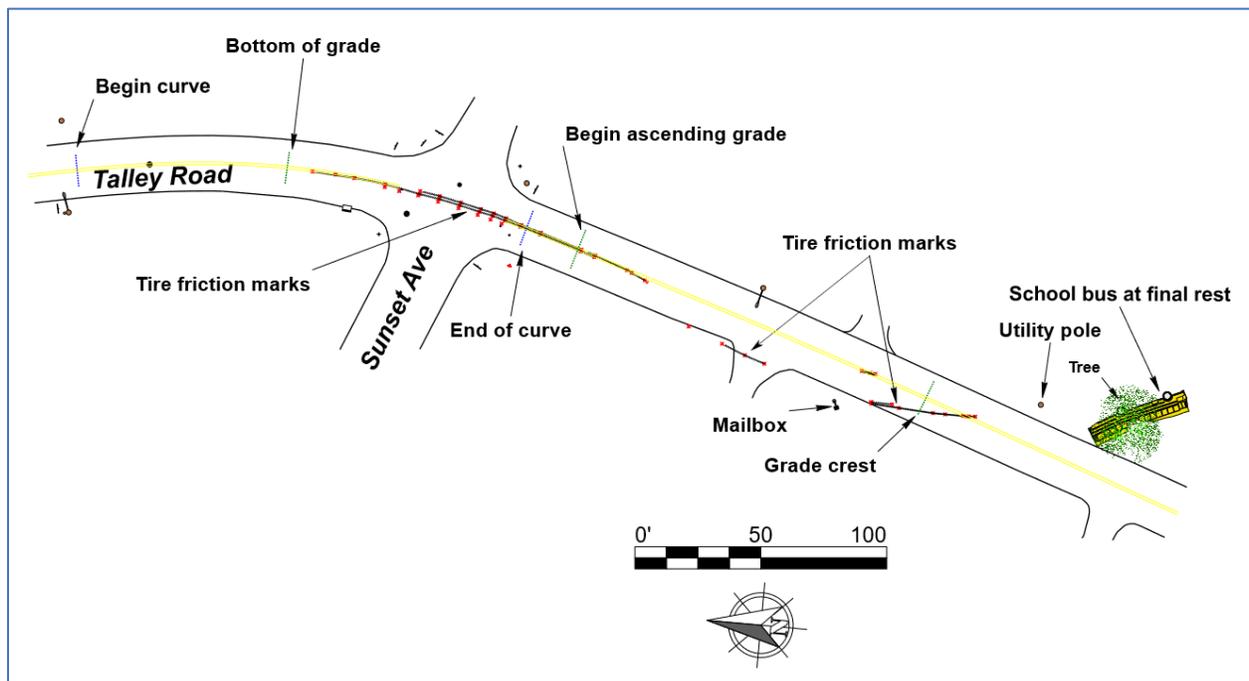


Figure 8. Crash scene diagram, Talley Road, Chattanooga.

Postcrash roadway evidence—consisting of tire friction marks, which tracked atop the pavement along the double yellow centerline or were slightly offset into the northbound travel lane—indicates that the bus driver began to lose control of the vehicle as he drove through the right curve near the intersection with Sunset Avenue. Twenty-five feet past the first set of tire marks, tire impressions parallel to the roadway were documented close to 2.4 feet off the southbound pavement edge to the right (past Sunset Avenue), as shown in figure 8.

As the right-side tires of the school bus traveled across a paved driveway, they created curvilinear friction marks, and the bus struck a roadside mailbox, which was anchored in concrete (figure 9). Tire friction marks on the pavement appeared again 15 feet beyond the mailbox, in a south-southwesterly direction (at a 24-degree angle), toward the northbound side of Talley Road, as shown in figure 8. The longest tire mark terminated in the northbound lane about 26 feet from the utility pole (shown in the figure 8 scene diagram).

³⁸ The tire marks shown in figure 8 near the mailbox are from the right-side tires of the school bus.

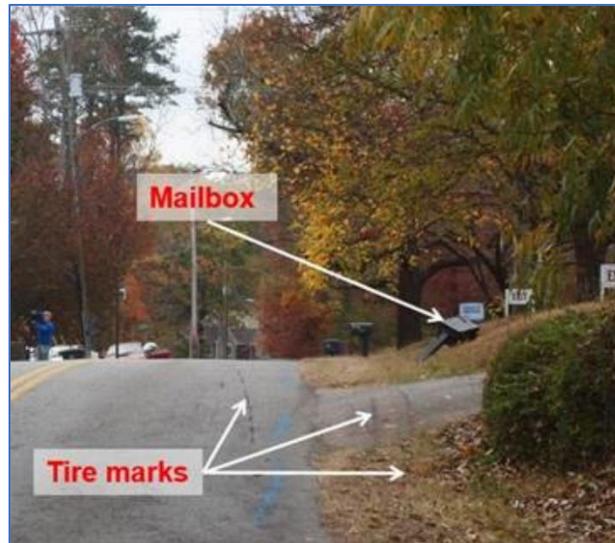


Figure 9. Tire marks on southbound Talley Road and damaged mailbox.

At the front of the bus, the concave-shaped utility pole damage (with an angular orientation of approximately 54 degrees relative to the horizontal ground surface) indicates that the bus was starting to roll over when it struck the pole. Upon impact, the utility pole fractured and was displaced between ground level and the lower tier of the telecommunication lines. At final rest, the bus was overturned on its passenger side against a tree located 36 feet from the utility pole.

2.2.1.4 In-Vehicle Camera Systems and Speed Calculations. The school bus was equipped with an inward-facing three-camera video recording system manufactured by Seon Design Inc.³⁹ Several onboard videos were used to estimate that the bus was traveling 52 mph immediately before it departed the roadway near Sunset Avenue. The onboard videos also captured the image of the white vehicle that was traveling north on Talley Road and passed the school bus less than 2 seconds after the bus had crossed Sunset Avenue.

The tire marks from the school bus are evidence of the vehicle's path and heading, and are considered to be critical speed scuff marks.⁴⁰ The calculated vehicle speed based on tire marks through the curve is somewhat lower than the video analysis data, because the results of friction testing can vary. For this reason, additional calculations were made to allow for a speed range of 45–53 mph. Speed calculations were then performed on the second set of tire marks in the southbound lane of Talley Road, crossing to the northbound side near the utility pole. These calculations showed the bus traveling 40–42 mph as it crossed Talley Road toward the utility pole.

³⁹ One camera was set facing the rear of the bus, one camera showed passengers as they entered the side loading door, and one camera faced forward from the rear of the bus. Reference points along a 623-foot segment of Talley Road (ending 123 feet before the utility pole and tree) were visible in the camera video recordings through the loading door and side windows; the school bus traveled this segment in 8.2 seconds.

⁴⁰ "Critical speed" is interpreted as the speed for a cornering vehicle at which its tires reach the limit of traction (side friction) and begin to sideslip. At the location of the tire scuff marks, the Chattanooga Police Department (CPD) used drag sleds to conduct tire–roadway friction tests.

2.2.1.5 Injuries. Six school bus passengers died in the Chattanooga crash, six were seriously injured, and 20 received minor injuries. Five passengers and the driver were uninjured. (See table 3, figure 10, and appendix C for additional information. NTSB investigators developed the figure 10 seating chart based on interviews with school bus passengers and video evidence.)

Table 3. Injury levels for Chattanooga school bus occupants.

Injury Severity^a	Fatal	Serious	Minor	None	TOTAL
School bus driver	0	0	0	1	1
School bus passengers	6	6	20	5	37
TOTAL	6	6	20	6	38

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

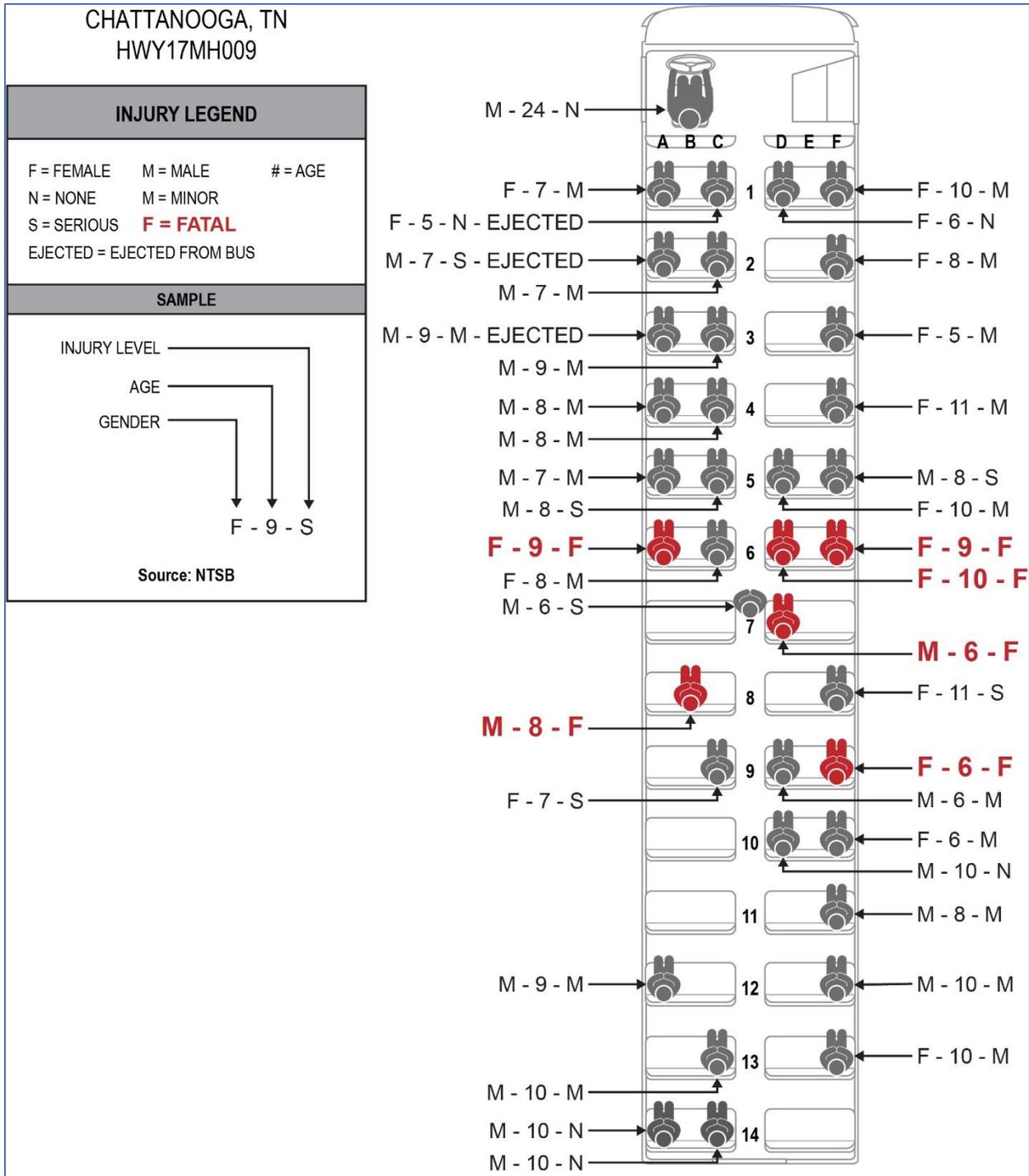


Figure 10. Durham school bus occupant seating chart with injury and demographic information.

2.2.1.6 Other Information. The Chattanooga crash occurred at 3:20 p.m. in daylight. The weather was clear, there was no precipitation, and the temperature was 55°F. Road conditions were dry.⁴¹

The 2008 Thomas Built school bus was equipped with a Cummins engine with an ECM capable of recording crash-relevant data. The bus had a fleet tracking telematic GPS that transmits latitude, longitude, and other data from the motor vehicle. The last recorded parameter was at 15:20:14 p.m. on November 21, at a speed of 0 mph—which corresponds to the crash sequence.

2.2.2 School Bus Driver

2.2.2.1 Licensing. The school bus driver held a Tennessee class B CDL with a school bus passenger endorsement, which was issued in April 2016 with an expiration date in April 2024.⁴²

2.2.2.2 Records Review. The school bus driver passed his medical examination for determination of commercial driver fitness in February 2016 and was issued a 1-year certification.⁴³ Postcrash, the Chattanooga Police Department (CPD) obtained a blood sample from the bus driver. Toxicological screening conducted by the Tennessee Bureau of Investigation was negative for alcohol and other tested-for substances.⁴⁴

NTSB investigators gathered information on the bus driver's precrash activities from employment records, the school bus in-vehicle camera recordings, and cell phone records. On the day of the crash, the driver completed his morning bus route on time and began his afternoon shift at 1:48 p.m.⁴⁵ Based on evidence from the in-vehicle school bus video recordings, it was determined that the driver was using his cell phone (in video mode) when the students loaded onto the bus in the school parking lot. As mentioned earlier, Zonar GPS data indicate that the bus departed the school at 3:13 p.m. A data download of the driver's cell phone, provided by the CPD, documented an incoming call at 3:17:20 p.m. The cell phone was in use and the call active until the crash occurred at 3:20:14 p.m. The call did not terminate until 3:21:10 p.m., postcrash.⁴⁶ The phone number assigned to the incoming call also sent a text message to the driver's phone at 3:21:59 p.m.

⁴¹ (a) Data from the weather station at the Chattanooga Metropolitan Airport, located 5 miles from the crash site, indicated that it was partly cloudy at 3:53 p.m. on November 21, 2016. Visibility was 10 miles. (b) For additional information, see appendix C and the NTSB public docket for this investigation (HWY17MH009).

⁴² A state of Tennessee class B CDL permits the holder to operate, in commerce, a vehicle with a GVWR of 26,001 pounds or more.

⁴³ Tennessee law requires school bus operators to obtain CDL medical certification annually. In the self-reporting health history section, the school bus driver indicated "no" to having had an illness or injury in the last 5 years. The certified medical examiner (CME) indicated that the driver reported negative health history, denied use of current or recent medications, and did not use supplements. The CME report noted no abnormalities.

⁴⁴ The blood was screened for opiates, buprenorphine and buprenorphine metabolites, cannabinoids, cocaine and cocaine metabolites, barbiturates, benzodiazepines, and ethyl alcohol.

⁴⁵ The driver and his family declined to be interviewed by NTSB investigators. Employment records showed that the driver was off work from about 6:30 a.m. on Saturday, November 19, until 6:00 a.m. on Monday, November 21, the day of the crash. No information was obtained regarding his activity during this time off.

⁴⁶ The school bus ECM indicated that the crash occurred at 3:20:14 p.m. The police received a 911 call reporting the crash at 3:20:25 p.m.

Tennessee law, effective July 1, 2016, specifies that school bus drivers cannot use prohibited portable electronic devices (mobile phones, electronic games, cameras, pagers, or laptop computers) while loading or unloading students, or while the bus is in motion and transporting students.⁴⁷ The law makes such use a class A misdemeanor offense, which carries a minimum sentence of 30 days in jail, a fine of at least \$1,000, and permanent prohibition from operating a school bus in Tennessee. The cell phone law specific to school bus drivers was enacted as the result of a December 2014 crash and rollover involving two school buses in Knoxville, Tennessee (NTSB 2016a).

2.2.2.3 Employment and Job Performance. At the time of the Chattanooga crash, the driver had about 5 nonconsecutive months of school bus driving experience, during which he had accumulated numerous complaints about his driving performance, as listed in table 4. For example, on November 16—5 days before the crash—six students sent a complaint about the driver’s intentional swerving and erratic driving to the Woodmore Elementary School principal. To investigate the complaint, the Durham terminal manager downloaded and reviewed the in-vehicle camera recording for the trip. The manager stated that he did not finish the review that week because of his workload, and then he became ill over the weekend. He also left work early on Monday, November 21 (the day of the crash), due to illness. When he returned to his review of the November 16 video (postcrash), he observed the students jostling in their seats, as if the bus driver had made abrupt steering and braking maneuvers.

⁴⁷ (a) *Tennessee Code 55-8-192* (2016), use of portable electronic device by school bus drivers. The Tennessee cell phone and texting laws are considered “primary” laws. (b) “Use” includes talking or texting.

Table 4. Chattanooga school bus driver complaint history, August 11–November 21, 2016.

Date (2016)	Event	Complainant
August 11	Speeding	Durham supervisor
August 12	Speeding	Durham supervisor
August 12	Missed stop	School principal
September 21	Failure to conduct child check ^a	Durham supervisor
September 28	Cursing at child and slamming on brakes, causing child to fall out of seat and hit head	Durham supervisor
<p>As a result, parent complains to school principal, who forwards email to HCDE transportation supervisor and Durham supervisor</p> <p><i>No record of followup action with driver</i></p>		
October 20	Crossing centerline, blocking traffic while discharging students, who then have to cross street	Durham supervisor
October 27	Speeding in parking lot	Durham supervisor
October 28	Speeding, obstructing traffic while discharging students, who then have to cross street	Durham supervisor
November 2	Student issues	Durham supervisor
November 08	Speeding	Durham supervisor
November 11	Speeding	School principal
<p>Principal sends email to HCDE transportation supervisor and Durham terminal manager requesting they review the school bus in-vehicle video for speeding, because she had observed the driver driving too fast when he left the school; she writes that his driving is not “as bad” as the previous day, but it is not optimal</p> <p><i>No record of disciplinary action or corrective training in driver file</i></p>		
November 16	Swerving, erratic driving	School principal
<p>As a result, principal forwards complaints to HCDE transportation supervisor, describing driver intentionally attempting to make students hit their heads or fall from their seats; one student writes that the school bus needs seat belts; HCDE transportation supervisor sends email to Durham requesting a copy of in-vehicle camera recordings</p> <p><i>No record of disciplinary action or corrective training in driver file</i></p>		
November 18	Speeding in school parking lot	School principal
November 21	Crash occurs	

^a A child check is a procedure in which the driver checks every seat on the bus at the end of each route to ensure that no child remains on the bus.

2.2.3 Crash Analysis

On the day of the Chattanooga crash, the school bus driver was less than 2 hours into his afternoon shift. Based on the information provided and evidence documented, he had not worked the previous day, had sufficient opportunity for rest, and completed his morning school bus route on time. Postcrash mechanical inspection of the bus identified no mechanical defects. The weather was clear, the crash occurred during daylight hours, there was no precipitation, and the roadway was dry.

From the NTSB video study and tire mark speed calculations, NTSB investigators determined a speed range of 45–53 mph for the school bus in a 30-mph zone in the right curve at Sunset Avenue. NTSB investigators calculated the geometric design critical speed for the rightward curve using tire–roadway friction values identified by CPD testing. In this case, the critical speed calculation determined that 57–59 mph is the maximum velocity at which the school bus could have effectively negotiated the horizontal right curve (and remained in the appropriate lane of travel).⁴⁸ This calculation—which was performed to evaluate the design aspects of the curve—also shows that, for a school bus traveling at the 30-mph posted speed limit, a lateral acceleration of about 0.17 g would occur, which is consistent with roadway design standards (American Association of State Highway and Transportation Officials [AASHTO] 2011).

In summary, these calculations reveal that the school bus critical speed for the roadway curve is about 5–7 mph higher than the estimated speed of 52 mph from the video study. NTSB investigators determined that there was sufficient friction for the school bus to have safely negotiated the curve at the speed of 52 mph, and NTSB simulations also support that the bus could have negotiated the curve at 52 mph. The NTSB concludes that none of the following were primary or contributing factors in the Chattanooga crash: (1) school bus driver licensing or medical certification; (2) substance impairment, medical condition, or driver fatigue; (3) mechanical condition of the school bus; (4) weather; or (5) roadway design or conditions.

The onset of the tire friction marks within the right curve indicates that the driver was nearing the traction limit of the school bus as he attempted to negotiate the curve. Although he negotiated the curve at 52 mph, the fact that the bus was at the limits of its cornering capability would have made it more difficult to control the bus due to the risk of sliding. The path of the tire marks indicates that the bus initially drifted toward the outside of the lane and then veered back across the lane as it exited the curve. This initial drift to the left, followed by redirection to the right, resulted in the bus traveling a smaller radius path (than if it had stayed in the center of the southbound lane)—which increased the risk that it would reach the limits of its cornering capability. This type of steering maneuver is consistent with a situation in which a driver overcorrects in an attempt to prevent the vehicle from traveling into the oncoming lane.

⁴⁸ The range in calculations is based on a uniform curve radius, as measured along the roadway centerline (352 feet); the average tire–roadway friction as reported by CPD investigators (0.61); and a variable cross slope or super-elevation (0–0.05). The change in cross slope through the curve suggests that the curve critical speed is slightly greater upon entry than through the Sunset Avenue intersection. Critical speed calculations rely on certain assumptions, such as the vehicle following an exact path across a constant radius curve, the vehicle being treated as a point mass that considers the forces acting on all tires to be the same, ignoring overlap in vertical roadway alignment, and the vehicle traveling at a constant speed.

NTSB simulations indicate that the excessive speed of the bus as it entered the curve was the greatest factor contributing to the loss of control. The high speed increased the risk that the bus would reach the limits of its cornering capability, resulting in handling changes that could cause the driver to lose control. Speed would also have reduced the amount of decision-making time available to the driver.

The simulations further indicate that the high speed would have required the bus driver to perform rapid counter-steers (greater than 300 degrees/second in the simulations) as he exited the curve to align the bus with the right lane and stabilize it. Such a maneuver could have been difficult given the driver's limited experience driving a bus and the fact that the bus was operating near the limits of its cornering capability. In the simulations, reducing the speed of the bus to the posted speed limit moved the bus away from the cornering limits and greatly reduced the handling changes and steering effort, which better enabled the driver model in the software program to safely direct the vehicle back into the right lane and align it with the roadway.

The NTSB simulation study identified other possible contributing factors, such as the initial drift of the bus to the left in the curve and the oncoming traffic (the white vehicle observed in the video). In both cases, the simulations indicate that slowing the bus would have reduced the potential risk factors associated with these hazards.

The NTSB concludes that at the accident speed of 52 mph, the Chattanooga bus would have been operating at close to the limits of its cornering capability as it entered the curve; and, if the driver had to suddenly increase steering for any reason while in the curve, the bus could quickly exceed the limits of its cornering capability and become difficult to control. In addition, the NTSB concludes that the high speed of the Chattanooga school bus through the curve was the primary contributing factor to the loss of vehicle control.

After exiting the curve and departing the right shoulder, the school bus crested the hill and struck the mailbox, with the passenger-side tires depositing a second set of curvilinear, critical speed tire scuff marks on the pavement (about 67 feet in advance of the utility pole). As the driver was exiting the curve, the simulations indicate that he initiated a rapid counter-steer to the left in an apparent attempt to prevent the vehicle from leaving the right side of the roadway. As he crossed onto the shoulder, the simulations indicate that he maintained an almost constant steer angle to the left, which caused the vehicle to veer back across the roadway. The resulting tire marks exhibited divergent characteristics, indicating that the bus was now yawing counterclockwise due to the left steering overcorrection. In summary, the NTSB concludes that the failure of the Chattanooga school bus driver to initially react with an appropriate steering input as the bus entered the right curve too fast resulted in the bus departing the roadway and the loss of control, followed by the left overcorrecting steering input—which led to the bus rollover and crash.

The day of the crash was not the first time the bus driver had exhibited risky and, therefore, unsafe driving maneuvers. Shortly after the beginning of the 2016 school year, he began reporting student disciplinary problems to HCDE school staff (the school principal and the HCDE transportation supervisor). As the school year continued, the problems between the driver and the

students continued, and he increased the number of discipline referrals to school administrators.⁴⁹ The driver was then counseled not to submit as many discipline referrals; about 1 week later, the HCDE and Durham received the first complaint that the driver was intentionally trying to make students fall.

Postcrash, NTSB investigators found emails and letters from parents and students about the bus driver's performance in the months leading to the crash, which provided insight into how the driver dealt with student behavioral issues during this period. Student passengers who normally rode this bus told NTSB investigators that when there was excessive noise, or some students refused to sit down, the driver would slam on the brakes or swerve, causing them to fall. (See section 5.2 for additional details.)

Durham did not take any action to relieve the driver of duty, nor were definitive steps taken to resolve the safety complaints. The NTSB concludes that, in attempting to control student behavior, the Chattanooga school bus driver had previously operated the bus in a manner that caused passengers to fall or be thrown from their seats, and that his precrash steering behaviors and speeding were consistent with these unsafe driving patterns.

Information from the driver's cell phone indicates that he answered an incoming voice call about 3 minutes prior to the crash, and the call was still active when the crash occurred. However, because the video did not capture the driver's head, NTSB investigators were unable to determine whether he had held the phone in his hand or had used the speaker. Audio from the video recordings inside the bus reflects a high sound level from the student passengers, which makes it highly unlikely that he could have held a conversation while on the speaker. If the cell phone was hand-held, it likely created a physical impediment to properly steering and controlling the school bus.

Regardless of whether a cell phone is hand-held or on speaker, research has found that talking on a cell phone while driving impairs driver performance through slower reaction times, poor maintenance of speed, reduction in driver scanning, and increases in reaction times to unexpected events (NHTSA 2013). Each of these factors likely contributed to the driver's inability to control the school bus. The NTSB concludes that the driver's cell phone use while operating the Chattanooga school bus increased his crash risk and impaired his ability to control the bus. Furthermore, the NTSB concludes that the Chattanooga school bus driver's speeding—combined with his use of a cell phone while driving—led to the vehicle loss-of-control, run-off-the-road, and rollover crash.

⁴⁹ A student discipline referral form is used to document a behavioral issue for school administrators for use in either counseling or disciplining the student.

3 Maryland Commercial Driver Licensing

3.1 Background

The Commercial Motor Vehicle Safety Act of 1986 instituted safeguards to help prevent driver license fraud. Until that time, significant security loopholes were present in the state processes for issuing driver licenses (American Association of Motor Vehicle Administrators [AAMVA] 2015b). According to AAMVA, people were readily able to obtain multiple driver licenses and identification cards in either single or multiple jurisdictions.

The Federal Motor Carrier Safety Administration (FMCSA) sets minimum CDL standards, while state governments issue CDLs. States are responsible for assessing the qualifications and validity of each driver.⁵⁰ According to the FMCSA, when an individual applies for a CDL or attempts to renew or update a CDL, the state must check its databases to ensure that the driver is not disqualified in that state or another jurisdiction, and does not possess a CDL from more than one jurisdiction.⁵¹

State departments of motor vehicles (DMV) are the primary repositories for driver records. Traffic violations, convictions, suspensions, revocations, and crashes are all reported to the state of license issuance. If a state determines that an applicant has falsified information or any of the required certifications, it must, at minimum, disqualify that person from operating a commercial motor vehicle (CMV) for at least 60 consecutive days. If the person is convicted of fraud related to the issuance of the CDL, the state must record this withdrawal in the driving record and the individual cannot reapply for at least 1 year.⁵²

The issuance of fraudulent CDLs is a nationwide problem. The US Department of Transportation (DOT) Office of Inspector General released a report in 2007 stating that suspected criminal activity had been identified in at least 16 CDL program jurisdictions. Large-scale fraud was identified in the CDL programs of Florida, Georgia, Illinois, and North Carolina. Hundreds of CDLs were fraudulently issued in each of these jurisdictions (DOT 2007). Nationwide, thousands of CDL holders have been retested due to suspicion concerning the issuance of their licenses. In Illinois alone, nine deaths could be directly traced to crashes involving CMV drivers who fraudulently obtained their CDLs. The states have since been working to detect and prevent CDL fraud.

In addition to a knowledge and skills test, all CDL applicants and drivers are required to undergo medical certification examinations (by a medical examiner registered with the FMCSA)

⁵⁰ See the [FMCSA website on overview of state CDL responsibilities](#), accessed June 4, 2018.

⁵¹ Resources include the Commercial Driver's License Information System and the National Driver Register. If the driver holds a license from another jurisdiction, the state must require the CDL applicant to surrender that license before issuing a new one. Provided that federal standards and criteria are met, states determine the application process, license fee, license renewal cycle, renewal procedures, and reinstatement requirements after a disqualification. States may elect to exceed the federal requirements for certain criteria, such as medical, fitness, and other driver qualifications.

⁵² See the [FMCSA website on overview of state CDL responsibilities](#), accessed June 4, 2018.

in accordance with the *Federal Motor Carrier Safety Regulations* (FMCSRs; see also section 4.1). AAMVA has declared that “there is also a public safety concern with individuals who are issued driving privileges when they are not medically eligible to drive” (AAMVA 2015a). Driver license issuance systems should be designed to detect and prevent anyone from fraudulently obtaining a CDL. The integrity of state programs is vital to ensuring the safety of the nation’s public roads. Regardless of whether CDL fraud involves someone who has not taken the appropriate training or passed the necessary tests, or who is medically unqualified to operate a CMV, it endangers passengers and decreases the safety of student transportation. Section 3.2 discusses the Baltimore bus driver’s ability to obtain multiple CDLs when he was not qualified to do so and how the state of Maryland is addressing the issue.

3.2 Baltimore School Bus Driver

3.2.1 Driver License Fraud

The Maryland Motor Vehicle Administration (MVA) records show that the bus driver had repeated license revocations and suspensions over several decades. He had been issued numerous CDLs after providing the MVA with required documents that showed different spellings of his name and different birth dates, including when he applied for and obtained his 2004 CDL.⁵³ Table 5 lists the documented licenses held by the school bus driver and their various forms of revocation and removal.

⁵³ The MVA generates unique driver license numbers through a combination of name and date of birth. The bus driver was able to obtain a new license number by slightly altering one or both identifying factors.

Table 5. MVA license history for Baltimore school bus driver, 1972–2008.

Licenses	Status
License #1a (name version #1, birthdate version #1) Unknown when obtained	Revoked 1972, 1974
Bus driver's license (#1a) was revoked due to points for minor traffic violations in 1972; no indication this license was reinstated; a second revocation was placed on this license in 1974 after a fraud conviction (using a false/fictitious name in license application)	
License #1b obtained through identity theft (see above)	Confiscated 1974
License #2 (name version #2, birthdate version #2) Obtained November 1973 as noncommercial license Upgraded to class A CDL in August 1977 Driver applied for duplicate class A CDL in September 1981 MVA began electronic verification for social security numbers in April 2003, driver stopped using this license when MVA requested verification of social security number Driver requested reinstatement in April 2004, but did not return Medical Advisory Board (MAB) request for further health/wellness and physician information	Destroyed by MVA 2004
MVA records (MAB documentation) from 2004 indicate that individual holding this license (#2) had license privileges refused in 1991, driver returned license to MVA for destruction	
License #3 (name version #3, birthdate version #1)	Refused 1991
Driver was referred to MVA by physician due to medical condition that caused lapses of consciousness MVA attempted to contact driver for interview but was unsuccessful MVA refused license privileges in February 1991 until driver was interviewed	
License #4 (name version #2, birthdate version #1) Obtained September 2004 Obtained school bus endorsement October 2008	Current

The bus driver had obtained a new driver's license in September 2004 by presenting the MVA with a social security card and birth certificate as proof of identity. Although the name on the social security card was not identical to the one on his birth certificate, this inconsistency was not detected by the social security verification service or by the MVA representative. As a result, the driver was issued the CDL, which he renewed in November 2013. A search of his driving history uncovered several violations since he obtained his 2004 license, as summarized in table 6.

Table 6. Personal vehicle driving violation history for Baltimore school bus driver, 2004–2015.

Personal Vehicle Violations^a	Date of Violation	Date of Conviction
Operating motor vehicle while operator/occupant not restrained	11/06/2004	06/17/2005
Driving unregistered vehicle	06/20/2007	01/14/2008
Operating motor vehicle without proper registration plates/stickers	06/20/2007	01/14/2008
Operating motor vehicle while operator/occupant not restrained	11/05/2009	03/29/2010
Operating motor vehicle while operator/occupant not restrained	03/26/2011	05/25/2011
Operating motor vehicle while operator/occupant not restrained	04/29/2011	08/08/2011
Driving vehicle with canceled/suspended/revoked registration	06/12/2011	09/16/2011
Failing to notify MVA within 30 days of change in name/address	01/19/2012	06/13/2012
Displaying registration plate issued to another vehicle or person	01/19/2012	06/13/2012
Failing to carry registration card in vehicle	01/19/2012	06/13/2012
Exceeding maximum speed limit by 10 mph	01/19/2012	06/13/2012
Driving vehicle with canceled/suspended/revoked registration	07/28/2015	11/03/2015

^a Data from US Department of Homeland Security, Federal Bureau of Investigation National Crime Information Center database.

3.2.2 Facial Recognition Technology

The goal of facial recognition technology for the issuance of driver licenses is to maintain a single record per driver and to deter fraud. The system improves public safety by identifying CDL holders who attempt to exploit the state licensing process either to evade traffic tickets and convictions, suspensions, and revocations, or to circumvent medical requirements.

In 2015, the MVA entered the FMCSA-sponsored pilot program to use facial recognition technology to prevent commercial drivers from fraudulently obtaining a commercial license in

their state of residence or in any other partner state.⁵⁴ This technology permits a state to quickly scan its data of current and previous license holders to identify, and prevent licensure to, anyone who has modified his or her name or date of birth to obtain secondary social security numbers for a new license or to bypass suspensions or revocations. Although some states have independently been using facial recognition technology, the pilot program models the sharing of data among states.

Under the FMCSA pilot program, the MVA started using facial recognition software for drivers who are obtaining or renewing a CDL. The pilot program allows the MVA up to 400,000 photographs (the database has 180,000 photographs, which includes current CDL holders, in addition to those of all drivers whose licenses were suspended/canceled/revoked in the past 10 years). Through the end of the pilot program in 2019, the state can incrementally add an additional 220,000 photographs.

Facial recognition technology also prevents an individual whose license was canceled or revoked due to a medical issue from bypassing the system and obtaining a new license. Although the technology was not in place in 2004—and, therefore, would not have detected the Baltimore bus driver when he fraudulently obtained his CDL—the pilot program and facial recognition can now prevent a driver whose CDL has been revoked by the MAB from fraudulently obtaining a license in Maryland or in any of the states with which Maryland shares this information.⁵⁵

3.2.3 Other State Licensing Programs

From 2010 to 2012, the New York DMV conducted a study to determine whether drivers with multiple license records pose a serious traffic safety risk on state roadways (AAMVA 2015a). Based on data compiled by the State University of New York Institute for Traffic Safety Management and Research, for drivers with multiple license records (more than 12,300 cases), 24 percent did not have a valid license, 67 percent had been involved in a crash, 10 percent had been convicted of impaired driving, 27 percent had been convicted of a cell phone violation, and 34 percent had accumulated six or more points on their license records within an 18-month period at some point after November 18, 2004.⁵⁶

After New York State began using facial recognition technology in 2010, through August 2015, it had arrested more than 3,500 people for possessing multiple licenses. Among

⁵⁴ (a) In 2016, Maryland also began issuing licenses that include an inventory control number unique to each license holder. Partner states in this pilot program include New York, New Jersey, and Connecticut. (b) AAMVA has developed model programs in motor vehicle administration, law enforcement, and highway safety—and promotes the “one driver, one record” driver license concept. According to AAMVA, “facial recognition is a fraud prevention, fraud detection, business integrity, and risk mitigation tool used by the majority of US and Canadian motor vehicle agencies.” To determine whether the person in one photograph is the same person in another photograph, the software automates the process of photo image matching. See the [AAMVA webpage on best practices and model legislation](#), accessed June 4, 2018.

⁵⁵ The MAB assesses the medical fitness to drive for those who have conditions that may affect their ability to safely operate a motor vehicle. See the [MVA website on the MAB process for medical referrals and review](#), managed by the MVA Driver Wellness and Safety Division, accessed June 4, 2018.

⁵⁶ The 67, 10, and 27 percentages compare to 43 percent, 2 percent, and 9 percent, respectively, of all New York State-licensed drivers.

people identified as having multiple license records, 50 percent of the licenses had been suspended or revoked under at least one name.⁵⁷

3.3 Safety Recommendations

In continuation of the facial recognition pilot program, the MVA plans to (1) examine the photographs of all CDL holders in the state to determine if any person has more than one CDL or an additional CDL in a partner state; and (2) compare the photographs of its CDL holders with archival photographs of drivers from the past 10 years whose licenses have been suspended, canceled, or revoked. However, the FMCSA-sponsored program in Maryland expires in 2019, at which time the state must provide funding.

On multiple occasions over a span of four decades, the Baltimore bus driver used “proof of identity” documentation inconsistent in name spelling or date of birth to obtain new driver licenses after previous licenses had been revoked or refused. Most recently, as shown in table 5, after his previous license was flagged by the MVA as belonging to someone who might have a disqualifying medical condition, he secured a new license by presenting identifying documentation that showed a different date of birth.

The NTSB concludes that the Baltimore school bus driver had fraudulently obtained his driver’s license by providing documents with different name spellings or birth dates to circumvent the MVA verification system. Based on the school bus driver’s ability to obtain a CDL he was not qualified to receive in 2004, the NTSB concludes that the MVA verification system failed to prevent the Baltimore school bus driver from obtaining a driver’s license through fraudulent means. Furthermore, the NTSB concludes that the MVA facial recognition program can help prevent persons identified as unqualified for licensure from continuing to operate a CMV under a fraudulently obtained license or from obtaining a CDL through fraudulent means. Therefore, to help prevent driver license fraud, the NTSB recommends that the state of Maryland continue the facial recognition program beyond 2019.

Currently, the pilot program in Maryland does not compare the photographs of CDL holders with *all* driver license holders in the state, or partnering states, to determine if someone has more than one driver’s license of any type. The MVA has stated that the database has the capacity to include photographs from as far back as the mid-1990s (when it began storing digital photographs); thus, if these photographs are included, the current application of the pilot program has the capability of identifying all CDL drivers who are unfit to drive or who possess more than one driver’s license. Therefore, the NTSB recommends that the MVA process all current CDL holders through the facial recognition software system to detect those drivers who may hold fraudulent licenses.

⁵⁷ In August 2015, the New York DMV and the New Jersey Motor Vehicle Commission were the first two motor vehicle agencies in the nation to share photographs for use in facial recognition systems. The two states had initiated this pilot program in response to a number of serious crashes throughout the country involving CDL drivers who possessed multiple licenses from different states. See the [New York DMV press release of August 17, 2015](#), accessed June 4, 2018.

4 School Bus Driver Fitness for Duty

The reliance on CDL holders to self-report medical conditions to certified medical examiners (CME) during the medical certification process is an ongoing commercial driver public safety issue.⁵⁸ The NTSB has a long history of investigating crashes in which drivers failed to report their medical conditions, were issued medical certificates, and were subsequently involved in fatal crashes in which the medical condition contributed to the event (NTSB 2016c; 2015d; 2013; 2012; 2011a; 2002a; 2002b; 2001b).⁵⁹ Section 4.2 examines (1) the disqualifying medical condition of the Baltimore school bus driver, (2) how the CMEs who issued him a medical certificate were unaware that he was not medically qualified to operate school buses (or any commercial vehicle), (3) how other health-care providers and non-law-enforcement first responders who medically treated the driver were aware that he had a seizure disorder and was a school bus driver, and (4) ways for nonphysician health-care providers (including non-law-enforcement first responders) and those within the school bus community to expeditiously refer drivers to state licensing agencies for evaluation.

4.1 Federal and Maryland Medical Examination Requirements

The FMCSA establishes regulations for the licensing of CMV drivers, including school bus drivers employed either directly by a local school district or by a contracted motor carrier that provides student transportation services. Under 49 *Code of Federal Regulations* (CFR) 391.41, the FMCSRs require that a person who operates CMVs in commerce be medically certified as physically qualified to operate such vehicles. This regulation explicitly prohibits drivers with epilepsy or other LOC conditions from obtaining a medical certificate. Drivers who demonstrate that they have been seizure-free and off antiseizure medication for a minimum of 10 years can apply for a waiver.⁶⁰ Typically, the medical certificate is valid for 2 years; however, in some states, including Maryland (under the *Code of Maryland Regulations* [COMAR]), school bus drivers must obtain a medical certificate annually, and no waivers are accepted.⁶¹

⁵⁸ Beginning in 2014, health-care providers performing these examinations are required to be certified by the FMCSA (49 CFR Part 390).

⁵⁹ These crashes occurred in Anaheim, California; Davis, Oklahoma; Chesterfield, New Jersey; Miriam, Nevada; Gray Summit, Missouri; Mountainburg, Arkansas; Jackson, Tennessee; and New Orleans, Louisiana, respectively.

⁶⁰ A driver may apply for a waiver if he or she meets certain criteria, and the waiver would allow that person to drive a CMV. Federally, a driver with epilepsy requires a waiver to drive commercially (49 CFR 391.41(b)(8); 49 CFR Part 391, appendix A, Medical Advisory Criteria, section H, Epilepsy).

⁶¹ Examinations for medical certification may result in one of four outcomes with respect to medical qualification. The driver may be found: (1) to meet the standards in 49 CFR 391.41 and be issued a medical certificate; (2) to meet the standards, but require periodic evaluation for one or more conditions and be qualified for 3 months, 6 months, or 1 year; (3) to be temporarily disqualified due to a condition or medication; or (4) to not meet the standards. For more information, see 49 CFR 391.41, 391.43, and 391.45. The state of Maryland has adopted the FMCSA medical standards for purposes of licensing individuals to drive CMVs intrastate under 49 CFR 391.41(b). See [COMAR 11.19.05.01, physical examination](#), accessed June 11, 2018.

4.2 Medical History of Baltimore School Bus Driver

Medical records from the school bus driver's primary care physician (beginning in November 2010) document a history of seizures and type 2 diabetes. Although he had been prescribed medications to treat both conditions, he was noncompliant with his medication regimen (discussed in section 2.1.2).⁶² In October 2011, the driver was also diagnosed with hypertension.

4.2.1 CDL Medical Examination History

Concentra, Inc., which provides occupational medicine services across the United States, conducted the bus driver's most recent medical examinations for commercial driver fitness determination (2014, 2015, and 2016).⁶³ On each of the commercial driver fitness forms—in the self-reporting health history section—the driver checked “no” to having had an illness or injury in the last 5 years, including seizures, epilepsy, diabetes, hypertension, and heart disease, and “no” to taking any medications.⁶⁴

During the bus driver's February 3, 2014, medical examination at Concentra, his blood pressure reading was 142/92.⁶⁵ Before the CME would issue a 1-year certificate, the driver was told to have his health-care provider complete a Concentra form for hypertension (see appendix D).⁶⁶ The FMCSA encourages CMEs to obtain additional information from treating physicians to make informed decisions about medical certification, though it offers no guidelines or suggested best practices for doing such. CMEs employed by Concentra use a variety of forms to obtain additional information from primary care providers for specific medical conditions, but, generally, the forms do not explicitly ask for all active medical conditions or medications.

On February 24, 2014, the bus driver returned with the form filled out by a nurse practitioner (not his primary care physician) whom he had visited on this one occasion. The driver denied knowing of any medical conditions or using any medications. The nurse practitioner recorded the driver's blood pressure as 132/89 and checked the box indicating that the identified condition should not cause sudden impairment or interfere with his ability to safely operate a vehicle. Concentra issued him a 1-year certificate.

In February 2015, during the driver's Concentra medical examination, the urinalysis and blood glucose testing suggested diabetes.⁶⁷ He was issued a 3-month medical certificate and instructed to have his primary care physician fill out the Concentra form regarding his diabetes.

⁶² In December 2010, the bus driver was prescribed metformin as treatment for diabetes.

⁶³ The BCPS contracted with Concentra to perform commercial driver medical examinations and certifications.

⁶⁴ This form is also referred to as the “DOT long form.”

⁶⁵ The FMCSA threshold for blood pressure readings is 140/90.

⁶⁶ On that day, the bus driver was issued a 3-month certificate, which expired in May 2014.

⁶⁷ A urine dip test during the medical examination identified 500 mg/dL of glucose, and results from a random blood glucose test were 226 mg/dL. A “normal” random blood glucose level is below 140 mg/dL; higher levels indicate diabetes. When blood glucose exceeds 180–200 mg/dL, the kidneys respond by allowing glucose to spill into the urine. Glucose in the urine indicates likely diabetes.

He did not return to Concentra for a medical examination before the certificate expired in May 2015.

On August 25, 2015, the bus driver was seen by his primary care physician, who responded to the questions on the Concentra form specific to diabetes, but did not report the patient's history of seizures or treatment with antiseizure medication (see section 2.1.2).⁶⁸ The physician noted on the form that the driver: (1) had a history of hypertension and type 2 diabetes; (2) was on oral diabetic medications and checked blood glucose levels daily; and (3) did not have a history of complications or hypoglycemic episodes. The physician also noted that his patient "was under false assumption he has no hypertension or diabetes because they are treated with medication." She responded "no" to the question of whether the driver's diabetes would impair his driving ability. On August 31, 2015, Concentra re-examined the driver; his physical exam and testing were unremarkable, and he was issued a 1-year certificate.

On June 20, 2016, the driver was again examined at Concentra; his physical exam and testing were unremarkable, and he was issued a 1-year certificate.

4.2.2 Emergency Medical Care

In addition to the bus driver's primary care physicians, other health-care providers were aware that he suffered from seizures. Between 2005 and 2017, the driver was seen in hospital emergency departments multiple times for multiple issues, and each time he reported his health history of epilepsy.⁶⁹ Medical records for a May 2005 hospital admission show that one of the treating physicians noted that the patient was a "bus driver" but was not working due to disability. For a September 2007 visit, the record noted that the patient was a "school bus driver" and had a history of a seizure disorder.

The driver also was seen in the emergency department following acute seizures in November 2008, April 2009, and August 2010; the records of these visits did not indicate his occupation. EMS responded to the driver's bus crash on October 14, 2011 (see table 2 in section 2.1.2). A bus passenger reported to EMS that the driver had passed out behind the wheel, and she tried to gain control of the bus when it struck a parked vehicle. The driver had been unconscious for 5–10 minutes. EMS noted that he was walking around but "confused" and unaware of what had happened; he was transported to the hospital.⁷⁰ This medical event occurred 3 days before the

⁶⁸ The driver was examined at Concentra in June 2015. Again, he did not indicate a history of medical conditions, such as seizures/epilepsy, diabetes, hypertension, or heart disease. His blood pressure was recorded as 138/86, which is slightly below 140/90, the FMCSA threshold for hypertension. The driver's urinalysis again suggested diabetes; and, as a result, Concentra withheld a medical certificate until a response was received from the primary care physician. The driver files include a second signed consent form allowing Concentra to request health information from his primary care physician.

⁶⁹ All but one of these visits were related to complications from a complex leg fracture in 2001, which apparently occurred during a tractor-trailer rollover crash (according to information the bus driver reported to his health care providers and they documented in his records). The remaining emergency department visit was to have a foreign object removed from his eye.

⁷⁰ The bus driver's Glasgow Coma Scale score (a method of scoring the degree of consciousness) was 14/15; the score for a normally functioning person is 15. His blood glucose measured 322 mg/dL. Due to his confusion status, EMS administered a dose of narcan (opioid antidote), which had no effect.

driver's visit to his primary care physician, when he reported seizures and having run out of carbamazepine. In January 2012, the driver visited the emergency department to request a refill of his antiseizure medication (carbamazepine).⁷¹

After the June 30, 2016, seizure witnessed by the Reliable bus attendant who called 911 (described in section 2.1.2), EMS transported the bus driver to a local hospital. The attending physician documented that the patient "states he was prescribed Dilantin as a child for seizures, but hasn't taken it in decades." The driver denied having any other medical conditions or using any medication and left the emergency department without completing the intended evaluation. Finally, on October 24, 2016, EMS was called to the AAAfordable office after the driver was witnessed having a seizure. According to the EMS report, the driver denied having seizures, was "reluctant to answer questions and purposefully avoids eye contact," would not permit a full assessment, and refused transport to a hospital.

4.2.3 Safety Recommendations

The bus driver had a history of seizures and noncompliance with his medication regimen. He did not meet the FMCSR waiver requirements for a CDL of any type, and his epilepsy would have disqualified him from ever driving a school bus in the state of Maryland. Although he routinely reported his epilepsy to his personal physicians and hospital health-care providers, he repeatedly denied the condition or use of medications to CMEs during occupational CDL exams.⁷² The NTSB concludes that the Baltimore school bus driver understood his diagnosis of epilepsy and intentionally hid the disqualifying medical condition and use of treatment medications during his commercial driver medical examinations to prevent denial of certification.

In the 2.5 years prior to the crash, when the physical examination tests (blood pressure and urine) detected the driver's hypertension and diabetes, Concentra had required him to obtain additional medical information prior to being issued a medical certificate. However, the Concentra form given to the primary care physicians narrowly focused on the identified conditions—rather than specifically requesting a report on *all* of the driver's medical conditions and medications.

The FMCSA allows CMEs to perform or obtain diagnostic tests or medical opinions from medical specialists or treating physicians. However, there are no FMCSA requirements that CMEs request additional information from a treating physician (FMCSA 2013).⁷³ The FMCSA medical examiner handbook states: "Seek further testing or evaluations for those medical conditions of which you are unsure." Concentra, which performs more than 800,000 CDL medical examinations

⁷¹ NTSB investigators obtained the driver's pharmacy records. His most recent prescriptions for lisinopril, glucose testing items, and a 30-day supply of carbamazepine were filled on August 7, 2015. No other pharmacy records were located after that date up to November 1, 2016, the day of the crash.

⁷² Deliberate omission or falsification of information may invalidate the examination and any corresponding certificate, and the driver's medical certificate for his CDL would likely have been revoked. A civil penalty may also be levied against the driver under 49 *United States Code* 521(b)(2)(b), either for making a false statement or for concealing a disqualifying condition.

⁷³ See the [FMCSA national registry webpage](#), accessed June 11, 2018.

each year, had established a process for its CMEs to obtain additional information during the medical examination process. This method goes beyond FMCSA requirements.

CMEs can make better medical fitness determinations if they are fully informed about a driver's medical problems and medications. In the Baltimore case, the bus driver intentionally hid his epilepsy from the CMEs. The NTSB concludes that the Concentra forms used to collect additional information provide an opportunity for CMEs to learn from treating health-care providers of the conditions that a driver has omitted from his or her medical history. To better document medical issues identified during CDL examinations, the NTSB recommends that Concentra revise its medical information request forms provided to consultants or treating providers to also include specific requests for a complete list of current medical conditions and medications.

The FMCSA has developed a standardized questionnaire to assist the CME in obtaining additional information on a driver's use of potentially impairing medications that are disclosed during the self-reporting history and physical examination for CMV driver certification. Appendix E provides a copy of the form, *391.41 CMV Driver Medication Form*, MCSA-5895.⁷⁴ According to the FMCSA, the completed form is intended to ensure that there are no disqualifying or underlying medical conditions or prescribed medications that could adversely affect safe driving or cause incapacitation, constituting a risk to the public.⁷⁵

The FMCSA form currently states: "During the medical evaluation, it was determined this individual is taking medication(s) that may impair his/her ability to safely operate a CMV." This statement assumes that the driver revealed the medication to the CME—and that the CME has the skill and experience to determine that the medication may be impairing.⁷⁶ In the case of the Baltimore bus driver, in the self-reporting section of the form, he intentionally omitted diagnosed medical conditions and prescribed medications. As a result, the CME would have had no reason to use the form to obtain additional medical information.

The NTSB concludes that—though a CME may use the *391.41 CMV Driver Medication Form* to record medications a driver is using to assist in determining certification status—the form does not specifically address medications that indicate a potentially impairing condition or conditions that may be directly hazardous. CMEs must be alerted to obtain appropriate and complete medical information from treating health-care providers, in addition to supplementary information on any identified condition. Therefore, the NTSB recommends that the FMCSA provide explicit guidance to encourage CMEs to request a complete list of current medical conditions and medications when obtaining supplemental information from a commercial driver's treating health-care provider.

⁷⁴ This form is optional and may be used at the discretion of the CME to communicate with prescribing health-care providers, enabling the CME to make a more informed determination for medical certification.

⁷⁵ See the [new collection notice for the CMV driver medication form](#) (81 *Federal Register* [FR] 44675, July 8, 2016; document number 2016-16199), accessed June 4, 2018.

⁷⁶ Many CMEs are licensed to perform physical examinations but not licensed to prescribe medication; they may not be aware of the impairing effects of prescribed or over-the-counter medications. The FMCSA provides no guidance for CMEs in identifying whether a given medication may be impairing.

4.3 Medical Condition Reporting to Driver Licensing Agencies

4.3.1 Categories and Methods of Referral

All state licensing agencies accept third-party reporting of drivers with medical conditions that may impair their ability to safely operate a vehicle. A state MAB then evaluates the medical condition and safety of the driver to determine if that person should continue to hold a license. In some states, law enforcement and physicians may have additional opportunities or requirements to report. In Maryland, the MVA provides statewide training workshops to help physicians, health-care professionals, social workers, and law enforcement identify medically at-risk drivers; work with the aging driver population; and make appropriate referrals when necessary.

From 2005 to 2007, the MVA assessed what factors prompt police officers to refer drivers to the MAB (Soderstrom and others 2009). The study included 486 police referrals; 59.1 percent of referred drivers had been involved in collisions, and almost 60 percent were referred because of concerns about medical fitness to drive. Although the study did not determine if medical conditions were related to crash causation, it did note that LOC was highly correlated with crash causation. Seizures are one of the most common causes of LOC associated with crashes, and seizures most often occur in individuals with a diagnosis of epilepsy (Sheth and others 2004).⁷⁷ Of the 486 drivers in the study, almost 90 percent of those who experienced LOC crashed. Overall, law enforcement decisions to refer drivers to the MAB were based on observed driving actions and observed medical conditions.

In October 2013, the MVA established a method for law enforcement to make an electronic medical referral of a driver through the Delta Plus system maintained by the Maryland State Police.⁷⁸ As shown in figure 11, referrals from law enforcement have increased since deployment of the electronic method for reporting a medically at-risk driver.

⁷⁷ The other common cause is severe hypoglycemia in persons with diabetes who require insulin to control blood glucose levels (Cox and others 2003; Songer and Dorsey 2006).

⁷⁸ According to the MVA, “medical referral,” “request for re-exam,” and “RRE” (paper form DC-039, Request for Re-Exam)—as well as “eReferral” through the Delta Plus system—are used interchangeably and describe the submission of a driver’s information to the MVA medical review process.

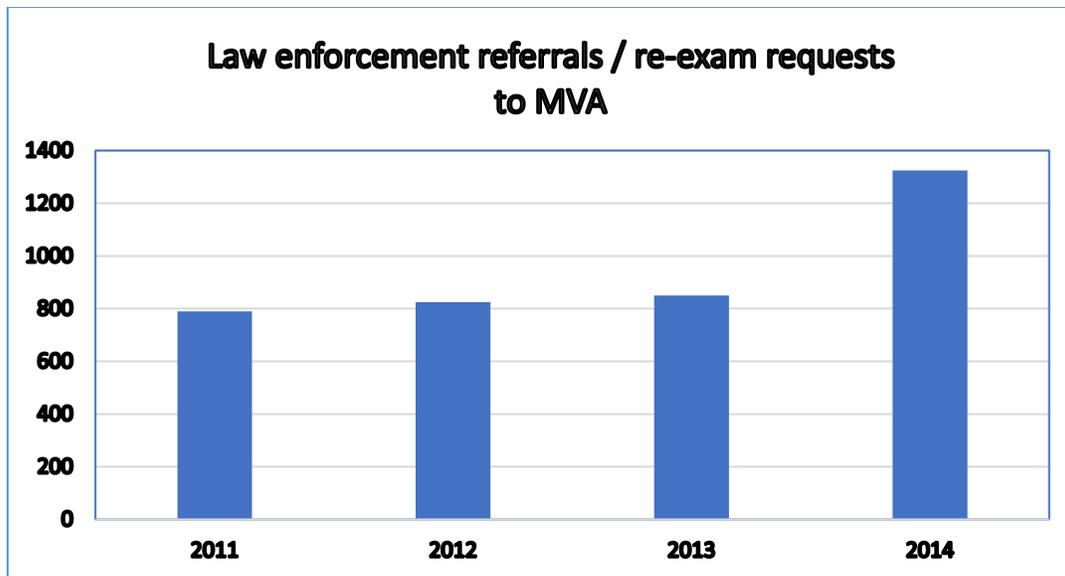


Figure 11. MVA data showing increase in law enforcement referrals of medically at-risk drivers. (Source: Maryland Department of Transportation)

Under COMAR, any physician or any other person authorized to diagnose, detect, or treat disorders characterized by lapses of consciousness *may* report a driver with these conditions to the MVA.⁷⁹ Physicians and other primary care providers (such as nurse practitioners or physician assistants) are strongly encouraged to refer patients to the MVA if they have any concerns about medical fitness to drive.⁸⁰ The state has provided an online electronic form (DC-220) to begin the medical referral process. Once the MVA forwards a physician or law enforcement referral to the MAB, it is required to arrange an examination of the reported person and cancel his or her license if they fail to meet statutory requirements.⁸¹ Although Maryland state law permits—and the MVA prioritizes—physician referrals of drivers with conditions, such as epilepsy, that can negatively affect the ability to safely operate a motor vehicle, based on documentation reviewed during the investigation, not one of the treating physicians who saw the bus driver in the years after 1991 reported him to the MVA.

⁷⁹ For specific state requirements, see *Annotated Code of Maryland*, Maryland Vehicle Law, Transportation Article, Section 16-119, and COMAR 11.17.03.02; [General Assembly of Maryland statute text for 16-119](#), accessed June 4, 2018.

⁸⁰ There are two basic types of referral: (1) referral of a patient for whom there is great concern about current fitness to drive, with a recommendation for suspension of the driving privilege; and (2) referral of possible concerns about fitness to drive, with a request for evaluation of the driver. In the first case, the referral should note medical conditions and the reasons why they are thought to preclude safe driving. The MVA affirms most recommendations for suspension.

⁸¹ See the [MVA webpage on MAB referrals](#), managed by the MVA Driver Wellness and Safety Division, accessed June 4, 2018.

Other health-care professionals (who are not physicians, such as registered nurses, paramedics, and EMS technicians) are required to make a referral directly to the MVA by letter.⁸² According to EMS records and hospital records, the Baltimore bus driver had been observed to seize or become unresponsive on multiple occasions, and numerous health-care providers either witnessed his seizures or were aware of his seizures or epilepsy diagnosis. Several were also aware of his occupation as a commercial driver, such as emergency department registered nurses and the paramedics and EMS technicians who responded to his crashes or to the AAAfordable office. These health-care providers made no reports to the MVA. According to the MVA, in 2014, health-care providers (clinical referral) accounted for only 8 percent of referrals, as shown in table 7.

Table 7. Composition of MVA driver referrals by source, 2014.

Source	Number of Referrals	Percentage of Referrals
Medical followup ^a	2,459	31
Self-report or branch referral	1,467	19
Law enforcement	1,319	17
Driver license reinstatement request	940	12
Other	698	9
Clinical referral	634	8
Administrative law judge	190	2
Court	41	1
Family/individuals	105	1
TOTAL	7,853	100

^a “Medical followup” refers to the reevaluation of a driver who has already been identified by the MVA as having a potentially impairing condition.

In addition, numerous school bus company coworkers and supervisors—and BCPS employees—knew of or witnessed the driver having a seizure or medical event, in some cases while he was driving or preparing to drive a school bus. The MVA accepts letters of concern from individuals about any person’s ability to drive. Letters of concern are first authenticated; if the concern is validated, the referred driver is requested to submit a medical report and health questionnaire for review. No one reported the school bus driver to the MVA.

⁸² See the [MVA webpage on the medical review process](#), managed by the MVA Driver Wellness and Safety Division, accessed June 4, 2018.

4.3.2 Safety Recommendations

The MVA has established an expedited electronic method for physicians and law enforcement personnel to report a driver with a medical condition. No electronic method is available for other concerned individuals. As a result, registered nurses, EMS technicians, paramedics, other first responders, and nonphysician health-care providers are required to submit letters of concern to initiate the process. Because first responders—such as EMS technicians and paramedics, and fire department personnel—routinely respond to crash scenes, they may be aware of a driver’s medical conditions from direct observation. They also have close working relationships with law enforcement officers and emergency department personnel. As such, first responders may be a valuable resource for reporting medically impaired drivers. Finally, in many situations, registered nurses spend the most time with patients and are aware of their medical conditions and social behaviors.

The state of Maryland established its MAB in 1947; it is one of the oldest licensing agency boards in the United States (Lococo 2003). Since then, the MVA has developed a comprehensive system of referral and evaluation for medical fitness to drive (Soderstrom and Joyce 2008). The MVA can assess database statistics to determine whether health-care professional (nonphysician) reporting of medically at-risk drivers is an active source of referrals to the MAB. Such an evaluation could also determine the effectiveness of the current reporting method (by letter rather than online electronic form).

Although crash risks associated with the entire population of epileptic drivers are not well understood, there is little controversy regarding the risks of a noncompliant driver who has experienced multiple recent seizures, as in the Baltimore crash (Classen and others 2012; Krumholz 2009; Naik and others 2015).⁸³ The NTSB concludes that nonphysician health-care providers and non-law-enforcement first responders are a potentially valuable, but underutilized, resource in the reporting of drivers with medical conditions. Therefore, the NTSB recommends that the MVA assess the volume of referrals by nonphysician health-care providers and first responders (other than law enforcement) to determine whether improved outreach and adjustments to current reporting methods may increase their reporting of medically at-risk drivers.

The bus driver’s coworkers and supervisors—and BCPS employees—who knew of his crashes due to either seizures or LOC had many opportunities to report him (even anonymously) to the MVA. The state provides no waivers for school bus drivers with a history of seizures. No one can be qualified to drive a commercial vehicle if it is known that they have a current clinical diagnosis of epilepsy or take antiseizure medication. The Baltimore crash might have been prevented had a coworker or BCPS employee reported the driver to the MVA.

However, it is unclear whether the bus driver’s coworkers and other BCPS employees who witnessed or knew of his lapses of consciousness were aware that they could refer him to the MVA. The NTSB concludes that school districts and their contracted student transportation service providers would benefit from awareness training on federal and state commercial driver fitness

⁸³ For states that require physician reporting, there is no evidence of decreased crash rates for patients with epilepsy when compared to states that do not have mandatory reporting (McLachlan, Starreveld, and Lee 2007).

regulations and the avenues available to report drivers with medical conditions that may make it unsafe to operate a school bus. The NTSB recommends that the MVA and the Maryland State Department of Education (MSDE) publicize to the state school districts and school bus communities the methods available for individual reporting of school bus drivers with medical conditions that may affect their ability to safely operate a school bus.

School bus drivers with potentially hazardous medical conditions are of concern nationwide. Every state allows individual reporting of medically unsafe drivers to the state licensing agency. Therefore, the NTSB also recommends that the National Association of State Directors of Pupil Transportation Services (NASDPTS), National Association for Pupil Transportation (NAPT), National School Transportation Association (NSTA), American School Bus Council, and Maryland School Bus Contractors Association inform their members of the circumstances of the Baltimore school bus crash and lessons learned from the crash investigation to help raise awareness of the avenues available to report school bus drivers with medical conditions that may make it unsafe for them to operate a school bus.

4.4 Electronic Health Records

4.4.1 High-Risk Medical Conditions and Driver Impairment

Few of the health-care providers who had treated the Baltimore school bus driver recorded that he held a CDL or drove a school bus—or addressed his driving status at all, even when caring for him in the emergency department following a seizure. Current state-of-the-art medical information systems could be used to remind health-care providers to address the driving status of patients with epilepsy or other LOC conditions—and could even inform them of the patient’s occupation. In the United States, electronic health records (EHR) are rapidly replacing paper charting systems. By 2015, 87 percent of office-based physicians were using some form of EHRs; and by 2016, over 95 percent of hospitals were using EHRs.⁸⁴

In addition to capturing the same information as paper-based systems, most EHRs offer health-care providers “decision support,” such as reminders for additional testing or specific treatments. This supporting information may include identifying drug interactions among medications, suggesting certain screening tests based on age and gender, offering vaccines at the appropriate times, and suggesting other tests related to the patient’s specific health conditions or medications.

Currently, a patient’s occupation is often entered into the EHR during the registration phase of a visit, when insurance and payment information is obtained. The patient’s occupation is generally not readily visible on the health-care provider’s screen view and may be difficult to locate. However, within an EHR, decision support could be developed to identify patients with chronic medical conditions or acute complaints that might indicate a potential driving hazard, such as LOC episodes or seizures; to notify the health-care provider of the patient’s occupation, such as commercial driver; to remind them to assess any physical or mental conditions that might pose a

⁸⁴ See the [US Department of Health and Human Services health information technology dashboard](#), accessed June 4, 2018.

driving risk; and to address the occupational and driving status of the patient, including a reminder to report concerns about the patient's driving to the state licensing agency.

4.4.2 Safety Recommendations

To improve the frequency with which health-care providers address the safety risks of seizures, particularly with respect to driving, the NTSB concludes that EHRs should be configured with reminders of specific data, such as the patient's occupation. Within the industry, the companies Epic, Cerner Corporation, eClinicalWorks, MEDITECH, and NextGen Healthcare account for roughly 54 percent of the EHR marketplace.⁸⁵ Therefore, the NTSB recommends that Epic, Cerner Corporation, eClinicalWorks, MEDITECH, and NextGen Healthcare develop decision support for the evaluation of nontraumatic LOC episodes or for a diagnosis of epilepsy that will notify providers of the patient's occupation, such as commercial driver; and remind them to address the occupational and driving status of the patient, including the opportunity to inform the state licensing agency of concerns about the patient's driving.

⁸⁵ As of 2016, all other vendors carry less than 4 percent of the market each; see the [WebMD Medscape 2016 EHR report](#), accessed June 4, 2018.

5 Oversight of Student Transportation Providers and Bus Drivers

Section 5 reviews NTSB findings from both the Baltimore and Chattanooga crashes and examines the lapses in oversight that allowed unsafe drivers to operate school buses. In both cases, the local school districts hired contractors to provide student transportation services; however, the two school districts handled the oversight of the contracted drivers in different ways. For example, in Baltimore, the BCPS maintained a direct role in overseeing the motor carrier and the bus drivers. In Chattanooga, the HCDE contract specified only minimal oversight of the motor carrier and delegated oversight of the bus drivers to Durham.

Section 5.1 discusses the BCPS oversight of AAAfordable, including two early NTSB safety recommendations to the BCPS and one early recommendation to the MSDE. Section 5.2 discusses the Chattanooga bus driver's failure to meet performance standards and Durham's inadequate driver monitoring, which led to a failure to remediate risky driver behavior.

5.1 Baltimore Crash

5.1.1 School Bus Contractors

AAAfordable began operations in 2004 after acquiring two school buses and the accompanying student transportation contracts in Howard County, Maryland. In 2009, the carrier purchased five buses from a BCPS-contracted transportation provider, which included the contracts. At the time of the crash, AAAfordable operated 16 school buses, employed 14 CDL bus drivers, and contracted to BCPS for seven routes and to Howard County for three routes.⁸⁶

On June 30, 2016 (just prior to being rehired by AAAfordable), the school bus driver had a seizure, which was witnessed by a fellow Reliable employee (previously noted in table 2 and section 2.1.2.3). The driver was transported to the hospital. After this incident, Reliable continued to dispatch the driver on school bus routes, despite not having a medical release for him. According to payroll records, the driver's last day of work for Reliable was August 12. On August 26, he was informed that prior to returning to work, he had to bring a note from his doctor stating that he was medically fit. The driver did not obtain a doctor's note and, according to Reliable, was terminated.⁸⁷ In the interim, on August 19, he had already returned to AAAfordable and was hired.

⁸⁶ AAAfordable was listed with the FMCSA as an intrastate motor carrier of passengers.

⁸⁷ Again, Reliable provided no details regarding the termination.

When AAAfordable rehired the driver, it did not conduct an adequate background check.⁸⁸ Had the carrier checked the previous employer history, modeling the FMCSA standard outlined in 49 CFR Parts 391 and 382/40, it might have learned about the previous crashes and the driver's June 30 seizure. As a result, any potential safety net intended to prevent a medically unfit and unsafe driver from operating school buses was rendered ineffective when ignored by contracted student transportation service providers—and the BCPS provided no oversight in this regard. Even as an intrastate motor carrier, a contracted student transportation provider is required to adhere to the FMCSRs for CDL requirements.

The NTSB investigation uncovered that AAAfordable had overlooked high-risk driver events. One week prior to the crash, the bus driver had a seizure at work, which was reported to EMS in a 911 call by the company dispatcher who witnessed it. When EMS arrived, the driver refused a full assessment and declined medical transport to a hospital. AAAfordable instructed him to get a medical evaluation before returning to duty. However, he returned without a medical release, and the carrier permitted him to operate a school bus with passengers, putting them at risk. At 49 CFR 392.3, the FMCSRs state:

No driver shall operate a commercial motor vehicle, and a motor carrier shall not require or permit a driver to operate a commercial motor vehicle, while the driver's ability or alertness is so impaired, or so likely to become impaired, through fatigue, illness, or any other cause, as to make it unsafe for him/her to begin or continue to operate the commercial motor vehicle.

AAAfordable should have followed the regulatory guidance at 49 CFR 391.41 and had the driver properly evaluated by a medical doctor and cleared for duty. The NTSB concludes that AAAfordable exercised poor driver safety oversight by allowing a known medically unfit driver to operate a school bus for 5 consecutive days leading up to, and including, the day of the Baltimore crash.

5.1.2 Baltimore City Public Schools

The BCPS provides student transportation by means of both city- and contractor-owned school buses.⁸⁹ At the time of the crash, the BCPS contracted with 10 motor carriers to provide student transportation services and maintained all documentation related to the bus drivers, such as CDL medical examinations; pre-employment, random, and postaccident alcohol and other drug testing; initial MVA records; and criminal background reports. Prior to hiring a driver, the BCPS was to review the applicant's credentials against its records of all school bus drivers and notify the contracted transportation provider if the driver met, or was "deficient" in meeting, any of the

⁸⁸ As required by 49 CFR 391.53, each motor carrier must maintain records relating to the safety performance history of a new or prospective driver. The record must include the previous employer's name and address, the date of contact, and the information received about the driver. Failure to contact a previous employer, or of the employer to provide the required safety performance history, must be documented. The driver file must include a copy of the response(s) received from each previous employer or documentation of good faith efforts to contact them. NTSB investigators reviewed both the Reliable and AAAfordable applications and found that the driver listed only three employers during a 10-year span and did not list the same employers on both applications.

⁸⁹ MTA buses and taxis also provide BCPS transportation services.

certification items, or if the driver had previously been disqualified.⁹⁰ Once certification criteria were met, the motor carrier could hire the driver for BCPS routes; however, the BCPS retained the authority to “disqualify (suspend or terminate) the certification of contractor employed bus personnel.”

The BCPS file on the bus driver showed that between 2008 and 2016, he had worked for five BCPS-contracted motor carriers.⁹¹ NTSB investigators reviewed BCPS accident records and found reports on four crashes (listed in table 2) in the driver file. Investigators also identified the July 19 crash, which the BCPS was notified of, but it did not appear in the driver file. As detailed in section 4.2, the driver’s 5-year history while employed by contractors for the BCPS included numerous crashes and incidents, in many of which LOC was mentioned as the cause, thereby strongly suggesting an underlying medical condition. Yet, the BCPS did not evaluate the driver’s fitness for duty as a school bus driver, even though it had the oversight responsibility and authority to disqualify, suspend, or terminate a driver employed by a contractor.

In addition, the BCPS was responsible for conducting in-person interviews with school bus drivers if they were involved in a school bus crash, administering disciplinary action, and requiring remedial training as necessary. The BCPS did not interview the bus driver after his bus crashes or medical events. Moreover, postcrash, NTSB investigators found that the BCPS lacked both guidance on disciplinary action for driver infractions and a threshold for the number of allowable crashes. For example, in 2015, the driver was suspended for 90 days for failing to report a crash and leaving the accident scene, but the BCPS lifted the suspension with no reason given. Although COMAR prohibits a school bus driver from having two crashes with \$1,500 or more in appreciable damages within 24 months, the BCPS operating guidance did not address how to manage drivers who are repeatedly involved in crashes, requirements for remedial training, or when other interventions are warranted.

5.1.3 Maryland State Department of Education

COMAR 13A.06.07 establishes regulatory guidance and oversight for student transportation throughout the state of Maryland. These regulations cover school bus driver qualifications, evaluation of drivers every 2 years, drug and alcohol testing requirements, general standards, vehicle inspections, routing, and operating procedures. The MSDE Office of Pupil Transportation develops and implements statewide policies and procedures for all aspects of transporting students to and from public schools. This office maintains databases for school bus driver crashes and offenses related to drugs and alcohol and coordinates activities with the MVA.

⁹⁰ Certification items included in the DOT physical include MVA record, copy of CDL with passenger and school bus endorsement, preservice training, certification expiration data, pre-employment drug test, criminal background check (conducted by the BCPS), social security number, and whether the applicant was BCPS certified. The MSDE maintains a confidential database of school bus drivers who meet disqualification criteria under COMAR. Disqualifications may be classified as “lifetime ban” for serious offenses, such as child abuse—while other infractions, such as driving record infractions, have a specific statute of limitations. Before hiring bus drivers, transportation managers in Maryland school districts are required to verify with the MSDE that the drivers are not listed on the disqualified database.

⁹¹ These companies were C&T Transportation, City Wide Bus Company, Barber Transportation, Reliable, and AAfordable.

5.1.4 Safety Recommendations

The NTSB identified deficiencies with the BCPS and MSDE oversight of school bus driver qualifications and operations. To address these failures in oversight, the NTSB issued an early safety recommendation report on the Baltimore crash (NTSB 2017b).

Among other deficiencies, the report identified the failure of the BCPS to adequately examine, track, or act in response to reports of previous crashes concerning the bus driver.⁹² Specifically, in the past 5 years, he had been involved in at least nine crashes or incidents while operating a school bus or personal vehicle. However, only a subset of these events had been reported to the BCPS—and even those were not adequately documented, considered, or reviewed. When each new crash was reported, the BCPS failed to scrutinize the reports of the driver's prior crashes—and did not recognize or respond to the pattern of documented medical events. Lastly, the BCPS did not take appropriate action to determine the driver's fitness for duty in response to the October 14, 2011, crash in which he passed out while driving a school bus. Because the BCPS did not adequately document the driver's previous crashes, BCPS personnel with oversight responsibilities had incomplete information to determine whether he should be disqualified from driving a bus for the school district.

These specific shortcomings in BCPS student transportation operating procedures, along with the deficiencies noted in the safety recommendation report, placed BCPS students and the traveling public at risk (NTSB 2017b). The NTSB concludes that though the BCPS was responsible for driver oversight, it failed to address multiple deficiencies and to identify the bus driver as high risk.

The BCPS did not perform many of its oversight responsibilities, was inconsistent in interpreting state regulations (COMAR) on what conditions disqualify school bus drivers from employment, and did not comply with federal and state regulations for reviewing or maintaining driver records. Because of concern that the risks posed by unqualified drivers were high, the NTSB issued two safety recommendations to the BCPS (NTSB 2017b):

Request that the Maryland State Department of Education have an independent and neutral third party conduct a performance audit of your transportation department that includes a review of crash reports and of disqualifying conditions for school bus drivers under *Code of Maryland Regulations* section 13A.06.07.07. (H-17-13) (Urgent)

As soon as the performance audit referenced in Safety Recommendation H-17-13 is complete, take the corrective actions recommended to improve internal controls and ensure that all school bus drivers meet the qualification standards under *Code of Maryland Regulations* sections 13A.06.07.06–.07 and that they do not pose any safety risks. (H-17-14)

⁹² The NTSB documented numerous instances in which the BCPS did not review crash reports, did not document crash costs, did not maintain criminal background reports, and had a drug-testing program that did not comply with the FMCSRs. BCPS postaccident drug testing did not meet the requirements of 49 CFR 382.303.

The NTSB also issued one safety recommendation to the MSDE:

Review and modify the *Code of Maryland Regulations* section 13A.06.07.07, “School Vehicle Driver Disqualifying Conditions and Termination,” to clarify the definitions of disqualifying conditions, and to require notification to the Maryland State Department of Education of all drivers who are determined to be not qualified during pre-employment screening. (H-17-15)

The BCPS requested that the MSDE have an independent and neutral third party audit the BCPS transportation department. On January 31, 2018, School Bus Contractors, under contract to the MSDE, completed the audit—which concluded that the BCPS had systemic organizational vulnerabilities, deficient internal controls, and a lack of necessary guidance from its governing authority as related to transportation services. These conclusions are consistent with issues discovered during the NTSB investigation of the BCPS and its contractors—and which led the NTSB to issue the urgent recommendation calling for an audit.

In addition to not following its own—though lacking—standard operating procedures, the BCPS was found to be out of compliance with several federal and state regulations. The audit further identified instances of medically unqualified drivers, inconsistent and inadequate postcrash actions by the BCPS and its contractors, and inappropriate drug and alcohol testing methodology.

The audit recommends immediate corrective actions, emphasizing the absence of BCPS leadership and oversight personnel. Based on the review of this audit and support of its recommendations, the NTSB classifies Safety Recommendation H-17-13 “Closed—Acceptable Action.”

The BCPS shortcomings in the oversight of school bus drivers placed BCPS students, as well as the public, at risk. Drawing further concern is the audit’s finding that the BCPS has made minimal progress in remedying these deficiencies since the November 1, 2016, crash. Although the BCPS provided NTSB investigators with information on some postcrash actions it has taken to better review crash reports and driver qualifications, until the corrective actions recommended in the audit report are completed and the BCPS processes are improved, Safety Recommendation H-17-14 remains classified “Open—Acceptable Response.” In October 2017, the MSDE and the state of Maryland informed the NTSB that COMAR was in the process of being modified.⁹³ As a result, Safety Recommendation H-17-15 is classified “Open—Acceptable Response.”

⁹³ In reviewing relevant sections of COMAR, NTSB investigators had found, for example, that the regulations did not define “crime of violence,” though school bus drivers could be disqualified for committing such. Although AAAfordable hired the driver to drive buses for the BCPS, the contractor for a neighboring school district had determined that he was not qualified due to a combination of traffic violations and items in his criminal record. Other terms not clearly defined in COMAR 13.06.07 were “unsafe actions,” “misfeasance,” and “incompetence.” The NTSB concluded that this lack of clarity in COMAR requirements introduced inconsistencies in the driver qualification processes for Maryland school districts.

5.2 Chattanooga Crash

5.2.1 State, County, and Contractor Oversight

At the time of the Chattanooga crash, Durham School Services was operating as a contracted student transportation service provider to the HCDE. Durham is a subsidiary of National Express LLC, which operates school buses under contract to public school districts in 36 states through several motor carrier companies.⁹⁴ Durham operates 13,806 school bus vehicles and employs 13,742 school bus drivers.⁹⁵

In Tennessee, for the 2014–2015 school year (most recent data available), 9,178 school buses transported 654,785 public school K–12 students daily. Of these, 6,399 school buses were district-owned, and 2,779 were contractor-owned.⁹⁶ As reported by Hamilton County, the HCDE transports more than 20,000 students to and from school each day, and has 231 bus routes covering 19,000 miles per day.⁹⁷ At the time of the crash, the state of Tennessee had limited oversight of contracted student transportation service providers. Tennessee state law incorporates the FMCSRs in 49 CFR Parts 390–397. The FMCSRs applicable to intrastate operations are the CDL requirements for drivers operating CMVs, as defined in 49 CFR 385.5, and the required controlled substances and alcohol testing for all CDL holders.⁹⁸

The HCDE, under its contract with Durham, had limited oversight of Durham operations.⁹⁹ The contract stated that Durham was responsible for “supervision, training and direction in the performance of personnel job duties.” All driver and vehicle issues were to be handled by Durham, and the school district was not responsible for investigating or tracking complaints against Durham drivers or vehicles. The established procedure was to forward all complaints to the carrier for resolution. However, postcrash, HCDE representatives stated that an HCDE official had the authority to prohibit children from getting on a Durham bus leaving the school premises if they believed it was warranted for safety reasons.¹⁰⁰

⁹⁴ National Express home-to-school companies operate more than 22,000 school buses, contract with more than 500 school districts in 36 states, and transport 1.2 million students daily; see [National Express website](#), accessed June 4, 2018.

⁹⁵ Data obtained from the FMCSA motor carrier identification report (form MCS-150).

⁹⁶ See the [IC Bus webpage on school transportation statistics](#), accessed June 4, 2018.

⁹⁷ See the [HCDE webpage on transportation services](#), accessed June 4, 2018.

⁹⁸ Exceptions to the regulations also include all school bus operations as defined in 49 CFR 390.5 (use of a school bus to transport only school children and/or school personnel from home to school and from school to home), except for the provisions of 49 CFR 391.15(e) and (f), 392.80, and 392.82. *Tennessee Code Annotated* 65-15-106 gives the Tennessee Highway Patrol the authority to stop and inspect CMVs and buses.

⁹⁹ The HCDE has a 42-page transportation policy document that applies to HCDE employees only—not to private for-hire carriers such as Durham.

¹⁰⁰ In one case, an HCDE principal stopped children from boarding a school bus because the driver was suspected of being impaired. Upon inquiry by NTSB investigators, the HCDE was unaware of whether the driver had been disciplined or terminated.

5.2.2 Employment, Training, and Driver Performance History

Durham hired the Chattanooga school bus driver in January 2016. The carrier provided him with in-house commercial driver training from January to April 2016, including instruction on driving and defensive driving skills, braking, and student management.¹⁰¹ He completed all training requirements and received approval to independently drive a school bus in May 2016. He did not drive a bus over the summer and resumed driving for Durham when the new school year began on August 11, 2016.

The bus driver was involved in two crashes while operating a school bus for Durham. The first crash occurred on August 18, 2016, when he struck a curb on the edge of a roadway, which damaged the bus. The driver did not report this crash to his supervisor.¹⁰² The second crash, on September 20, 2016, involved sideswiping another vehicle and causing property damage. Following each crash, Durham conducted a driver evaluation and retraining.¹⁰³ In addition, Durham had counseled the driver for several performance-related issues, such as being late for work and taking a school bus home.¹⁰⁴

National Express provided Durham and its employees with a 66-page employee handbook. The handbook enumerates serious safety violations that may result in termination on the first offense—which include failure to perform a proper child check and failure to report an accident or injury in a timely manner.¹⁰⁵ The policy requires employees to immediately report any accident, incident, or injury to supervisors or managers (the driver was documented as having committed each of these violations); and employees are required to attend all mandatory safety meetings and safety training, which the driver did not do.¹⁰⁶

In addition to the driver's two crashes in a school bus, his repeated instances of tardiness, and his failure to perform a proper child check, as discussed in section 2, he had accumulated numerous complaints about his driving performance. The HCDE provided parents with a telephone

¹⁰¹ Additional topics included pretrip inspection, injury prevention, backing skills, student loading and unloading, preparing to drive, intersections, railroad crossings, and safe work practices.

¹⁰² The crash was discovered when a Durham employee noticed the damage to the bus when it was returned to the bus yard at the end of the day. The crash did not involve another vehicle and was not reported to the police department.

¹⁰³ The bus driver's license history listed this property-damage-only crash (sideswiped a passing vehicle on a curve), which occurred on September 20, 2016 (no injuries), for which he was issued a citation. As of February 2018, the traffic citation had not been adjudicated and was not indicated in his license history. The driver had a non-CDL license suspension in October 2013 for failure to show proof of insurance while operating a private vehicle.

¹⁰⁴ The driver was counseled for being late to work on August 22, 2016; on October 4, he received written counseling for being late on six occasions; and on October 26, he received a final warning notice and written counseling for being late to work on eight occasions. The driver took a school bus to his home on November 17.

¹⁰⁵ The handbook also states that the use of a cell phone or other personal communication device while operating a company vehicle is a serious safety violation that may result in termination on the first offense.

¹⁰⁶ (a) Durham was unable to locate documentation of the driver attending any of the mandatory safety events. (b) Payroll records did not show the driver having attended a mandatory safety event, and carrier representatives were unable to provide information as to why he did not attend. (c) At the time of the crash, tracking and managing safety meeting attendance was performed at the local level. Beginning in January 2018, a BeaconInsight software system is being used to track attendance (or nonattendance) at safety meetings and required makeup sessions.

number at the beginning of the school year to report transportation issues, but calls made to this number were received by Durham at the Chattanooga terminal rather than by the school district. Some complaints by parents and students were reported directly to the Woodmore Elementary School principal, as well as by email to the HCDE transportation supervisor, to a Durham site supervisor, and to the Durham–Chattanooga terminal manager (see table 8). The HCDE policy was to forward driver performance complaints directly to Durham; the HCDE transportation manager routed the emails to Durham’s terminal manager. NTSB investigators found no documentation that an HCDE transportation supervisor sought to obtain any final resolution or feedback as to the outcome of the forwarded complaints.

Table 8. Chattanooga school bus driver history with student behavior management issues, September–November 2016.

Date (2016)	Event/Response
September 19	Driver submits two student discipline referrals to school administrator Response: <i>School administrator acknowledges receipt of referrals by email, no course of action noted, no information in driver file</i>
September 28	Parent complains driver cursed at child and slammed on brakes, causing child to fall out of seat and hit head; school principal forwards email to HCDE transportation supervisor and Durham terminal supervisor Response: <i>No record of followup action</i>
November 2	School staff observes driver arguing with student and shouting profanities, driver insists student be removed or he will not drive bus Response: <i>School administrator responds and speaks with bus driver, HCDE transportation supervisor sends email to Durham terminal manager recommending driver be coached on dealing with students, no record in driver file of corrective action or counseling regarding this incident or student interaction</i>
November 9	Driver submits list of students for discipline referral; complains of students facing rearward, standing, and engaging in “horseplay” while bus is in motion Response: <i>No information</i>
November 10	Driver submits list of 10 students for discipline referral, complains of students standing while bus is in motion, expresses concern students will be injured if he brakes unexpectedly Response: <i>On November 11, HCDE transportation supervisor sends email to school principal and Durham terminal manager saying he will speak to driver about discipline referrals, HCDE transportation supervisor acknowledges driver has legitimate concerns but states “he can’t be turning in 10 referrals in a day”</i>
November 21	Crash occurs

According to Durham, the site supervisor hand-recorded telephone and email complaints in notebooks. Postcrash, NTSB investigators found numerous complaints in notebooks and in additional emails that were not documented in the bus driver's employee file.¹⁰⁷ Investigators interviewed several complainants about the driver's speeding and other issues—such as intentionally swerving or braking hard, causing students to fall out of their seats and be injured. They found that many of these additional complaints were not documented in the site supervisor's notebooks or in the employee file. When asked about a formal process for handling driver performance complaints, both National Express and Durham representatives stated that they did not have a centralized complaint tracking system. Although some of the complaints about the driver were mentioned in written company communications, details of the complaints (including outcome or resolution) were not documented.

Since the crash, Durham has implemented a driver monitoring program for the HCDE and other contract locations as a means of addressing bus driver complaints and documenting resolutions. An electronic portal allows both school system employees and Durham management to record complaints, collects the information in a central database, logs the response actions, and documents disciplinary or training actions in the driver's employee file.

National Express and Durham implemented a company-wide program to allow the public, employees, and carrier management to initiate a driver complaint. The database collects and stores information about the complaint, prioritizes complaints based on risk, and tracks complaint resolution and response deadlines.¹⁰⁸

Durham has installed additional driver performance monitoring in-vehicle camera systems (DriveCam by Lytx, Inc.) on Chattanooga school buses to provide outward as well as driver-facing camera views.¹⁰⁹ The recording begins when the driver has an unusual driving event, such as hard braking, a sharp turn, excessive speed, or a crash. After every trip with an unusual driving event, video from the bus is uploaded for review; Durham is notified if an unsafe driving event has occurred.

¹⁰⁷ According to the Durham–Chattanooga terminal manager, the complaint system process was as follows: the terminal manager evaluates whether the complaint can be addressed; GPS and on-board video from the school bus are downloaded and reviewed; the validity of the complaint is determined; and the complaint is sent to the site supervisor, if minor, or remains with the terminal manager for resolution (typically coaching or written disciplinary action). If there is no direct evidence of speeding or other violation, no further action is taken. Alternatively, some complaints are handled at the site supervisor level and are not recorded in the employee file.

¹⁰⁸ According to National Express, it uses an online system, BusReport, in all school bus locations, including Chattanooga. Response deadlines are generated by a computer-based predetermined priority; the greater the safety risk of the complaint, the higher the priority and the shorter the response deadline. When a complaint response deadline is delinquent, senior management is notified. In addition, a toll-free number is posted on school buses in Tennessee, Illinois, New York, and Connecticut. National Express customers may also set up a portal to input feedback directly to BusReport. Public access to the portal is available through each school system or county department of education website.

¹⁰⁹ The accident bus had a camera facing the loading door, a rearward-view aisle camera, and a front-facing aisle camera from the last row. The camera views did not show the forward path of the school bus or the driver's head or upper body. With the new DriveCam system, event recordings are transmitted to the monitoring service daily. Upon receiving notification of an event trigger, the monitoring service screens the event to determine if it is a driver problem or a nonsignificant occurrence. If it is determined to be a driving-related event, the incident is forwarded to management.

Durham's response to recorded unsafe driver events must be indicated within the allotted time, along with the actions taken for resolution.¹¹⁰ When response parameters are not met, the next management level is notified, and notification continues until the system indicates an adequate response. The amount of time allowed for a response/resolution is determined by event severity. To address driver performance issues, National Express stated that it will conduct refresher training or additional training—or initiate disciplinary action as needed. As of March 2017, National Express had over 2,000 driver performance monitoring camera systems installed and in use in nine locations. Full company-wide implementation is expected by the end of 2019.

5.2.3 Management of Student Behavior

On school buses, as with any vehicle, passenger behavior has the potential to be a source of driver distraction and a safety hazard. The management of student behavior is the process by which bus drivers interact with school children during transportation to and from school. It is a prescribed approach that addresses both disciplinary and safety issues.

The Chattanooga bus driver received training on student behavior management during his CDL training with Durham prior to being permitted to independently operate a school bus route. The Durham curriculum provided guidance on communicating with students, keeping students seated while the bus is in motion, techniques and directives for dealing with problem students and enforcing discipline, and communicating problems to school administrators. The curriculum also discussed the submission of student discipline referrals.¹¹¹

As shown in table 8, NTSB investigators documented numerous instances in which the bus driver was involved in student behavior management issues. The driver file showed no record of specific student management remedial training or employee counseling, nor did Durham take corrective action after receiving complaints that indicated escalating issues with his handling of student behavior.

The school bus driver's poor performance leading up to the crash escalated to risky driving maneuvers, such as unsafely steering or swerving and speeding to address unruly student behavior by making students fall or be thrown from their seats, as documented in parent and HCDE employee complaints. However, the HCDE contract with Durham conveyed all oversight of drivers to the motor carrier, which failed to adequately track driver complaints or intervene in performance and safety issues. As a result, even with numerous parent and staff complaints about the bus driver's unsafe driving behaviors—which placed student safety at risk—neither Durham nor the HCDE intervened; and the HCDE did not follow up to determine the outcome of the reports of unsafe driving. The NTSB concludes that the HCDE failed to follow up to determine the

¹¹⁰ A medium-to-low risk event severity response time is 5 days. A high-risk event severity requires a 48-hour response time. The regional manager is notified if the complaint is not acknowledged within 24 hours.

¹¹¹ According to Durham, the driver was tested on his knowledge of the curriculum in a written examination. During his final behind-the-wheel evaluation, he passed an on-the-road driving test under observation of his ability to apply the principles of student behavior management.

outcome of driver-related complaints and remove an unsafe driver from transporting county students.

Following the Chattanooga crash, the state of Tennessee, on May 19, 2017, enacted a law that establishes a program for the monitoring and oversight of transportation services for local education authorities, school districts, and charter schools.¹¹² The legislation, effective January 1, 2018, directs the Tennessee Department of Education and the Tennessee Department of Safety to:

- Develop and deliver a mandatory annual training program for all transportation supervisors.
- Establish a system for monitoring district and charter school compliance with state and federal laws regarding student transportation services.
- Prepare and annually update and disseminate guidelines on best practices for the management of student transportation services.
- Require that school districts develop formal policies for responding to school bus safety complaints.

NTSB investigators discovered numerous instances in which the bus driver violated Durham safety policies and procedures in the several months of his employment beginning in May 2016. The Durham policy manual is clear as to the severity of some of these violations, stating that “immediate termination of employment can and may result.” The driver had at least three such violations within his 5 months of driving for Durham: failing to perform a child check, failing to report a crash, and inappropriate verbal interactions with a child. When investigators examined the driver’s employee file, they found documentation of each violation, but no evidence of him having been counseled or actions taken to terminate or otherwise discipline him beyond remedial driving training for the preventable crash he did not report and written warnings for being late to work.

In addition, Durham had no systematic method for recording, tracking, or investigating complaints of driver behavior. Many of the complaints found during the investigation in emails or in the supervisor’s notebook, for example, were not documented in the driver’s employee file, and there was no apparent resolution of any investigation into misconduct or safety violations.¹¹³ The HCDE, Woodmore Elementary School administrators, and several Durham employees had received numerous driving-specific complaints about the driver’s risky operating behavior, which was increasing in frequency and severity. Although a Durham supervisor logged these complaints,

¹¹² Amends *Tennessee Code Annotated* Title 49-6-21, section 55-50-302; and Title 55-9-6. The law also requires that new school bus drivers complete a training program prior to transporting students and that a driver be at least 25 years old to receive an initial school bus driver license endorsement.

¹¹³ Durham did not use GPS data from the bus to track the driver’s adherence to his assigned route. He had been driving the route since August 2016; however, GPS data show that he drove the route in reverse order on Friday, November 18—and also on the following Monday, the day of the crash. The crash occurred 1 mile from the school (which was the origin of the route). Durham was unaware that the driver had varied his route, though it was aware that this was a common practice among some drivers.

no evidence of action or counseling was found in the driver's employee file. Consequently, carrier officials did not have an accurate understanding of the driver's pattern of escalating performance issues. Since the crash, as discussed in section 5.2.2, Durham has implemented a system to address these issues.

5.2.4 Safety Recommendations

The NTSB concludes that Durham (1) did not adhere to established policies and procedures for handling school bus driver disciplinary issues; (2) lacked a systematic and detailed process to manage complaints or allegations concerning its drivers; and (3) was, therefore, deficient in driver oversight. The NTSB further concludes that Durham failed to resolve complaints so as to remediate the bus driver's risky driving behavior, and to intercede and remove him from operating the school bus—even though some Durham supervisors were aware of the numerous complaints of his mishandling of student discipline, including unsafe driving behaviors.

The NTSB recommends that National Express implement a process to track driver complaints from initial call to case resolution throughout its student transportation service provider companies, including Durham. The NTSB also recommends that National Express use industry best practices to establish resolution accountability for serious or recurring safety violations, to include effective remediation of unsafe driver behavior.

6 Large School Bus Occupant Protection

6.1 Overview

Because of their robust design and unique operating environment, school buses are one of the safest modes of transportation. For example, school buses are designed with a passive form of occupant protection, termed “compartmentalization,” which requires no action by the passenger and functions by forming a compartment around the bus occupant. The closely spaced, energy-absorbing high-backed seats deform in a crash and allow passengers to “ride down” the collision.¹¹⁴ Compartmentalization is designed to contain passengers within their seating compartments during frontal and rear impact collisions. A key aspect of this occupant protection system is that passengers remain within the compartment prior to, and during, an impact, so that they benefit from the energy-absorbing design of the seats.

For many years, the NTSB has advocated for enhancements to school bus safety, including issuing occupant-protection-related safety recommendations for large school buses (NTSB 2016a; 2013; 2011a; 2009b; 2002a; 2001a; 2000; and 1999).¹¹⁵ These recommendations particularly address side impact collisions and rollovers, in which compartmentalization is incomplete and provides insufficient protection for school bus occupants.

6.1.1 NHTSA Data and Federal Standards

More than 15 years ago, NHTSA crash testing showed that school bus passengers were better protected from head injury with lap/shoulder belts than with compartmentalization or lap belts only. NHTSA has also evaluated school bus occupant protection and estimates that lap/shoulder belts in school buses may reduce rollover fatalities by 74 percent. However, to date, there is no federal requirement for large school buses to be equipped with seat belts, a vital component for occupant protection. In 2008, NHTSA published a final rule (with an effective date of October 21, 2011) that upgraded the school bus occupant protection requirements of various *Federal Motor Vehicle Safety Standards* (FMVSS), including (1) the requirement for lap/shoulder belts (rather than lap belts) for all passenger seating positions on school buses with a GVWR equal to or less than 10,000 pounds; and (2) the establishment of performance standards for seat belts *voluntarily* installed by states or school districts on school buses with a GVWR greater than 10,000 pounds (these vehicles are referred to as “large school buses”).¹¹⁶ Currently, NHTSA advocates

¹¹⁴ A “ride-down” effect brings the bus passenger to a stop with the vehicle—rather than having the passenger continue to move and strike the interior parts of the bus.

¹¹⁵ These recommendations were products of the following crash investigations: Knoxville, Tennessee; Chesterfield, New Jersey (including also Port St. Lucie, Florida); Gray Summit, Missouri; Milton, Florida; Mountainburg, Arkansas; Conasauga, Tennessee; and Central Bridge, New York, respectively—in addition to the bus crashworthiness SIR.

¹¹⁶ (a) See 49 CFR Part 571, “Federal Motor Vehicle Safety Standards, Seating Systems, Occupant Crash Protection, Seat Belt Assembly Anchorages, School Bus Passenger Seating and Crash Protection, Final Rule.” (b) The final rule developed performance standards for both lap belts and lap/shoulder belts on large school buses if the belts were *voluntarily* installed. The rule requires higher seatbacks for all school buses, but does not require that passenger lap or lap/shoulder belts be installed in large school buses.

that compartmentalization is the best means of providing crash protection to passengers of large school buses.¹¹⁷

Although many school buses are designed with compartmentalization as the sole occupant protection system, precrash, lateral, and rollover motions still expose unbelted passengers to injury-producing components within the vehicle, to intrusion, to movement out of the seating compartment, and to ejection. For 1985 through 2016, Fatality Analysis Reporting System data document that 352 school bus occupants were fatally injured in 3,492 school bus crashes; within this group, crashes involving rollovers were far more likely to result in fatalities, with 124 deaths in 117 rollover crashes. More recently, NHTSA reported that from 2007 to 2016—of the fatal crashes involving school transportation vehicles—more than 50 percent were not frontal crashes, for which compartmentalization was designed. For maximum safety in all types of crashes, school bus passengers need additional protection beyond compartmentalization. Passengers without lap/shoulder belts remain vulnerable to either ejection or injury within the school bus interior, sometimes from being thrown into an intrusion area. To provide additional protection for passengers of large school buses, some states require that all new school buses be equipped with passenger lap belts or lap/shoulder belts.

6.1.2 State Requirements

The states of Arkansas, California, Florida, Louisiana, New Jersey, New York, Nevada, and Texas have all passed state laws requiring seat belts for large school buses, as noted below:

- Arkansas, California, Nevada, and Texas require lap/shoulder belts.¹¹⁸
- Florida, Louisiana, and New Jersey require lap belts.¹¹⁹

¹¹⁷ See the [NHTSA road safety webpage on school bus safety](#), accessed June 4, 2018.

¹¹⁸ (a) *Arkansas Code* 6-19-117 states “if funding is provided as required in §6-19-30(d), a school bus that is purchased new or leased, and that is to be used in Arkansas on or after January 1, 2018, shall be equipped with a passenger restraint system as defined in §6-19-30.” *Arkansas Code* 6-19-30 defines the passenger restraint system to be used as a type 2 assembly—which is a combination of pelvic and upper torso restraints (lap/shoulder belt). (b) California law requires three-point seat belts on school buses manufactured on or after July 1, 2005, that carry more than 16 passengers; and on all other school buses manufactured on or after July 1, 2004. (c) Nevada requires that any new school bus purchased by a school district on or after July 1, 2019, be equipped with a shoulder-harness-type safety belt assembly for each permanent passenger seating position. (d) Texas requires that each bus purchased by a school district starting September 1, 2010—and each school-chartered bus contracted for use by a school district starting September 1, 2011—be equipped with three-point seat belts for the passengers and the driver.

¹¹⁹ (a) Florida requires that each school bus purchased new after December 31, 2000, and used to transport students in grades pre-K–12 be equipped with safety belts or with any other restraint system approved by the federal government in a number sufficient to allow each student who is being transported to use a separate safety belt or restraint system. Florida statutes define “safety belt” as a seat belt assembly that meets the requirements established under FMVSS 208, 49 CFR 571.208. (b) Louisiana law requires the state Board of Elementary and Secondary Education to adopt rules and regulations requiring that every bus used primarily to transport students be equipped with seat belts by June 30, 2004; and to require the governing authority of each public and private school to comply with these rules and regulations. Compliance with the law is contingent on the appropriation of funds.

- New York requires seat belts but does not specify lap belts or lap/shoulder belts.¹²⁰

According to the National Conference of State Legislatures (NCSL), at least 29 states have introduced bills that would require passenger seat belts on large school buses.¹²¹ In states that have not yet passed large school bus seat belt legislation, many local school districts require that their large school buses be equipped with lap/shoulder belts. For example, school districts in Indiana, North Carolina, Pennsylvania, Texas, and Wyoming have recently installed or required lap/shoulder belts in their new large school bus fleets.¹²²

6.2 Chattanooga School Bus

6.2.1 Crash Phases and Vehicle Damage

The Chattanooga crash involved three main phases:

- Precrash high-speed swerving and counter-steering motions that threw passengers from their seating compartments.
- The school bus striking a utility pole while beginning to overturn toward the passenger side.
- Rollover into a tree, which abruptly ended the vehicle movement and resulted in severe intrusion into the school bus interior (see figure 12).¹²³

¹²⁰ The New York State law requires that all school buses manufactured after July 1, 1987, be equipped with seat belts.

¹²¹ See the [NCSL webpage on school bus safety](#), accessed June 4, 2018.

¹²² (a) See the [NHTSA webpage on its 2016 school transportation safety symposium, B. Chodrow presentation on lap/shoulder belts in school buses](#), accessed June 4, 2018. (b) See the [STN Media School Transportation News November 2015 article on the Houston program](#), accessed June 4, 2018. (c) For the 2017–2018 school year, North Carolina expanded its implementation project to 13 school districts, to include 114 school buses equipped with lap/shoulder belts. See the [STN Media School Transportation News August 2017 article on the North Carolina program](#), accessed June 4, 2018.

¹²³ Tree impacts often challenge the crashworthiness of a vehicle because the impact forces are localized to a small area. However, because the Chattanooga school bus rolled over and struck the tree, roof strength was determined not to be a safety issue.



Figure 12. Passenger (right) side of Chattanooga school bus postcrash.

As discussed earlier, the school bus was equipped with an onboard continuous video recording system that recorded the motion of the passengers during the precrash, crash, and postcrash phases. In the precrash phase (while the bus is still on the roadway, traveling at high speed, and steered to the right and then back to the left), the video shows one student standing in the aisle and at least five passengers being thrown from their seating compartments into the aisle. These passengers, as well as several others, are seen being thrown from the driver side of the bus toward the passenger side. Once out of the seating compartment, they are no longer afforded the benefits of compartmentalization. In the crash phase, as the bus begins to roll, the video shows additional passengers being displaced from their seating compartments. As the bus strikes the pole and the tree, three passengers are ejected, while many others in the middle of the bus become trapped in the intrusion zone.

The deformation of the vehicle frame around the tree, along with severe roofline intrusion, reduced the survival space for many of the Chattanooga school bus passengers. The vertical intrusion into the passenger compartment covered the region of rows 2–8 on the passenger side and rows 4–8 on the driver side. The intrusion was most severe in rows 7 and 8. Figure 13 shows the roof crush from the tree impact overlaid onto the school bus occupant seating chart.¹²⁴

¹²⁴ (a) Figure 13 shows the seating positions of the bus occupants before lateral forces displaced many of them from their seating compartments just preceding the tree impact and resulting roof crush. (b) The roof crush described represents residual roof crush. Typically, during a crash, the vehicle will crush to a maximum extent and then the metal will “spring back.” Residual crush is always less than maximum crush.

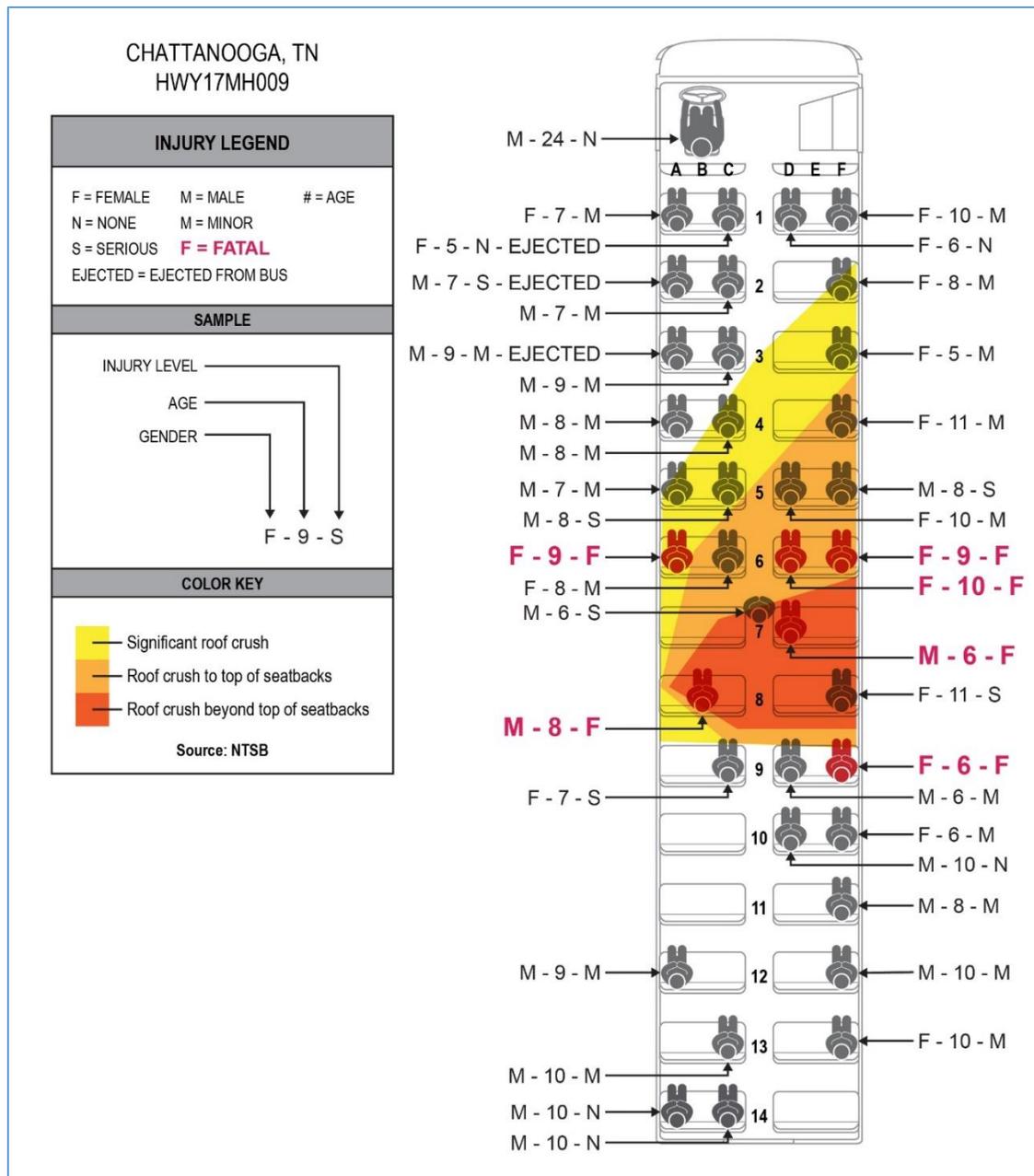


Figure 13. Overlay of postcrash tree-intrusion zones on Durham school bus occupant seating chart.

6.2.2 Occupant Injuries and Seating Locations

Four passengers were thrown into the intrusion zone during the Chattanooga crash sequence. The two students in seats 6A and 9F were fatally injured as a result of the crash, and the two others (5C and 9C) were seriously injured. Further, when the bus struck the utility pole and the tree, three passengers seated in the front (1C, 2A, and 3A) were ejected from the vehicle. One

of the ejected passengers (2A) was seriously injured, one received minor injuries (3A), and one was not injured (1C).

In general, passengers located in an intrusion zone are vulnerable to injury, whether belted or unbelted. In this crash, 10 passengers were originally located in the area of maximum intrusion. Of those students, four (6D, 6F, 7D, and 8B) sustained fatal injuries; three (5F, 8F, and the person standing in the aisle at row 7) were seriously injured; and those seated in 4F, 5D, and 6C received minor injuries.

Based on the video evidence and occupant injuries, unbelted passengers were vulnerable to injury in many respects:

- During the precrash vehicle motions, many students were thrown from their seating compartments, rendering compartmentalization ineffective for the remainder of the crash sequence. Without compartmentalization, these students had no occupant protection inside the bus.
- Passengers at the front of the bus were vulnerable to injury due to ejection.
- Multiple students were thrown into the maximum intrusion zone during the precrash and crash phases of the bus motion, exposing them to harm.

As concluded in the NTSB bus crashworthiness report, “Current compartmentalization is incomplete in that it does not protect school bus passengers during lateral impacts with vehicles of large mass and in rollovers, because in such accidents, passengers do not always remain completely within the seating compartment” (NTSB 1999). The Chattanooga crash further emphasizes the incompleteness of compartmentalization during severe precrash maneuvers.

The NTSB concludes that the Chattanooga school bus passengers were at risk due to the precrash vehicle motions that threw them from their seating compartments prior to the bus striking the utility pole and during the rollover sequence, rendering compartmentalization ineffective.

6.3 Management of Student Behavior and Seat Belt Use

In several NTSB school bus crash investigations, onboard video systems have provided evidence of the effects of seat belt use. For this SIR, NTSB investigators reached out to school districts that currently use seat belts to acquire information on their experiences.

6.3.1 Onboard Video Recording Data in School Bus Crash Analyses

Onboard video recordings were used in the crash analyses for three school buses crashes investigated by the NTSB—in Port St. Lucie, Florida; Houston, Texas; and Anaheim, California. In addition, in 2001 and 2011, respectively, the NTSB investigated school bus crashes in

Conasauga, Tennessee, and Gray Summit, Missouri, in which continuous video systems provided information critical to the crash analyses (NTSB 2001a; 2011a).¹²⁵

In the Port St. Lucie crash investigation, NTSB investigators found that the continuous video system provided valuable kinematics data on the complexity and duration of the occupant motion in a severe collision (NTSB 2013).¹²⁶

The Houston, Texas, investigation used video analysis to confirm that none of the four students were wearing the available lap belts (NTSB 2016b).¹²⁷ In November 2015, the Houston Independent School District announced that all new school buses (including 40 purchased and due to arrive in November 2016) would include lap/shoulder belts in all seating positions. The school district was responding to 2015 NHTSA guidance suggesting that students have access to lap/shoulder belts.

Video analysis for the Anaheim, California, crash investigation established that two students seated in the area of intrusion and most at risk for injury were properly wearing their lap/shoulder belts (NTSB 2016c).¹²⁸ Because of the general vulnerability of students in the areas of intrusion in school bus crashes, the NTSB conducted an occupant kinematics study to better understand the restraining action of the passenger lap/shoulder belts. Generally, the simulations predicted the lowest injury levels for lap/shoulder-belted occupants. The NTSB concluded that the properly worn lap/shoulder belts of the two occupants in row 8 likely reduced their injuries related to upper body flailing, which commonly occur when passengers are restrained by lap belts only. Further, the NTSB clarified in the probable cause that the proper use of the lap/shoulder belts by the student passengers seated in the area of maximum intrusion reduced the severity of their injuries.

These previous crash investigations have shown an evolution of seat belts on school buses—and, ultimately, the most benefits from using lap/shoulder belts on large school buses. Lap/shoulder belts enhance compartmentalization by restraining the upper body and pelvis within

¹²⁵ (a) In the Conasauga crash event—a collision between a school bus and a freight train—the video recordings from a single camera on the interior roof showed that the bus driver had disregarded safety procedures and crossed the railroad tracks without stopping on the day of the crash—and on at least eight previous occasions. (b) The Gray Summit crash event was a multivehicle collision involving two school buses, a truck-tractor, and a pickup truck. In this case, the continuous video system on the school bus that had been following the accident bus provided information essential to the analysis of precollision events.

¹²⁶ (a) See the NTSB public docket for Port St. Lucie, Florida (HWY12FH008). The Port St. Lucie crash is discussed in the Chesterfield, New Jersey, highway accident report (NTSB 2013) and in the commercial vehicle onboard video systems safety report (NTSB 2015a). (b) From the video, approximately 15 minutes of recorded footage documented the school bus motion, occupant motion, and postcrash events—capturing short-term injury outcomes—which generated valuable and extremely detailed information about seat belt use and restraint performance. The complexity of the crash—coupled with the use of passenger lap belts and the video recordings—prompted the NTSB to work with researchers at the Children’s Hospital of Philadelphia and the University of Virginia in documenting injuries, occupant kinematics, and LOC duration in a manner supportive of future biomechanical and pediatric trauma research.

¹²⁷ See the NTSB public docket for Houston, Texas (HWY15FH010).

¹²⁸ The school bus speed was derived from the continuous onboard video recording system. See the NTSB public docket for Anaheim, California (HWY14FH010).

the seating compartment during all crash scenarios, thus allowing the passenger to benefit from the protection of the strong bus body, the compartmentalized seating, and ride-down in the crash event. For passengers on the Chattanooga school bus, properly worn passenger lap/shoulder belts would have reduced exposure to the intruding tree and eliminated the risk of ejection.

6.3.2 Use of Lap/Shoulder Belts

The use of passenger lap/shoulder belts on school buses has also been shown to affect daily operations. Although research on this subject is limited, publicly available information includes a 6-month pilot study conducted in North Carolina in 2007 and a series of meetings held by NHTSA in 2015–2016 highlighting the experiences of states and school districts that operate school buses equipped with passenger lap/shoulder belts.¹²⁹ The North Carolina study and the NHTSA meeting reports established the potential positive effect of passenger lap/shoulder belts in improving student behavior.

NTSB investigators also solicited input from school transportation officials whose school districts operate buses equipped with lap/shoulder belts. This outreach was based on known stakeholders who have participated in public discussions or had representatives attend school transportation conferences. The positive responses have included reduced driver distraction, improved student behavior, and plans to expand the use of lap/shoulder belts on additional school buses.¹³⁰ Challenges include the costs associated with new school buses and the need for a comprehensive training program for both school districts and school bus drivers.¹³¹

6.4 Safety Recommendations

In its 1999 report on bus crashworthiness, the NTSB issued two recommendations requesting that NHTSA (1) develop performance standards for school bus occupant protection systems that account for frontal, side, and rear impact collisions, and for rollovers; and (2) once pertinent standards have been developed, require newly manufactured school buses to install systems to retain passengers within the seating compartments throughout the crash sequence for all accident scenarios (Safety Recommendations H-99-45 and -46; NTSB 1999).

Once NHTSA published the October 21, 2008, final rule on school bus passenger seating and crash protection, FMVSS 222, the NTSB classified Safety Recommendation H-99-45 “Closed—Acceptable Alternate Action.” FMVSS 222 implements improvements to school bus passenger protection, including increasing the minimum height of seatbacks, requiring the installation of lap/shoulder belts on small school buses, and establishing performance requirements

¹²⁹ In response to a school bus rollover crash in September 2007, the Cumberland County School District in Fayetteville installed lap/shoulder belts on one school bus for two routes (high school and elementary). Video—along with student feedback and parent surveys—supported the driver’s observations of improved student behavior. The program also reported consistent seat belt usage, and administrative policies reinforced the importance of wearing the lap/shoulder belts. See the [NHTSA webpage on its 2015 school bus occupant protection meeting](#) and the [NHTSA webpage on its 2016 meeting on school transportation safety](#), accessed June 4, 2018.

¹³⁰ Helena, Montana, public school district; Clark Pleasant Community School Corporation, Indiana; Port St. Lucie, Florida, school district; and Nevada Department of Education.

¹³¹ Nevada Department of Education and California Twin Rivers unified school district.

for *voluntarily* installed lap belts and lap/shoulder belts on large school buses. Although the final rule did not establish a single solution to address all crash scenarios, the recommendation classification reflects the NTSB determination that it developed performance standards for lap/shoulder belts on large school buses—accounting for frontal, side, and rear impact collisions, and for rollovers. FMVSS 222 constitutes a safety improvement in school bus occupant protection. However, the NTSB classified Safety Recommendation H-99-46 “Closed—Unacceptable Action,” because the final rule failed to require that all newly manufactured buses install occupant protection systems that address all crash scenarios, as recommended.

The NTSB informed NHTSA that in its continued commitment to improving school bus safety, it would monitor school bus crashes and evaluate whether future recommendations are warranted. Currently, the performance standards for voluntarily installed lap/shoulder belts on large school buses are established, because the crash safety benefits are well documented. Additionally, the benefits of lap/shoulder belts in helping to manage student behavior are emerging.

With the federal regulation in place defining performance standards for large school bus passenger lap/shoulder belts, school bus and seat manufacturers are designing large school buses with this safety improvement. In addition, design improvements—such as flexible seating systems—have reduced the impediments for equipping large school buses with this key safety feature.¹³² States and local school districts that have required or installed lap/shoulder belts in large school buses report additional improvements beyond occupant protection—which include reduced driver distraction and improved student behavior.

To provide the best protection for all occupants of large school buses—and to make these buses even safer—the remaining step is for each state to require the installation of lap/shoulder belts in all new large school buses. As concluded in the Chesterfield, New Jersey, report, properly worn lap/shoulder belts provide the best protection for school bus passengers (NTSB 2013). Again, as a result of the Chattanooga school bus crash investigation, the NTSB concludes that properly worn lap/shoulder belts provide the highest level of protection for school bus passengers in all crash scenarios, including frontal, side, and rear impacts—and rollovers.

The NTSB commends Arkansas, California, Nevada, and Texas—and the multiple jurisdictions across the United States—that require the installation of passenger lap/shoulder belts in large school buses. The NTSB recognizes the commitment of Florida, Louisiana, New Jersey, and New York to the safety of large school buses by requiring lap belts in school buses, yet encourages these state legislatures to amend their current laws to mandate lap/shoulder belts (rather than lap belts) as the restraint system in large school buses. Therefore, the NTSB recommends that the states of Florida, Louisiana, New Jersey, and New York amend their statutes to upgrade the seat belt requirement from lap belts to lap/shoulder belts for all passenger seating positions in new large school buses in accordance with FMVSS 222 standards.

¹³² According to NHTSA, flexible seating systems include lap/shoulder belts and can accommodate three smaller passengers or two larger passengers. They are designed to avoid a loss of seating capacity on school buses equipped with passenger lap/shoulder belts. See [NHTSA Final Rule, 49 CFR Part 571, FMVSS 222](#), accessed June 4, 2018.

Further, the NTSB recommends that 42 states, the District of Columbia, and the territory of Puerto Rico—which do not yet require passenger belts in large school buses—enact legislation to require that all new large school buses be equipped with passenger lap/shoulder belts for all passenger seating positions in accordance with FMVSS 222 standards.¹³³

¹³³ The 42 states are Alabama, Alaska, Arizona, Colorado, Connecticut, Delaware, Georgia, Hawaii, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, New Hampshire, New Mexico, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Utah, Vermont, Virginia, Washington, West Virginia, Wisconsin, and Wyoming.

7 Crash Prevention Technologies

7.1 Collision Avoidance Systems and Automatic Emergency Braking

The NTSB has advocated for collision avoidance systems (CAS) for CMVs (including buses) for more than 22 years, beginning with a multivehicle crash in Menifee, Arkansas, in 1995 and continuing to a 2016 motorcoach crash in San Jose, California (NTSB 1995; 2017a). Collision avoidance technology mitigates or prevents crashes by detecting moving, stopped, or stationary vehicles ahead. When appropriate, systems equipped with AEB apply brakes to prevent or mitigate a collision.

7.1.1 Historical Review

AEB is typically activated after a warning system alerts the driver of a potential rear-end collision and the driver fails to respond. The benefits of a forward CAS with AEB apply regardless of the driver's level of vigilance.¹³⁴ In the 91 crashes from 2007 through 2016 in which at least one occupant of a school transportation vehicle died, 55 of those crashes (60 percent) involved at least one other vehicle, and 41 (45 percent) involved a frontal impact (NHTSA 2018). Although drowsy, distracted, or impaired drivers may require more time to detect a potential conflict and initiate an avoidance maneuver, CAS technologies may, at the very least, lessen the severity of a collision. Furthermore, AEB would intervene, even if a driver is medically or otherwise incapacitated, as in the Baltimore crash.

As a result of the investigation of a 2005 truck-tractor semitrailer rollover and motorcoach collision in Osseo, Wisconsin, the NTSB recommended that NHTSA determine the potential benefits of ESC and AEB in CMVs and, if deemed effective, require the technology in new commercial vehicles (Safety Recommendation H-08-15; NTSB 2008c). Research conducted by NHTSA and others has shown the considerable potential of these systems to prevent crashes in both passenger and commercial vehicles. When AEB applies braking force, it relies on the vehicle's ESC to provide stabilization. ESC is a necessary component to ensure the full benefits of AEB.¹³⁵ Furthermore, ESC hardware and logic serve as a baseline for more advanced systems, such as CAS and AEB. Despite the benefits of these systems, NHTSA has not required them in new CMVs.

¹³⁴ AEB systems designed to work at high speeds require mid- or long-range sensors, while those designed for lower speeds use short-range sensors. Some current AEB systems can prevent collisions (up to certain speeds), while others may be capable of only mitigating collisions. AEB may apply partial or full braking force—or cascaded braking, which is the application of partial braking followed by full braking.

¹³⁵ ESC systems use a complex set of logic in monitoring wheel speed, vehicle speed, lateral acceleration, vehicle yaw, and driver input. An onboard ECM analyzes this information. Once a sensor indicates an unstable vehicle condition, the control module evaluates the data and determines if there is an impending rollover or loss of control. The ECM can then intervene by sending a signal to apply the brakes at any one or a combination of wheel locations to redirect and slow the vehicle. This communication occurs within fractions of a second in an attempt to prevent a rollover or loss of directional control.

As a result of the investigation of the 2009 rollover of a truck-tractor and cargo tank semitrailer in Indianapolis, Indiana, the NTSB made the following recommendations to NHTSA (NTSB 2011b):

Develop stability control system performance standards for all commercial motor vehicles and buses with a gross vehicle weight rating greater than 10,000 pounds, regardless of whether the vehicles are equipped with a hydraulic or a pneumatic brake system. (H-11-7)

Once the performance standards from Safety Recommendation H-11-7 have been developed, require the installation of stability control systems on all newly manufactured commercial vehicles with a gross vehicle weight rating greater than 10,000 pounds. (H-11-8)

In 2015, in a special investigation report on the use of forward CAS to prevent and mitigate rear-end collisions, the NTSB concluded that the full benefits of AEB for commercial vehicles can only be achieved when it is installed on vehicles also equipped with ESC, regardless of whether the vehicles are equipped with hydraulic or pneumatic braking systems (NTSB 2015b). Therefore, the NTSB reiterated Safety Recommendations H-11-7 and -8 to NHTSA and also recommended that both passenger and commercial vehicle manufacturers install these technologies as standard equipment (Safety Recommendation H-15-9).

Because of the lack of progress in the development of CAS performance standards in commercial vehicles, the NTSB classified Safety Recommendation H-08-15, from the Osseo investigation, “Closed—Unacceptable Action,” while clarifying that NHTSA’s lack of progress should not preclude the use of such systems in these vehicle types. Currently available CAS and AEB provide clear benefits and merit deployment in vehicles, even without published NHTSA performance standards.

Following NTSB publication of the collision avoidance SIR, NHTSA issued a final rule (effective August 24, 2015) introducing a new safety standard, FMVSS 136, Electronic Stability Control Systems for Heavy Vehicles. FMVSS 136 requires ESC systems on most truck-tractors and buses with a GVWR greater than 26,000 pounds.¹³⁶ The new standard includes a requirement for the installation of ESC-related equipment and for the ESC-equipped vehicle to meet objective performance requirements when subjected to specified dynamic test maneuvers. These requirements will help prevent untripped rollovers as well as mitigate understeer or oversteer

¹³⁶ FMVSS 136 is applicable to all new typical three-axle truck-tractors manufactured on or after August 1, 2017, and certain buses with GVWRs greater than 26,000 pounds. Buses over 33,000 pounds GVWR must comply within 3 years of the date of the final rule. Buses with GVWRs between 26,000 and 33,000 pounds must comply within 4 years of the date of the final rule. FMVSS 136 is not applicable to school buses, urban transit buses, or other hydraulically braked vehicles between 10,000 and 26,000 pounds GVWR. See 49 CFR Part 571.

conditions that could lead to a loss of directional, or steering, control.¹³⁷ However, FMVSS 136 does not apply to school buses.¹³⁸

In 2017, the Canadian government incorporated by reference the ESC safety standard for heavy vehicles into its motor vehicle safety regulations, “thus introducing a new Canadian safety standard that is aligned with the United States.”¹³⁹ Section 136 of the *Canadian Motor Vehicle Safety Standards* targets the same vehicle types subject to FMVSS 136 (certain truck-tractors and buses with a GVWR greater than 26,000 pounds), manufactured on or after August 1, 2019, which must be equipped with ESC systems to reduce the occurrence of rollover and loss-of-control crashes.

Unlike the US safety standard, the Canadian amendment requires ESC systems for school buses and notes that ESC “includes requirements to enhance the vehicle’s directional control and mitigate rollover instability through the control of engine torque distribution and brake application of individual wheels.” The Canadian decision is based on the argument that manufacturers also provide virtually identical versions of these buses for the commercial market—where ESC will be required—thus, the requirement for ESC systems on school buses.

7.1.2 Safety Recommendations

In the absence of CAS and ESC requirements for school buses, some manufacturers—such as Thomas Built Buses and Blue Bird—are moving ahead on developing these technologies for their vehicles. Since 2015, they have offered ESC as an option and have installed the feature on 230 pneumatically braked vehicles.¹⁴⁰

NTSB crash investigations and industry research have shown that CAS with AEB and ESC is an effective countermeasure to prevent or mitigate the severity of crashes and to reduce the frequency of rear-end or loss-of-control crashes.

The Baltimore school bus driver was medically incapacitated when the school bus struck the car, entered the oncoming traffic lanes, and struck the transit bus. The NTSB concludes that had the newly manufactured Baltimore school bus been equipped with a forward CAS with AEB, the initial impact with the car would likely have been mitigated; and the subsequent impact between the school bus and the transit bus would not have occurred.

¹³⁷ An untripped rollover is a rollover event that occurs without the vehicle striking a curb or other roadside object.

¹³⁸ NHTSA asserted in its 2015 rulemaking that most school bus crashes are *not* rollover or loss-of-control crashes—which ESC systems can prevent; and, for this reason, it exempted school buses from having to be equipped with ESC. See 49 CFR Part 571 36057; 80 FR 120, June 23, 2015.

¹³⁹ Regulations Amending the Motor Vehicle Safety Regulations, P.C. 2017-563, June 2, 2017. See the [Canadian government Motor Vehicle Safety Act website](#), accessed June 4, 2018.

¹⁴⁰ Thomas Built Buses offers CAS (with forward CAS, lane departure, and headway monitoring through a driver visual and audio warning) as a factory-installed option. See the [Thomas Built Buses webpage on the Saf-T-Liner C2 school bus](#), accessed June 4, 2018.

In the Chattanooga crash, the driver lost control of the 2008 Thomas Built school bus in a situation in which ESC systems might have mitigated the outcome.¹⁴¹ NTSB investigators used simulations to evaluate the potential effects of an ESC system on a school bus traversing this roadway at the same speed as the Chattanooga bus. Results of these vehicle dynamic simulations showed that an ESC system would have activated and reduced the speed of the bus on the curve immediately preceding the crash location. The simulated ESC activation achieved speed reductions of about 10 mph (to 42 mph from 52 mph). Although it was not possible to determine if the driver could have successfully negotiated the curve at the reduced speed, the simulations showed that the associated changes in handling characteristics would have made the bus more controllable during the maneuver. Further, if a crash still resulted, the reduced speed would have decreased the severity of the crash forces.

The NTSB concludes that had the vehicle instability—caused by the Chattanooga bus driver’s excessive speed and steering input—occurred in a newly manufactured school bus equipped with an ESC system, the technology could have assisted the driver in maintaining vehicle control and mitigated the severity of the crash by reducing the speed of the vehicle.

Although statistics show that school buses offer the safest transportation to and from school, CAS, AEB, and ESC offer large safety benefits in helping to prevent or mitigate the severity of crashes. According to NHTSA, when it was developing the final rule for FMVSS 136, school buses were excluded from the performance standard because ESC technology was not available on the vehicles being researched and tested. Since that time, the NTSB has met with NHTSA to discuss that ESC-equipped school buses are now available and can be tested. Therefore, the NTSB reiterates Safety Recommendations H-11-7 and -8 to NHTSA. Furthermore, the NTSB also recommends that NHTSA require all new school buses to be equipped with CAS and AEB technologies.

In March 2016, 20 automobile manufacturers—representing more than 99 percent of the US passenger car market—committed to making AEB a standard feature on virtually all new cars no later than September 1, 2022, which begins the NHTSA reporting year. This unified commitment by the automobile industry was accomplished without a NHTSA mandate. The NTSB recognizes that some school bus manufacturers are beginning to install CAS in school buses. In support of this effort, the NTSB recommends that Blue Bird Corporation, Collins Industries, Inc., IC Bus, Starcraft Bus, Thomas Built Buses, Trans Tech, and Van-Con, Inc., install CAS with AEB as standard equipment on all newly manufactured school buses.

¹⁴¹ The mechanical condition of the vehicle’s foundation brakes and tires must also be considered. Stability control systems rely on the capability of the brakes to provide deceleration and the tires to provide adequate friction with the roadway. Brakes and tires in poor condition limit the effectiveness of ESC systems. However, in the Chattanooga postcrash vehicle inspection, the brakes and tires were found to be in good condition.

7.2 Event Data Recorders

7.2.1 Historical Review

In its bus crashworthiness report, the NTSB discussed the importance of event data in the reconstruction of crashes and the continued development of school bus occupant protection systems (NTSB 1999). Among 10 safety recommendations to NHTSA was the following:

Develop and implement, in cooperation with other government agencies and industry, standards for on-board recording of bus crash data that address, at a minimum, parameters to be recorded, data sampling rates, duration of recording, interface configurations, data storage format, incorporation of fleet management tools, fluid immersion survivability, impact shock survivability, crush and penetration survivability, fire survivability, independent power supply, and ability to accommodate future requirements and technological advances. (H-99-54)

The NTSB has reiterated this recommendation numerous times since 1999. In the investigation of a 2009 medium-size bus rollover near Dolan Springs, Arizona, the NTSB found that crash data would also be useful in the reconstruction of precrash events and crash dynamics for medium-size buses (NTSB 2010).¹⁴² The NTSB recommended that NHTSA:

Require that all buses above 10,000 pounds gross vehicle weight rating be equipped with on-board recording systems that: (1) record vehicle parameters, including, at minimum, lateral acceleration, longitudinal acceleration, vertical acceleration, heading, vehicle speed, engine speed, driver's seat belt status, braking input, steering input, gear selection, turn signal status (left/right), brake light status (on/off), head/tail light status (on/off), passenger door status (open/closed), emergency door status (open/closed), hazard light status (on/off), brake system status (normal/warning), and flashing red light status (on/off; school buses only); (2) record status of additional seat belts, airbag deployment criteria, airbag deployment time, and airbag deployment energy; (3) record data at a sampling rate sufficient to define vehicle dynamics and be capable of preserving data in the event of a vehicle crash or an electrical power loss; and (4) are mounted to the bus body, not the chassis, to ensure recording of the necessary data to define bus body motion. (H-10-7)

Heavy vehicle event data recorders (HVEDR) can yield information on vehicle parameters, driver precrash actions, and vehicle dynamics through the crash event sequence.¹⁴³ Such data are valuable in reconstructing and evaluating occupant kinematics, injury exposure, and the potential

¹⁴² See also reports on the Davis, Oklahoma; Orland, California; and Atlanta, Georgia, investigations (NTSB 2015d; 2015c; and 2008b, respectively) and the pedal misapplication SIR (NTSB 2009a). Safety Recommendation H-10-7 superseded Safety Recommendation H-99-53, which specified that EDRs be required for school buses and motorcoaches. See the [NTSB webpage on the safety recommendation history for H-99-53](#), accessed June 4, 2018.

¹⁴³ For heavy vehicles, which this report defines as CMVs weighing more than 10,000 pounds, event data recorders are referred to as HVEDRs. An HVEDR is a device or function designed to record dynamic time series data prior to (such as vehicle speed versus time) and during (such as delta V versus time) a crash event.

benefits of occupant protection systems. However, there is still no requirement for HVEDR installation and use on school buses. As recently as April 2016, NHTSA informed the NTSB that it had studied the issues related to establishing performance requirements for HVEDRs and decided not to do so. Both Safety Recommendations H-99-54 and H-10-7 remain classified “Open—Unacceptable Response.”

7.2.2 Accident School Buses

The Baltimore school bus was equipped with an electronically controlled engine with an ECM. The ECM did not have any event recording features because of the type and series of the engine. However, even if the ECM had been capable of recording event data, it was not an HVEDR. The primary role of an ECM is to monitor fuel delivery and engine performance; data recording, when available, is only a secondary function. Although ECM data can be extremely useful, a dedicated HVEDR yields precision crash data on driver input and vehicle dynamics throughout a collision sequence. An HVEDR also has crash-protected features of device and data survivability through thermal, submersion, and loss-of-power events. There is no expectation that ECMs or their data would survive such events.

The Chattanooga school bus was also equipped with an ECM. Although the ECM did have recording features, it captured no crash-relevant data.¹⁴⁴ The availability of recorded event data for the school bus, as provided by an HVEDR, would have resulted in a more complete account of the driver’s input and the vehicle loss of control. Likewise, the availability of recorded event data for the Baltimore school bus, if equipped with an HVEDR, could have allowed for a more detailed analysis of the collision-mitigating features of CAS with AEB.¹⁴⁵

7.2.3 Safety Recommendations

The NTSB continues to believe that learning as much as possible about real-world crash dynamics in a school bus collision can be crucial in developing even safer school buses and other student transportation vehicles.

NHTSA has not developed standards, nor required the use of HVEDRs, for the commercial passenger vehicles that transport pupils to and from school, school-related activities, and other events—such as school buses, transit buses, or even motorcoaches. These vehicles also transport other passengers for tourism and in commerce, where expectations of safety should parallel those of other modes of commercial passenger transportation. Crash-protected recorders have been required for many years—in some cases, decades—in most large commercial airplanes, marine vessels, and train locomotives. The NTSB concludes that with the continued lack of standards and requirements for HVEDRs, crash data valuable to better understand highway collisions and to improve highway safety continue to go unrecorded. Therefore, the NTSB reiterates Safety Recommendations H-99-54 and H-10-7 to NHTSA.

¹⁴⁴ The ECM in the Chattanooga school bus contained three sudden deceleration events that predated the crash. The crash event may not have triggered the ECM deceleration threshold of 7 mph prior to the bus losing power.

¹⁴⁵ The ECM in the 2005 transit bus had the capability of recording sudden deceleration and last stop records, but it failed to capture the Baltimore crash—likely due to the sudden and catastrophic power loss from the collision.

Moreover, all school bus ECMs should have recording capabilities. Although ECM data are not as detailed as HVEDR data in terms of capturing crash-relevant information, they can still be instrumental in understanding driver input and vehicle response. The NTSB concludes that, in the Baltimore crash, the ECM recorded no useful crash-related data, because it lacked the secondary function of event data recording. Having school bus manufacturers equip all ECMs with recording features will allow the ECM to capture some relevant crash-related data to improve school bus safety, though the NTSB prefers the long-term solution of HVEDR performance standards and required installation. In the meantime, the NTSB recommends that IC Bus develop and implement engine recording features for the event data recorder in the ECM for newly manufactured school buses.

8 Conclusions

8.1 Findings

1. None of the following were primary or contributing factors in the Baltimore, Maryland, crash: (1) distraction, substance impairment, or fatigue for either of the two bus drivers; (2) licensing or experience of the transit bus driver; (3) medical condition of the transit bus driver; (4) mechanical condition of the school bus or transit bus; (5) weather; or (6) roadway lighting or conditions.
2. The Baltimore school bus driver was likely incapacitated by a seizure due to his long-standing seizure disorder, which resulted in collisions with the car and the transit bus.
3. None of the following were primary or contributing factors in the Chattanooga, Tennessee, crash: (1) school bus driver licensing or medical certification; (2) substance impairment, medical condition, or driver fatigue; (3) mechanical condition of the school bus; (4) weather; or (5) roadway design or conditions.
4. At the accident speed of 52 mph, the Chattanooga bus would have been operating at close to the limits of its cornering capability as it entered the curve; and, if the driver had to suddenly increase steering for any reason while in the curve, the bus could quickly exceed the limits of its cornering capability and become difficult to control.
5. The high speed of the Chattanooga school bus through the curve was the primary contributing factor to the loss of vehicle control.
6. The failure of the Chattanooga school bus driver to initially react with an appropriate steering input as the bus entered the right curve too fast resulted in the bus departing the roadway and the loss of control, followed by the left overcorrecting steering input—which led to the bus rollover and crash.
7. In attempting to control student behavior, the Chattanooga school bus driver had previously operated the bus in a manner that caused passengers to fall or be thrown from their seats, and his precrash steering behaviors and speeding were consistent with these unsafe driving patterns.
8. The driver's cell phone use while operating the Chattanooga school bus increased his crash risk and impaired his ability to control the bus.
9. The Chattanooga school bus driver's speeding—combined with his use of a cell phone while driving—led to the vehicle loss-of-control, run-off-the-road, and rollover crash.
10. The Baltimore school bus driver had fraudulently obtained his driver's license by providing documents with different name spellings or birth dates to circumvent the Maryland Motor Vehicle Administration verification system.

11. The Maryland Motor Vehicle Administration verification system failed to prevent the Baltimore school bus driver from obtaining a driver's license through fraudulent means.
12. The Maryland Motor Vehicle Administration facial recognition program can help prevent persons identified as unqualified for licensure from continuing to operate a commercial motor vehicle under a fraudulently obtained license or from obtaining a commercial driver's license through fraudulent means.
13. The Baltimore school bus driver understood his diagnosis of epilepsy and intentionally hid the disqualifying medical condition and use of treatment medications during his commercial driver medical examinations to prevent denial of certification.
14. The Concentra, Inc., forms used to collect additional information provide an opportunity for certified medical examiners to learn from treating health-care providers of the conditions that a driver has omitted from his or her medical history.
15. Although a certified medical examiner may use the *391.41 CMV Driver Medication Form* to record medications a driver is using to assist in determining certification status, the form does not specifically address medications that indicate a potentially impairing condition or conditions that may be directly hazardous.
16. Nonphysician health-care providers and non-law-enforcement first responders are a potentially valuable, but underutilized, resource in the reporting of drivers with medical conditions.
17. School districts and their contracted student transportation service providers would benefit from awareness training on federal and state commercial driver fitness regulations and the avenues available to report drivers with medical conditions that may make it unsafe to operate a school bus.
18. To improve the frequency with which health-care providers address the safety risks of seizures, particularly with respect to driving, electronic health records should be configured with reminders of specific data, such as the patient's occupation.
19. AAAfordable Transportation exercised poor driver safety oversight by allowing a known medically unfit driver to operate a school bus for 5 consecutive days leading up to, and including, the day of the Baltimore crash.
20. Although Baltimore City Public Schools was responsible for driver oversight, it failed to address multiple deficiencies and to identify the bus driver as high risk.
21. The Hamilton County Department of Education failed to follow up to determine the outcome of driver-related complaints and remove an unsafe driver from transporting county students.
22. Durham School Services (1) did not adhere to established policies and procedures for handling school bus driver disciplinary issues; (2) lacked a systematic and detailed process

to manage complaints or allegations concerning its drivers; and (3) was, therefore, deficient in driver oversight.

23. Durham School Services failed to resolve complaints so as to remediate the bus driver's risky driving behavior, and to intercede and remove him from operating the school bus—even though some Durham supervisors were aware of the numerous complaints of his mishandling of student discipline, including unsafe driving behaviors.
24. The Chattanooga school bus passengers were at risk due to the precrash vehicle motions that threw them from their seating compartments prior to the bus striking the utility pole and during the rollover sequence, rendering compartmentalization ineffective.
25. Properly worn lap/shoulder belts provide the highest level of protection for school bus passengers in all crash scenarios, including frontal, side, and rear impacts—and rollovers.
26. Had the newly manufactured Baltimore school bus been equipped with a forward collision avoidance system with automatic emergency braking, the initial impact with the car would likely have been mitigated; and the subsequent impact between the school bus and the transit bus would not have occurred.
27. Had the vehicle instability—caused by the Chattanooga bus driver's excessive speed and steering input—occurred in a newly manufactured school bus equipped with an electronic stability control system, the technology could have assisted the driver in maintaining vehicle control and mitigated the severity of the crash by reducing the speed of the vehicle.
28. With the continued lack of standards and requirements for heavy vehicle event data recorders, crash data valuable to better understand highway collisions and to improve highway safety continue to go unrecorded.
29. In the Baltimore crash, the engine control module recorded no useful crash-related data, because it lacked the secondary function of event data recording.

8.2 Probable Causes

The National Transportation Safety Board determines that the probable cause of the *Baltimore, Maryland*, school bus crash was (1) the loss of vehicle control due to incapacitation of the bus driver because of a seizure stemming from a long-standing seizure disorder; (2) the bus driver's continued operation of a school bus with a disqualifying medical condition and a fraudulently obtained commercial driver's license; and (3) the failure of AAAfordable Transportation and the Baltimore City Public Schools to provide adequate bus driver oversight, allowing the medically unfit driver to drive a commercial vehicle with a medical condition that they knew, or should have known, could lead to the unsafe operation of the school bus. Contributing to the severity of the crash was the lack of a collision avoidance system with automatic emergency braking on the school bus.

The National Transportation Safety Board determines that the probable cause of the *Chattanooga, Tennessee*, crash was (1) the school bus driver's excessive speed and cell phone use, which led to the loss of vehicle control; (2) Durham School Services' failure to provide adequate bus driver oversight, allowing an inexperienced driver to operate a commercial vehicle with escalating risky driving behaviors that it knew, or should have known, could lead to the unsafe operation of the school bus; and (3) the Hamilton County Department of Education's lack of followup to ensure that Durham had addressed a known driver safety issue. Contributing to the severity of the crash was the lack of passenger lap/shoulder belts on the school bus.

9 Recommendations

9.1 New Recommendations

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

To the Federal Motor Carrier Safety Administration:

Provide explicit guidance to encourage certified medical examiners to request a complete list of current medical conditions and medications when obtaining supplemental information from a commercial driver's treating health-care provider. (H-18-7)

To the National Highway Traffic Safety Administration:

Require all new school buses to be equipped with collision avoidance systems and automatic emergency braking technologies. (H-18-8)

To the states of Florida, Louisiana, New Jersey, and New York:

Amend your statutes to upgrade the seat belt requirement from lap belts to lap/shoulder belts for all passenger seating positions in new large school buses in accordance with Federal Motor Vehicle Safety Standard 222. (H-18-9)

To the states of Alabama, Alaska, Arizona, Colorado, Connecticut, Delaware, Georgia, Hawaii, Idaho, Illinois, Indiana, Iowa, Kansas, Maine, Maryland, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, New Hampshire, New Mexico, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Rhode Island, South Carolina, South Dakota, Tennessee, Utah, Vermont, Washington, West Virginia, Wisconsin, and Wyoming; the commonwealths of Kentucky, Massachusetts, Pennsylvania, and Virginia; the District of Columbia; and the territory of Puerto Rico:

Enact legislation to require that all new large school buses be equipped with passenger lap/shoulder belts for all passenger seating positions in accordance with Federal Motor Vehicle Safety Standard 222. (H-18-10)

To the state of Maryland:

To help prevent driver license fraud, continue the facial recognition program beyond 2019. (H-18-11)

To the Maryland State Department of Education:

Publicize to the state school districts and school bus communities the methods available for individual reporting of school bus drivers with medical conditions that may affect their ability to safely operate a school bus. (H-18-12)

To the Maryland Motor Vehicle Administration:

Process all current commercial driver's license holders through the facial recognition software system to detect those drivers who may hold fraudulent licenses. (H-18-13)

Assess the volume of referrals by nonphysician health-care providers and first responders (other than law enforcement) to determine whether improved outreach and adjustments to current reporting methods may increase their reporting of medically at-risk drivers. (H-18-14)

Publicize to the state school districts and school bus communities the methods available for individual reporting of school bus drivers with medical conditions that may affect their ability to safely operate a school bus. (H-18-15)

To the National Association of State Directors of Pupil Transportation Services, National Association for Pupil Transportation, National School Transportation Association, American School Bus Council, and Maryland School Bus Contractors Association:

Inform your members of the circumstances of the Baltimore, Maryland, school bus crash and lessons learned from the crash investigation to help raise awareness of the avenues available to report school bus drivers with medical conditions that may make it unsafe for them to operate a school bus. (H-18-16)

National Express LLC:

Implement a process to track driver complaints from initial call to case resolution throughout your student transportation service provider companies, including Durham School Services. (H-18-17)

Use industry best practices to establish resolution accountability for serious or recurring safety violations, to include effective remediation of unsafe driver behavior. (H-18-18)

To Blue Bird Corporation, Collins Industries, Inc., IC Bus, Starcraft Bus, Thomas Built Buses, Inc., Trans Tech, and Van-Con, Inc.:

Install a collision avoidance system with automatic emergency braking as standard equipment on all newly manufactured school buses. (H-18-19)

To IC Bus:

Develop and implement engine recording features for the event data recorder in the engine control module for newly manufactured school buses. (H-18-20)

To Epic, Cerner Corporation, eClinicalWorks, MEDITECH, and NextGen Healthcare:

Develop decision support for the evaluation of nontraumatic loss of consciousness episodes or for a diagnosis of epilepsy that will notify providers of the patient's occupation, such as commercial driver; and remind them to address the occupational and driving status of the patient, including the opportunity to inform the state licensing agency of concerns about the patient's driving. (H-18-21)

To Concentra, Inc.:

To better document medical issues identified during commercial driver's license examinations, revise your medical information request forms provided to consultants or treating providers to also include specific requests for a complete list of current medical conditions and medications. (H-18-22)

9.2 Previously Issued Recommendations

The National Transportation Safety Board issued the following recommendations in a March 2017 highway safety recommendation report (NTSB 2017b).

To the Baltimore City Public Schools:

Request that the Maryland State Department of Education have an independent and neutral third party conduct a performance audit of your transportation department that includes a review of crash reports and of disqualifying conditions for school bus drivers under *Code of Maryland Regulations* section 13A.06.07.07. (H-17-13) (Urgent)

Safety Recommendation H-17-13 is reclassified from "Open—Acceptable Response" to "Closed—Acceptable Action."

As soon as the performance audit referenced in Safety Recommendation H-17-13 is complete, take the corrective actions recommended to improve internal controls and ensure that all school bus drivers meet the qualification standards under *Code of Maryland Regulations* sections 13A.06.07.06–.07 and that they do not pose any safety risks. (H-17-14)

Safety Recommendation H-17-14 is classified "Open—Acceptable Response."

To the Maryland State Department of Education:

Review and modify the *Code of Maryland Regulations* section 13A.06.07.07, "School Vehicle Driver Disqualifying Conditions and Termination," to clarify the definitions of disqualifying conditions, and to require notification to the Maryland State Department of Education of all drivers who are determined to be not qualified during pre-employment screening. (H-17-15)

Safety Recommendation H-17-15 is classified "Open—Acceptable Response."

9.3 Previously Issued Recommendations Reiterated in This Report

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

To the National Highway Traffic Safety Administration:

Develop and implement, in cooperation with other government agencies and industry, standards for on-board recording of bus crash data that address, at a minimum, parameters to be recorded, data sampling rates, duration of recording, interface configurations, data storage format, incorporation of fleet management tools, fluid immersion survivability, impact shock survivability, crush and penetration survivability, fire survivability, independent power supply, and ability to accommodate future requirements and technological advances. (H-99-54)

Require that all buses above 10,000 pounds gross vehicle weight rating be equipped with on-board recording systems that: (1) record vehicle parameters, including, at minimum, lateral acceleration, longitudinal acceleration, vertical acceleration, heading, vehicle speed, engine speed, driver's seat belt status, braking input, steering input, gear selection, turn signal status (left/right), brake light status (on/off), head/tail light status (on/off), passenger door status (open/closed), emergency door status (open/closed), hazard light status (on/off), brake system status (normal/warning), and flashing red light status (on/off; school buses only); (2) record status of additional seat belts, airbag deployment criteria, airbag deployment time, and airbag deployment energy; (3) record data at a sampling rate sufficient to define vehicle dynamics and be capable of preserving data in the event of a vehicle crash or an electrical power loss; and (4) are mounted to the bus body, not the chassis, to ensure recording of the necessary data to define bus body motion. (H-10-7)

Develop stability control system performance standards for all commercial motor vehicles and buses with a gross vehicle weight rating greater than 10,000 pounds, regardless of whether the vehicles are equipped with a hydraulic or a pneumatic brake system. (H-11-7)

Once the performance standards from Safety Recommendation H-11-7 have been developed, require the installation of stability control systems on all newly manufactured commercial vehicles with a gross vehicle weight rating greater than 10,000 pounds. (H-11-8)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

ROBERT L. SUMWALT, III
Chairman

EARL F. WEENER
Member

T. BELLA DINH-ZARR
Member

Adopted: May 22, 2018

Members Weener and Dinh-Zarr filed the following statements.

Board Member Statements

Member Earl F. Weener, Ph.D.

Concurring

May 29, 2018

I was heartened by the robust discussion of medical fitness in this report and during the related Board Meeting. In this and other recent cases, we have seen the tragic consequences resulting from medically unfit operators. Generally, only commercial operators are required to undergo medical screening. While those screenings are important, and we have made recommendations to improve the screening process, the reality is that pre-employment or licensing-based screenings rely on the candor of the person being assessed. Many conditions that impair driving ability are not detectable through routine physical examination. Unfortunately, but foreseeably, a driver whose livelihood depends on a license may be less than forthcoming about conditions which the driver knows may result in license restriction or rescindment.

This investigation acknowledges the limitations of self-reporting and looks at other ways state driver licensing authorities can identify and address medically unfit drivers. One valuable source of information about unsafe commercial and noncommercial drivers is a treating physician. Given the number of Americans injured and killed each year in automobile crashes, unsafe driving prevention is a legitimate health consideration for both the patient and the public. Doctors are unique reporters in that they have both the knowledge of a condition and the training to understand the impairment a condition may cause. The American Medical Association Code of Medical Ethics has addressed a physician's responsibility to consider and potentially report medically impaired drivers to driver license authorities. However, states address physician reporting in a variety of different ways.

Maryland permits but does not require reporting, although it does provide some liability protection if a physician reports a patient. In this case, the Maryland bus driver had a long-term seizure disorder that we know had prompted at least one physician in the past to report him to the MVA. Unfortunately, despite relatively recent treatment by various physicians, our investigators found no other reports to MVA regarding the bus driver's potentially impairing medical condition. While we do not know why these doctors may have failed to report the driver to MVA, we are issuing a recommendation intended to prompt doctors to consider their patients' medical conditions in terms of driving safety.

I think it is important to point out that the language of our recommendation asks for decision support to notify providers not just of a patient's occupation, but also of the patient's driving status. It is very important to understand that a physician's duty to report a driver may exist whether or not the patient is a professional driver. In this case, the fact that this driver was entrusted with the transportation of school children is particularly shocking. However, it is important to remember that one of the most horrific school bus crashes in U.S. history, which

happened just over 30 years ago, was not caused by the school bus driver. In that crash, a substance impaired driver drove his non-commercial vehicle into the path of the school bus causing a catastrophic collision and subsequent fire. We must remember that any vehicle being operated by an unfit driver poses a risk. Not only should the Maryland school bus driver not have been allowed to operate a school bus, he should not have had a driving privilege to operate any motor vehicle.

While non-commercial drivers do not generally need medical screens, prior to getting a license to drive, states can impose self-reporting requirements. In fact, Maryland state statute required the driver to disclose his history of epilepsy prior to obtaining any driving license. There is no evidence that the driver made this disclosure. However, all drivers, whether they are driving someone else's children or their own, must be medically fit. To this end, we have made a recommendation intended to assist doctors with reporting medically unsafe drivers, whether they do or do not hold a commercial privilege. We have also discussed the many other people, including medical personnel, law enforcement, employers, and coworkers, who had reason to be concerned about the Maryland bus driver's ability to operate a vehicle safely. It is tragic to consider that had the MVA received the right information, this crash may have been prevented. But, the reason for our investigations is to learn from tragedy so that we can do better in the future.

This investigation has impressed on me once more the need for medical fitness in all modes of transportation and for every person behind the wheel of vehicles. We are all responsible for reporting unsafe drivers. Each state driver licensing authority has a medical review board. Anyone can call to ask questions about reporting an unsafe driver. To borrow from security messaging, if you see something, say something. While the privilege to drive may be very valuable, it is never more valuable than the right of the public to travel safely.

Chairman Sumwalt and Member Dinh-Zarr joined this statement.

Notation 579053 – Selective Issues in School Bus Transportation Safety: Crashes in Baltimore, Maryland, and Chattanooga, Tennessee (HWY17MH007 and HWY17MH009)

Board Member T. Bella Dinh-Zarr, Concurring

May 29, 2018

This special investigation report highlights the importance of protecting our most vulnerable road users—school children—as well as those who share the road with school buses. When these crashes occurred in close succession, I initially was skeptical of combining the two individual crashes into a single investigation report. My concern was that the impact and importance of each individual crash would be diminished. However, the final result showed quite the opposite was true. By combining these two crashes into a single report, the NTSB Highway Safety staff has shown that these crashes were not simply problems isolated to Chattanooga or Baltimore City, but rather systemic issues that could be found in many school districts across our country. I also worried that the families affected by these crashes might feel that the loss or injury of their loved ones was not adequately addressed. I hope, after reading this report, that those who were most affected by these crashes will feel that the lifesaving potential of the safety recommendations is amplified rather than diminished by this combined SIR. By combining these crashes into a single report and better highlighting the commonalities between the crashes, this investigation has the potential to improve the safety of school buses and communities across our nation.

While we know that school buses remain one of the safest forms of transportation for children, this special investigation report highlighted some of the areas where improvements can be made. In both crashes, the investigation highlighted school districts' lack of oversight of student transportation service providers, poor management of unsafe school bus drivers by the motor carriers and school districts, and lack of electronic stability control, automatic emergency braking, and event data recorders. The report contains new recommendations to federal agencies and states as well as pupil transportation groups, motor carriers, and school bus manufacturers which, if enacted, will make our roads even safer for school children. Notably, the two probable causes in this report, while rightly identifying the immediate proximate cause of each crash, also both identified a broader issue, the failure of bus driver oversight, as a key factor in both crashes. Better bus driver oversight, including measures such as implementing better processes for tracking driver complaints and medical issues to ensure bus drivers are qualified and safe before they get behind the wheel, could have prevented these tragedies. This is classic primary prevention.

This report also highlights other preventive measures, such as installation of collision avoidance systems with automatic emergency braking as standard equipment on buses just as it is becoming standard equipment on all automobiles. And it recommends that those states that do not have legislation requiring new large school buses be equipped with passenger lap/shoulder belts for all passenger seating positions pass such legislation so that deaths and injuries can be prevented once a collision occurs.

All of these types of preventive measures will serve to protect not only children on school buses and the adults who ride with them, but they will protect all road users who share the roads with school buses.

Chairman Sumwalt and Member Weener joined this statement.

Appendix A: Investigations

Baltimore, Maryland

The National Transportation Safety Board (NTSB) was notified of the Baltimore crash on November 1, 2016, and dispatched an investigative team to the site. The NTSB established groups to investigate human performance; motor carrier operations; and highway, survival, and vehicle factors.

Parties to the investigation were the Federal Motor Carrier Safety Administration, Federal Transit Administration, Maryland Transit Administration, Maryland Transit Administration Police, Maryland Transportation Authority Police, Baltimore Police Department, Baltimore City Public Schools, and New Flyer.

Chattanooga, Tennessee

The NTSB was notified of the Chattanooga crash on November 21, 2016, and dispatched an investigative team to the site. The NTSB established groups to investigate human performance; motor carrier operations; and highway, survival, and vehicle factors. Then-Chairman Christopher A. Hart was the NTSB spokesperson on scene.

Parties to the investigation were the Federal Motor Carrier Safety Administration, Chattanooga Police Department, Chattanooga Department of Transportation, and Hamilton County Department of Education.

Appendix B: Supplemental Information, Baltimore Crash

Crash Description

About 6:30 a.m. on Tuesday, November 1, 2016, a 2015 IC Bus 64-passenger school bus was traveling east in the 4000 block of Frederick Avenue in Baltimore, Maryland, when it struck the rear of a 2012 Ford Mustang, which was also traveling east on Frederick Avenue. The school bus, operated by the motor carrier AAAfordable Transportation LLC, under contract to Baltimore City Public Schools (BCPS), was occupied by the 67-year-old driver and a school bus attendant. No students were on the bus at the time.

After striking the car, the school bus continued east on Frederick Avenue, crossed the center turn lane, and entered the westbound travel lane, where it collided with the driver side of a 2005 New Flyer transit bus operated by the Maryland Transit Administration (MTA). The transit bus was occupied by the 33-year-old driver and 13 passengers. As a result of the crash, the drivers of both buses and four transit bus passengers died. Five transit bus passengers were seriously injured; four transit bus passengers, the school bus attendant, and the driver of the car received minor injuries.

The New Flyer transit bus had 39 passenger seats and capacity for 15 standees. The driver seat was equipped with a lap/shoulder belt. All 39 seats were constructed of the same molded fiberglass shell and high-strength thermoplastic back. Passenger seats were not equipped with restraints.¹⁴⁶ The transit bus sustained extensive impact damage that started at the front left bumper corner and extended vertically to the windshield header and down the driver side—tearing away the windows, sheet metal, and fiberglass, resulting in an approximate 6-foot-tall opening (see figure B-1).

¹⁴⁶ Under the *Federal Motor Carrier Safety Regulations*, 49 *Code of Federal Regulations* (CFR) 390.3(f)(2), the transit bus is exempt and not required to meet occupant protection standards (*Federal Motor Vehicle Safety Standard* [FMVSS] 201, Occupant Protection in Interior Impact; and FMVSS 202, Head Restraints) or crash protection standards for the occupant compartment (FMVSS 208, Occupant Crash Protection).



Figure B-1. Driver-side postcrash view of 2005 New Flyer transit bus.

Injury Details

Both bus drivers were fatally injured. The school bus driver injuries included cervical and thoracic fractures, torso blunt force injuries, and left leg fractures. The transit bus driver injuries included blunt force head and torso injuries, along with multiple vertebral and upper and lower bilateral extremity fractures. The fatally injured transit bus passengers sustained blunt force head and torso injuries, and multiple fractures to the vertebra, pelvis, and bilateral upper and lower extremities.

Among the transit bus passengers, serious injuries included facial, vertebral, and torso blunt force trauma; upper and lower extremity fractures; and abrasions, contusions, and lacerations. A passenger who self-reported to the hospital complained of cervical strain, left arm pain, and a headache. The school bus attendant sustained an abrasion and forehead contusion. The driver of the car received left shoulder contusions.

Emergency Response and Vehicle Egress

Baltimore County dispatchers were notified of the crash through the 911 system at 6:28 a.m. At 6:32 a.m., the Baltimore City Fire Department (BFD) dispatched truck 8 with the initial incident commander, rescue squad 20, and medic 15. Truck 8 and the incident commander arrived on scene at 6:35 a.m., followed by squad 20 at 6:38 a.m. and the first-arriving BFD medic 15 at 6:41 a.m. The Baltimore Police Department was dispatched at 6:33 a.m., and its first unit arrived at 6:34 a.m. The MTA police were notified of the crash at 6:35 a.m., and their first unit arrived on scene at 6:46 a.m.

At 6:40 a.m., the acting incident commander declared the crash a mass casualty incident and requested three additional medic units and a rescue group.¹⁴⁷ When the BFD battalion chief arrived on scene at 6:44 a.m., he assumed incident command and proceeded to set up a command post. Both roadways were immediately closed, and traffic was redirected. The roadways were reopened at 5:37 p.m. In total, eight local emergency response agencies responded to the crash with seven fire units and eight ambulance units.

National Transportation Safety Board (NTSB) interviews of the transit bus passengers and the school bus attendant revealed the following:

- Two passengers exited the bus postcrash through the side rear door.
- One passenger exited from the passenger-side emergency exit window.
- One passenger was helped out through the intrusion area on the driver side of the bus.
- One passenger was carried out on a stretcher.
- First responders removed eight passengers on backboards.
- One passenger exited the bus on his own, but his exit path is unknown.
- Ground ambulances transported eight passengers and the school bus attendant to five area hospitals.
- One passenger with minor injuries left the scene and later went to a hospital for treatment.

Postcrash Actions by MVA

In Maryland, school districts (as well as nongovernmental entities, such as motor carriers) have access to the Motor Vehicle Administration (MVA) license monitor system, which is a subscription service that provides daily, weekly, or monthly email alerts on drivers whose licensing status has been canceled or downgraded for traffic convictions or expired medical certificates, among other infractions.¹⁴⁸ The BCPS subscribed to the service. By federal regulation, a state driver licensing agency has up to 60 days to downgrade a commercial driver's license (CDL) if a driver does not submit a valid medical certificate.

The school bus driver's qualification file included a copy of his current medical certification. However, he had not provided the MVA with a copy of his new medical certificate;

¹⁴⁷ The BFD categorizes any incident involving more than 10 patients requiring treatment and transport as a mass casualty incident and uses method of operation 807-1 for handling the event. Mass casualty incidents are further classified as level 1, 2, or 3 based on the number of patients. According to method 807-1, this crash was categorized as a level 1 response (with 11–25 patients).

¹⁴⁸ Government agencies and local school districts have free access to the system, and nongovernmental entities can subscribe. The email alert provides a link to a secure portal that provides access to traffic records. Subscribers can receive annual reports on selected drivers.

the medical certificate on file with the MVA had expired August 31, 2016.¹⁴⁹ As a result, on September 8, 2016, the MVA sent a letter informing the driver that, as of September 1, he was no longer authorized to drive a commercial motor vehicle. The MVA letter was found opened in the driver's personal vehicle postcrash.¹⁵⁰

On October 31, 2016, the bus driver's license should have been downgraded. The MVA recorded his license as downgraded in the license monitor system on November 2 (the day after the crash).¹⁵¹ When interviewed by NTSB investigators postcrash, the MVA deputy administrator reported that the delay was due to software changes in the transitioning process to comply with the *Maryland Driving Privilege Preservation Act of 2016*, which went into effect on October 1. The new law requires a CDL downgrade to a noncommercial driver's license when an individual fails to submit a valid medical certificate, as opposed to canceling driving privileges entirely. Because the driver's medical certificate expired so close to the effective date of the new law, the process to implement the license downgrade (and notify license monitor system subscribers of the status change) was extended.

In December 2016, the MVA removed the 60-day grace period for license monitor system notification. The system currently notifies all subscribers of a commercial driver's medical certification status the day after expiration. In addition, the MVA conducted a postcrash audit of its database to ensure that all commercial drivers with Maryland CDLs possess a current medical certificate (verifying that no driver with a Maryland-issued CDL is operating in a 60-day grace period status without a current medical certificate).

¹⁴⁹ The bus driver's medical certificate indicated National Registry 5427926492, Concentra, which—according to the Federal Motor Carrier Safety Administration medical database—is an authorized medical examiner.

¹⁵⁰ The letter stated that if the bus driver did not either submit a valid medical certificate or downgrade to a noncommercial license by October 10, 2016, he would lose his driving privileges entirely. Title 49 CFR 383.33 requires drivers who receive notification that their license has been canceled, suspended, or revoked to notify the carrier by the end of the next business day. There is no evidence that the driver notified AAAfordable of the MVA letter.

¹⁵¹ On November 2, a notice was distributed through the MVA license monitor system to inform subscribers of the change in license status.

Appendix C: Supplemental Information, Chattanooga Crash

Crash Description

On Monday, November 21, 2016, about 3:20 p.m., a 2008 Thomas Built 84-passenger school bus was traveling south in the 300 block of Talley Road in Chattanooga, Tennessee, when it departed the road to the left and struck a utility pole, overturned onto its right side, and subsequently collided with a tree (see figure C-1). The school bus was operated by the motor carrier Durham School Services LP and occupied by a 24-year-old driver and 37 student passengers.

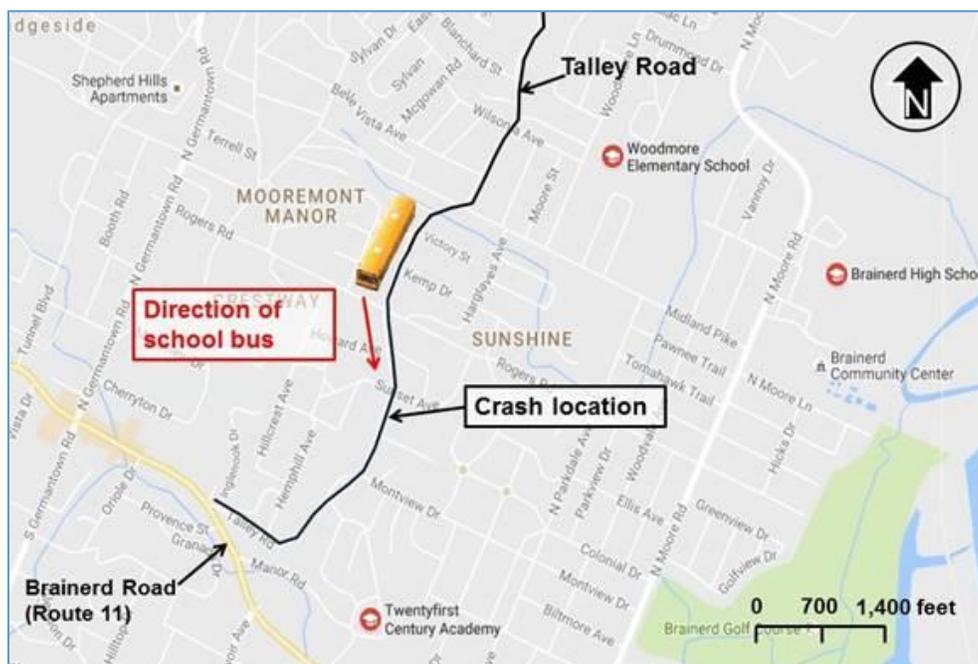


Figure C-1. Map of Chattanooga crash location on Talley Road. (Source: Internet map of schools in Hamilton County, modified)

On the day of the crash (and for several days before the crash), the bus driver did not follow the scheduled drop-off route. Table C-1 lists, in numerical order, the drop-off locations and scheduled drop-off times for the driver's afternoon route.

Table C-1. Scheduled drop-off locations and times for Chattanooga school bus.

Stop Number	Description of Drop-Off Location	Time (p.m.)
1	School: Woodmore Elementary pickup	3:00
2	Phoenix Avenue & Belle Vista Avenue	3:08
3	Gillespie Road & Shannon Avenue	3:09
4	Gillespie Road & Terrell Street	3:09
5	Ridgeside Road & Gillespie Road	3:10
6	N Germantown Road & Ridgeside Road	3:11
7	Ridgeside Road & Booth Road	3:11
8	404 Tunnel Boulevard – Shepherd Hills apartments	3:13
9	Booth Road & Ridgevale Avenue	3:15
10	Booth Road & Howard Avenue	3:15
11	Cherryton Drive & N Germantown Road	3:16
12	Montview Drive & Sunnyside Drive	3:18
13	N Germantown Road & Montview Drive	3:21
14	Montview apartments	3:22
15	Dellwood Place & Woodlawn Drive	3:23
16	Pinewood Avenue & N Seminole Drive	3:25
17	Pinewood Avenue & Pinewood Terrace Lane	3:25
18	3301 Pinewood Ave – Pinewood Trace apartments	3:26
19	Pinewood Avenue & Dellwood Place	3:27
20	Corbly Drive & Inglenook Drive & Talley Road	3:29
21	99 Talley Road	3:31

Figure C-2 shows the route the driver should have taken when departing the elementary school in the afternoon. The route is plotted on a map, with red arrows showing the direction of travel; the stops are numbered as listed in table C-1.

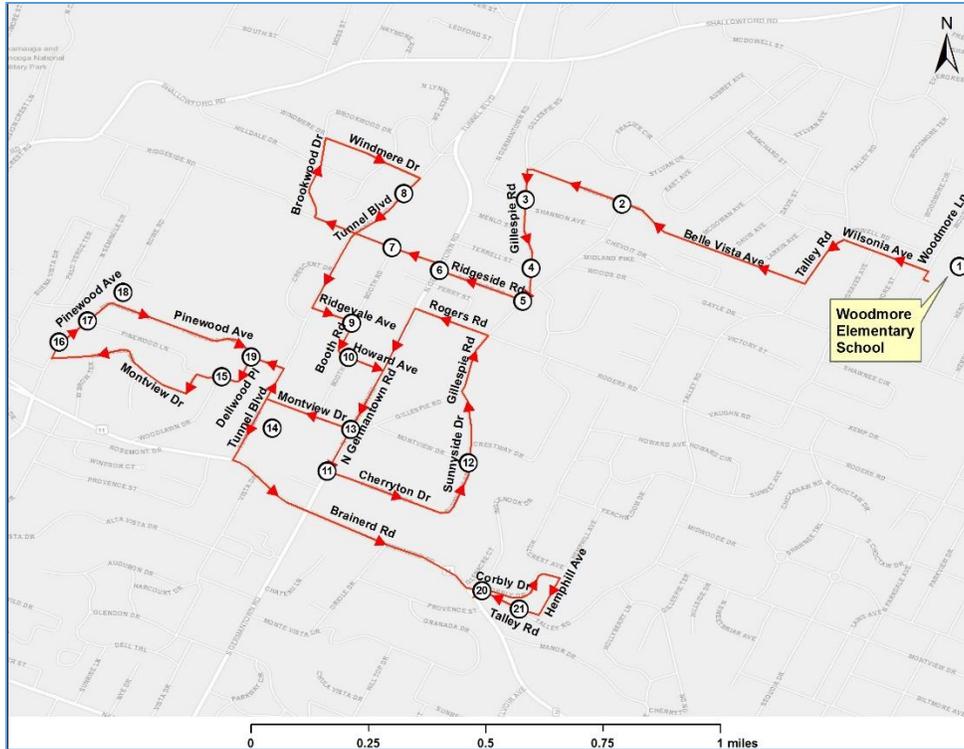


Figure C-2. Scheduled afternoon route for Chattanooga school bus driver.

Figure C-3 shows the actual route the driver took for the afternoon shift on November 21. At the time of the crash, he had not reached any of his scheduled drop-off locations. This map was developed using Zonar data from the bus. Durham used Zonar to assist with global positioning system tracking.

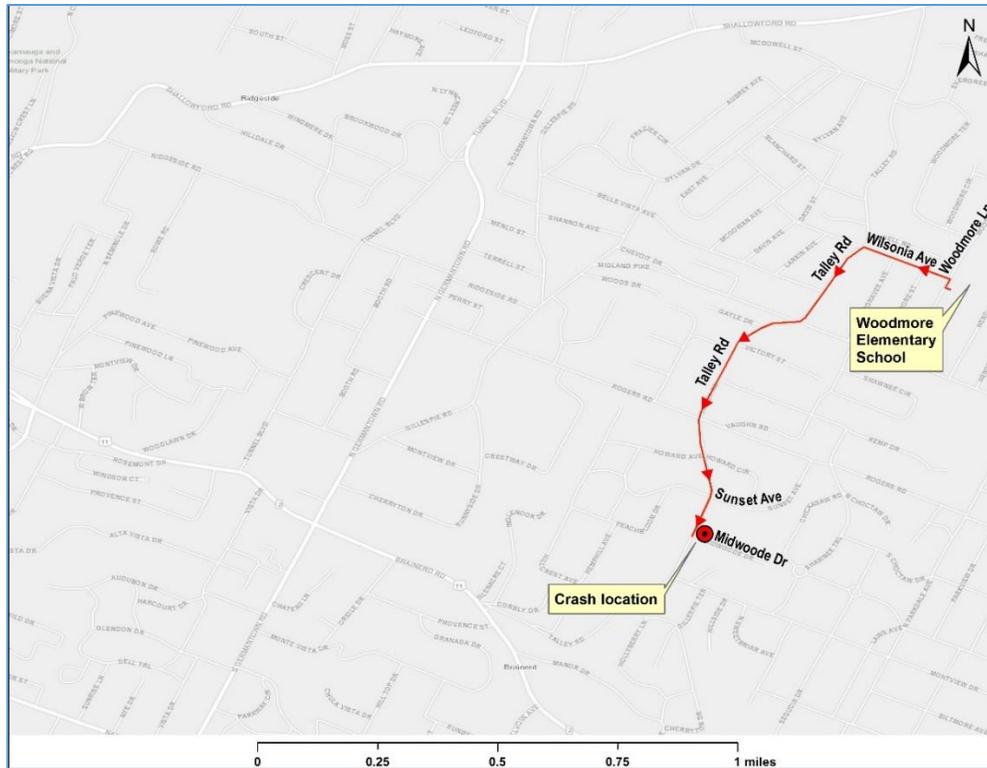


Figure C-3. Actual route traveled by Chattanooga school bus driver on day of crash.

Emergency Response

Hamilton County call center dispatchers were notified of the crash through the 911 system at 3:20 p.m. At 3:21 p.m., emergency medical service (EMS) units and a Chattanooga Police Department (CPD) officer were dispatched; they arrived on scene at 3:24 p.m. and 3:27 p.m. respectively. By 3:22 p.m., dispatchers announced the call as a multiagency EMS and fire incident; and a Chattanooga Fire Department (CFD) unit was also dispatched to the scene, arriving at 3:27 p.m.

The CFD dispatched two fire trucks, three rescue squad units, and three battalion chiefs. The initial responding unit arrived on scene at 3:27 p.m. and assumed incident command. At 3:32 p.m., the Hamilton County EMS supervisor arrived on scene, declared the crash a mass casualty incident, and requested four additional units. The roadway was closed immediately following the crash, and traffic was redirected. The roadway was reopened at 8:34 p.m.

In total, 25 CPD units were dispatched and responded to the scene within 16 minutes of the initial 911 call. The CFD responded with 29 EMS and fire units. Among the bus occupants, 18 passengers were transported by ambulance and 13 passengers were transported by bus to Erlanger Hospital, with varying degrees of injury; and one passenger was treated and released on scene and later transported by private vehicle to another hospital.

Roadway Information

Talley Road is functionally classified as a local urban street. Figure C-4 shows the horizontal curves immediately preceding the crash location. On December 1, 2016, the city of Chattanooga conducted a 24-hour vehicle classification study in the 318 block of Talley Road southbound. Passenger vehicles accounted for 58 percent of the total classified vehicles; vans and pickups, 33 percent; buses and trucks, 4 percent; and other vehicles, 5 percent.

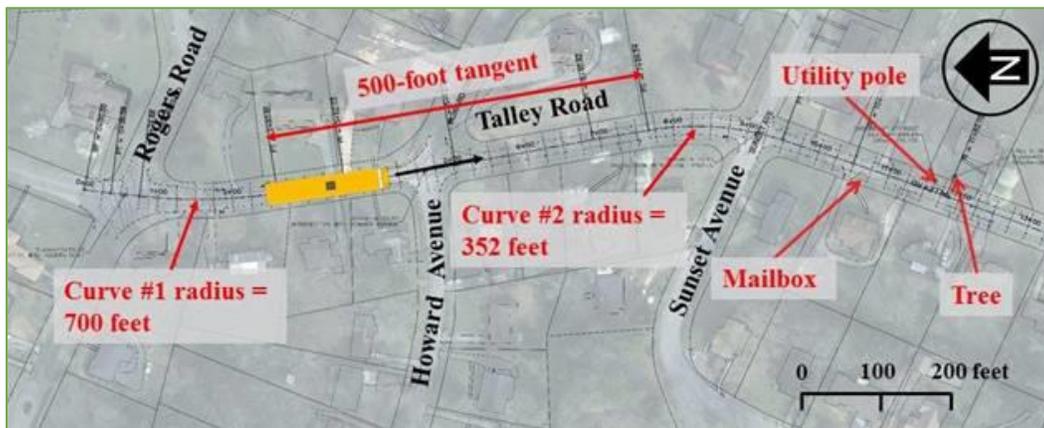


Figure C-4. Horizontal curves immediately preceding Talley Road crash location (Source: city of Chattanooga, modified)

Horizontal curve #1 turns to the left for motorists traveling south on Talley Road and has a radius of 700 feet. Horizontal curve #2 turns to the right for motorists traveling south on Talley Road and has a radius of 352 feet. A tangent distance of 500 feet separates the horizontal curves. The vertical grades for Talley Road in the southbound direction of travel consist of a -8.17 percent downgrade slope located 1,190 feet from the tree; a -4.9 percent downgrade slope located 750 feet from the tree; and a +6.9 percent upgrade maximum slope (4.3 percent overall average slope) located 190 feet from the tree.

Motor Carrier

National Express operates school buses under contract to public school districts through several motor carrier companies, such as Durham. According to the Federal Motor Carrier Safety Administration (FMCSA) Motor Carrier Management Information System, both Durham and National Express are registered as interstate “for-hire” motor carriers.

Prior to the crash, between 2007 and 2013, Durham had had one comprehensive compliance review (CR) and six nonrated, or focused, CRs. A comprehensive CR applies when three or more behavior analysis and safety improvement categories (BASIC) have exceeded their thresholds—and may be used if the carrier was involved in a crash or there has been a complaint about the carrier’s operation. A comprehensive CR normally results in a safety rating, which is

determined by the FMCSA using the safety rating methodology outlined in 49 *Code of Federal Regulations* (CFR) 385.5.¹⁵²

A focused CR is used when two or fewer BASICs have exceeded their thresholds or when only certain portions of the CFR relate to the carrier's operations. A focused CR normally does not result in a safety rating and is usually classified as "nonrated" when complete; however, in certain circumstances, it may result in an adverse safety rating (conditional or unsatisfactory).¹⁵³

At the time of the crash, the FMCSA safety measurement system profile for Durham showed that the carrier's vehicle and driver out-of-service rates were 3.5 percent and 1.8 percent, respectively (the national average vehicle and driver out-of-service rates were 20.7 percent and 5.5 percent, respectively). Durham displayed an alert in driver fitness (score of 93) and had shown a driver fitness alert for 10 of the 12 past months precrash.¹⁵⁴

The FMCSA conducted a comprehensive postcrash CR of the Durham Chattanooga terminal.¹⁵⁵ Due to the operation of the bus in school-to-home service, violations discovered during the CR were limited to commercial driver's license requirements and alcohol and controlled substances testing, in accordance with 49 CFR 390.3T(f)(1). As a result, the following violations were noted:

- Using a driver who has refused to submit to an alcohol test.
- Using a driver before a negative pre-employment test result.¹⁵⁶

¹⁵² (a) A safety rating is "satisfactory," "conditional," or "unsatisfactory" using the factors prescribed in 49 CFR 385.7. (1) **Satisfactory**: a motor carrier has in place functioning safety management controls to meet the safety fitness standards prescribed in 49 CFR 385.5. (2) **Conditional**: a motor carrier does not have adequate safety management controls in place to ensure compliance with the safety fitness standards, which could result in occurrences listed in 49 CFR 385.5 (a) through (k). (3) **Unsatisfactory**: a motor carrier does not have adequate safety management controls in place to ensure compliance with the safety fitness standard, which has resulted in the occurrences listed in 49 CFR 385.5 (a) through (k). (4) **Unrated**: the FMCSA has not assigned a safety rating to the motor carrier. (b) Acute violations are those where noncompliance is so severe as to require immediate corrective action by the motor carrier regardless of its overall safety posture. Critical violations relate to management or operational controls that show a pattern of noncompliance. Title 49 CFR Part 385, appendix B, lists acute and critical violations.

¹⁵³ All six focused CRs (nonrated) were initiated as the result of complaints, crashes, or drug and alcohol task forces. Between the October 2007 comprehensive CR and the postcrash November 2016 comprehensive terminal review, the FMCSA conducted no risk-based reviews. See 49 CFR Part 385, appendix B.

¹⁵⁴ Durham's crash category score at the time of the crash was 45. The safety measurement system had shown an alert for this category in 6 of the previous 12 months precrash, with a score of 50 or higher.

¹⁵⁵ This review was not rated, because the scope of a terminal review is limited.

¹⁵⁶ Under 49 CFR 382.301, motor carriers are required to administer pre-employment controlled substance testing and not employ a driver in a safety-sensitive function (driving) until a negative test result is obtained. Also, under 49 CFR 382.305, motor carriers are required to randomly test all subject drivers for alcohol and controlled substances. One violation was discovered in the postcrash CR: on August 16, 2016, the driver had driven a bus (during training, no students were on board) before a negative pre-employment controlled substance test result was received. The driver had two pre-employment tests, in February 2016 and April 2016, when he was first hired. Those tests had negative results.

- Failing to conduct a postcrash test.
- Failing to ensure that random test dates are reasonably spread throughout the calendar year.¹⁵⁷

Because of violations discovered during the postcrash CR, the FMCSA conducted a comprehensive CR of the carrier's complete operations on May 18, 2017. The final postcrash CR rating was "satisfactory," though violations included:

- Failing to maintain on file a record stating why a postcrash alcohol and controlled substance test did not occur.
- Failing to ensure that each driver subject to random alcohol/controlled substance testing has an equal chance of being selected.
- Failing to ensure that random testing dates are reasonably spread throughout the calendar year.

¹⁵⁷ Not all drivers were employed by the carrier during the summer break from school. As a result, drivers were not subject to random alcohol or controlled substance testing during the summer break. The *Federal Motor Carrier Safety Regulations* require that any driver who has been removed from the random pool have a new pre-employment test prior to being allowed to drive again. The bus driver did not have a new pre-employment controlled substance test after returning from summer break.

Appendix D: Concentra Form



DOT Medical Examiner Letter to Clinician: Hypertension

Date: _____

Driver Name: _____ DOB: _____

Dear medical clinician:

During a Department of Transportation (DOT) medical certification examination, the above driver was:

- Disqualified
- Given a Limited Certification expiring on: _____
- Given a Pending Determination – expires 45 days from: : _____

The following condition(s) and/or concerns were identified:

U.S. CFR 391.41 (b)(6) states: A person is physically qualified to drive a commercial motor vehicle if that person has no current clinical diagnosis of high blood pressure likely to interfere with the ability to operate a commercial motor vehicle safely.

Satisfactory long term control is defined by the DOT as blood pressures $\leq 140/90$.

We request that you evaluate and treat the driver for the above condition(s). Upon completion of treatment, please complete the bottom section of this form and provide any additional documentation requested, as follows:

- Current blood pressure readings - please provide at least ____ readings with the dates obtained.
- Current antihypertensive treatment
- Laboratory results

This driver's ability to operate a commercial motor vehicle in interstate commerce depends on your timely response to this request before the referenced expiration date.

Treating clinician's statement

As the treating clinician of the above commercial driver, I am familiar with the driver's condition(s) and treatment. I have read the relevant DOT regulation(s) and guidelines; I understand that the driver is in compliance and that:

- The identified condition(s) and/or treatment should not cause sudden impairment or interfere with the driver's ability to safely operate a commercial motor vehicle.
- The following condition(s) and/or treatment have the potential to suddenly impair or interfere with the safe operation of a commercial vehicle:



DOT Medical Examiner Letter to Clinician: Hypertension

Clinician name: _____
Specialty: _____
Address: _____
City: _____ ST: _____ Zip: _____
Phone: _____ Fax: _____
Signature: _____

Please return this completed form and any additional requested documentation to:

Concentra Medical Centers Fax: _____

_____ For questions, please call:
_____ Phone: _____



DOT Medical Examiner Letter to Clinician: Hypertension

Thank you for your cooperation.

Driver consent for release of medical information

I, _____ hereby authorize the release of the following medical information to Concentra Medical Centers for certification determination:

Driver signature

Witness signature

Date

Date

Appendix E: FMCSA Driver Medication Form MCSA-5895

MCSA-5895

OMB Control Number: 2126-0064
Expiration Date: 1/31/2020

U.S. Department of Transportation
Federal Motor Carrier Safety Administration

A Federal agency may not conduct or sponsor, and a person is not required to respond to, nor shall a person be subject to a penalty for failure to comply with a collection of information subject to the requirements of the Paperwork Reduction Act unless that collection of information displays a current valid OMB Control Number. The OMB Control Number for this information collection is 2126-0064. Public reporting for this collection of information is estimated to be approximately 8 minutes per response, including the time for reviewing instructions, gathering the data needed, and completing and reviewing the collection of information. All responses to this collection of information are voluntary. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to: Information Collection Clearance Officer, Federal Motor Carrier Safety Administration, MC-RRA, 1200 New Jersey Avenue, SE, Washington, D.C. 20590.

391.41 CMV DRIVER MEDICATION FORM

Driver Name: _____ DOB: _____

The above patient/driver is being evaluated to determine whether he/she meets the medical standards of the Federal Motor Carrier Safety Administration (FMCSA) to operate a commercial motor vehicle (CMV) in interstate commerce. During the medical evaluation, it was determined this individual is taking medication(s) that may impair his/her ability to safely operate a CMV. As the certified Medical Examiner (ME), I request that you review the regulations as noted below, complete this form, and return it to me at the mailing address, email address, or fax number specified below. The final determination as to whether the individual listed in this form is physically qualified to drive a CMV will be made by the certified ME.

49 CFR 391.41, Physical Qualifications for Drivers: A person is physically qualified to drive a CMV if that person ... (12)(i) Does not use any drug or substance identified in 21 CFR 1308.11 Schedule I, an amphetamine, a narcotic, or other habit-forming drug. (ii) Does not use any non-Schedule I drug or substance that is identified in the other Schedules in 21 part 1308 except when the use is prescribed by a licensed medical practitioner, as defined in § 382.107, who is familiar with the driver's medical history and has advised the driver that the substance will not adversely affect the driver's ability to safely operate a CMV.

1. List all medications and dosages that you have prescribed to the above named individual.

2. List any other medications and dosages that you are aware have been prescribed to the above named individual by another treating health care provider.

3. What medical conditions are being treated with these medications?

4. It is my medical opinion that, considering the mental and physical requirements of operating a CMV and with awareness of a CMV driver's role (consistent with "The Driver's Role" statement on page 2), my patient:
(a) has no medication side effects from medication(s) that I prescribe that would adversely affect the ability to safely operate a CMV; and
(b) has no medical condition(s) that I am treating with the above medication(s) that would adversely affect the ability to safely operate a CMV.

___ Yes ___ No (check response)

Signature of Prescribing Healthcare Provider

Date

Printed Name of Prescribing Healthcare Provider

State of Licensure

Street Address

City, State, Zip Code

Phone/Fax

Email

391.41 CMV DRIVER MEDICATION FORM

THE DRIVER'S ROLE

49 CFR 391.43

Responsibilities, work schedules, physical and emotional demands, and lifestyles among commercial drivers vary by the type of driving that they do. Some of the main types of drivers include the following: turn around or short relay (drivers return to their home base each evening); long relay (drivers drive 9-11 hours and then have at least a 10-hour off-duty period), straight through haul (cross country drivers); and team drivers (drivers share the driving by alternating their 5-hour driving periods and 5-hour rest periods.) The following factors may be involved in a driver's performance of duties: abrupt schedule changes and rotating work schedules, which may result in irregular sleep patterns and a driver beginning a trip in a fatigued condition; long hours; extended time away from family and friends, which may result in lack of social support; tight pickup and delivery schedules, with irregularity in work, rest, and eating patterns, adverse road, weather and traffic conditions, which may cause delays and lead to hurriedly loading or unloading cargo in order to compensate for the lost time; and environmental conditions such as excessive vibration, noise, and extremes in temperature. Transporting passengers or hazardous materials may add to the demands on the commercial driver. There may be duties in addition to the driving task for which a driver is responsible and needs to be fit. Some of these responsibilities are: coupling and uncoupling trailer(s) from the tractor, loading and unloading trailer(s) (sometimes a driver may lift a heavy load or unload as much as 50,000 lbs. of freight after sitting for a long period of time without any stretching period); inspecting the operating condition of tractor and/or trailer(s) before, during and after delivery of cargo; lifting, installing, and removing heavy tire chains; and, lifting heavy tarpaulins to cover open top trailers. The above tasks demand agility, the ability to bend and stoop, the ability to maintain a crouching position to inspect the underside of the vehicle, frequent entering and exiting of the cab, and the ability to climb ladders on the tractor and/or trailer(s). In addition, a driver must have the perceptual skills to monitor a sometimes complex driving situation, the judgment skills to make quick decisions, when necessary, and the manipulative skills to control an oversize steering wheel, shift gears using a manual transmission, and maneuver a vehicle in crowded areas.

Signature of Certified Medical Examiner

Date

Printed Name of Certified Medical Examiner

Email

Street Address

City, State, Zip Code

Use of this form by the certified medical examiner is voluntary.

This document contains sensitive information and is for official use only. Improper handling of this information could negatively affect individuals. Handle and secure this information appropriately to prevent inadvertent disclosure by keeping the documents under the control of authorized persons. Properly dispose of this document when no longer required to be maintained by regulatory requirements.

References

- AAMVA (American Association of Motor Vehicle Administrators). 2015a. *Best Practices for the Deterrence and Detection of Fraud*. Arlington, Virginia: AAMVA.
- _____. 2015b. *Facial Recognition Program Best Practices*. Arlington, Virginia: AAMVA.
- AASHTO (American Association of State Highway and Transportation Officials). 2011. *A Policy on Geometric Design of Highways and Streets*. Washington, DC: AASHTO.
- Classen, S., A. M. Crizzle, S. M. Winter, W. Silver, and S. Eisenschenk. 2012. “Evidence-Based Review on Epilepsy and Driving,” *Epilepsy Behavior* 23 (2): 103–112.
- Cox, D. J., J. K. Penberthy, J. Zrebiec, K. Weinger, J. E. Aikens, B. Frier, B. Stetson, M. DeGroot, P. Trief, H. Schaechinger, N. Hermanns, L. Gonder-Frederick, and W. Clarke. 2003. “Diabetes and Driving Mishaps, Frequency and Correlations From a Multinational Study,” *Diabetes Care* 26: 2329–2334.
- DOT (US Department of Transportation). 2007. *Commercial Driver’s License Third Party Testing Anti-Fraud System, Phase II–Prototype, Pilot Testing and Evaluation, Final Report, FMCSA-RRT-07-026*. Washington, DC: DOT.
- FMCSA (Federal Motor Carrier Safety Administration). 2013. *National Registry of Certified Medical Examiners, Complete Guide to Medical Examiner Certification*. Washington, DC: FMCSA.
- Krumholz, A. 2009. “Driving Issues in Epilepsy: Past, Present, and Future,” *Epilepsy Currents* 9 (2): 31–35.
- Lococo, K. H. 2003. *Summary of Medical Advisory Board Practices*. Kulpsville, Pennsylvania: Transanalytics.
- McLachlan, R. S., E. Starreveld, and M. A. Lee. 2007. “Impact of Mandatory Physician Reporting on Accident Risk in Epilepsy,” *Epilepsia* 48 (8): 1500–1505.
- Naik, P. A., M. E. Fleming, P. Bhatia, and C. L. Harden. 2015. “Do Drivers With Epilepsy Have Higher Rates of Motor Vehicle Accidents Than Those Without Epilepsy?” *Epilepsy Behavior* 47: 111–114.
- NHTSA (National Highway Traffic Safety Administration). 2018. *Traffic Safety Facts*. Washington, DC: NHTSA.
- _____. 2013. *The Impact of Hand-Held and Hands-Free Cell Phone Use on Driving Performance and Safety-Critical Event Risk, Final Report, DOT-HS-811-757*. Washington, DC: NHTSA.

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

www.nts.gov/investigations/AccidentReports/Pages/HAR1701.aspx

_____. 2017b. *Shortcomings of Driver Qualification Processes for Baltimore City Public Schools and of the Disqualified Driver Database for All Maryland School Districts*, NTSB/HSR-17/02 (H-17-13, -14, -15). Washington, DC: NTSB.

www.nts.gov/investigations/AccidentReports/Pages/HSR1702.aspx

_____. 2016a. *Collision of Two School Buses with Subsequent Rollover, Knoxville, Tennessee, December 2, 2014*, NTSB/HAB-16/04. Washington, DC: NTSB.

www.nts.gov/investigations/AccidentReports/Pages/HAB1604.aspx

_____. 2016b. *Passenger Vehicle and School Bus Collision and Roadway Departure, Houston, Texas, September 15, 2015*, NTSB/HAB-16/05. Washington, DC: NTSB.

www.nts.gov/investigations/AccidentReports/Pages/HAB1605.aspx

_____. 2016c. *School Bus Roadway Departure, Anaheim, California, April 24, 2014*, NTSB/HAB-16/06. Washington, DC: NTSB.

www.nts.gov/investigations/AccidentReports/Pages/HAB1606.aspx

_____. 2015a. *Commercial Vehicle Onboard Video Systems*, NTSB/SR-15/01. Washington, DC: NTSB.

www.nts.gov/safety/safety-studies/Pages/SR1501.aspx

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

www.nts.gov/safety/safety-studies/Pages/SIR1501.aspx

_____. 2015c. *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.

www.nts.gov/investigations/AccidentReports/Pages/HAR1501.aspx

_____. 2015d. *Truck-Tractor Semitrailer Median Crossover Collision With Medium-Size Bus on Interstate 35, Davis, Oklahoma, September 26, 2014*, NTSB/HAR-15/03. Washington, DC: NTSB.

www.nts.gov/investigations/AccidentReports/Pages/HAR1503.aspx

_____. 2013. *School Bus and Truck Collision at Intersection, Near Chesterfield, New Jersey, February 16, 2012*, NTSB/HAR-13/01. Washington, DC: NTSB.

www.nts.gov/investigations/AccidentReports/Pages/HAR1301.aspx

_____. 2012. *Highway–Railroad Grade Crossing Collision, US Highway 95, Miriam, Nevada, June 24, 2011*, NTSB/HAR-12/03. Washington, DC: NTSB.

www.nts.gov/investigations/AccidentReports/Pages/HAR1203.aspx

_____. 2011a. *Multivehicle Collision Interstate 44 Eastbound, Gray Summit, Missouri, August 5, 2010*, NTSB/HAR-11/03. Washington, DC: NTSB.

www.nts.gov/investigations/AccidentReports/Pages/HAR1103.aspx

_____. 2011b. *Rollover of a Truck-Tractor and Cargo Tank Semitrailer Carrying Liquefied Petroleum Gas and Subsequent Fire, Indianapolis, Indiana, October 22, 2009*, NTSB/HAR-11/01. Washington, DC: NTSB.

www.nts.gov/investigations/AccidentReports/Pages/HWY10MH001.aspx

_____. 2010. *Bus Loss of Control and Rollover, Dolan Springs, Arizona, January 30, 2009*, NTSB/HAR-10/01. Washington, DC: NTSB.

www.nts.gov/investigations/AccidentReports/Pages/HAR1001.aspx

_____. 2009a. *Pedal Misapplication in Heavy Vehicles*, NTSB/SIR-09/02. Washington, DC: NTSB.

www.nts.gov/safety/safety-studies/Pages/SIR0902.aspx

_____. 2009b. *School Bus Struck in Left Rear by Automobile, Loss of Control, and Rollover on Interstate 10, Milton, Florida, May 28, 2008*, NTSB/HAB-09/03. Washington, DC: NTSB.

www.nts.gov/investigations/AccidentReports/Pages/HAB0903.aspx

_____. 2008a. *Frontal and Sideswipe Collision Between a School Bus and a Trash Truck. Arlington, Virginia, April 18, 2005*, NTSB/HAB-08/01. Washington, DC: NTSB.

www.nts.gov/investigations/AccidentReports/Pages/HAB0801.aspx

_____. 2008b. *Motorcoach Override of Elevated Exit Ramp, Interstate 75, Atlanta, Georgia, March 2, 2007*, NTSB/HAR-08/01. Washington, DC: NTSB.

www.nts.gov/investigations/AccidentReports/Pages/HAR0801.aspx

_____. 2008c. *Truck-Tractor Semitrailer Rollover and Motorcoach Collision With Overturned Truck, Interstate Highway 94 Near Osseo, Wisconsin, October 16, 2005*, NTSB/HAR-08/02. Washington, DC: NTSB.

- www.nts.gov/investigations/AccidentReports/Pages/HAR0802.aspx
- _____. 2002a. *Collision Between Truck-Tractor Semitrailer and School Bus Near Mountainburg, Arkansas, May 31, 2001*, NTSB/HAR-02/03. Washington, DC: NTSB.
- www.nts.gov/investigations/AccidentReports/Pages/HAR0203.aspx
- _____. 2002b. *Work Zone Collision Between a Tractor-Semitrailer and a Tennessee Highway Patrol Vehicle, Jackson, Tennessee, July 26, 2000*, NTSB/HAR-02/01. Washington, DC: NTSB.
- www.nts.gov/investigations/AccidentReports/Pages/HAR0201.aspx
- _____. 2001a. *Collision of CSXT Freight Train and Murray County School District Bus Near Conasauga, Tennessee, March 28, 2000*, NTSB/HAR-01/03. Washington, DC: NTSB.
- www.nts.gov/investigations/AccidentReports/Pages/HAR0103.aspx
- _____. 2001b. *Motorcoach Run-Off-The-Road Accident, New Orleans, Louisiana, May 9, 1999*, NTSB/HAR-01/01. Washington, DC: NTSB.
- www.nts.gov/investigations/AccidentReports/Pages/HAR0101.aspx
- _____. 2000. *School Bus and Dump Truck Collision Near Central Bridge, New York, October 21, 1999*, NTSB/HAR-00/02. Washington, DC: NTSB.
- www.nts.gov/investigations/AccidentReports/Pages/HAR0002.aspx
- _____. 1999. *Bus Crashworthiness*, NTSB/SIR-99/04. Washington, DC: NTSB.
- www.nts.gov/safety/safety-studies/Pages/SIR9904.aspx
- _____. 1995. *Multiple Vehicle Collision with Fire During Fog Near Milepost 118 on Interstate 40, Menifee, Arkansas, January 9, 1995, and Special Investigation of Collision Warning Technology*, NTSB/HAR-95/03. Washington, DC: NTSB.
- www.nts.gov/investigations/AccidentReports/Pages/HAR9503.aspx
- Sheth, S. G., G. Krauss, A. Krumholz, and G. Li. 2004. "Mortality in Epilepsy: Driving Fatalities vs Other Causes of Death in Patients With Epilepsy," *Neurology* 63: 1002–1007.
- Soderstrom, C., M. Scottino, J. Joyce, C. Burch, S. Ho, and T. Kerns. 2009. "Police Referral of Drivers to the Maryland Motor Vehicle Administration's Medical Advisory Board," *Annals of Advances in Automotive Medicine* 53: 105–116.
- Soderstrom, C. A., and J. J. Joyce. 2008. "Medical Review of Fitness to Drive in Older Drivers: The Maryland Experience," *Traffic Injury Prevention* 9: 341–348.

Songer, T. J., and R. R. Dorsey. 2006. "High-Risk Characteristics for Motor Vehicle Crashes in Persons With Diabetes by Age," *Annual Proceedings, Association of Advanced Automotive Medicine* 50: 335–351.