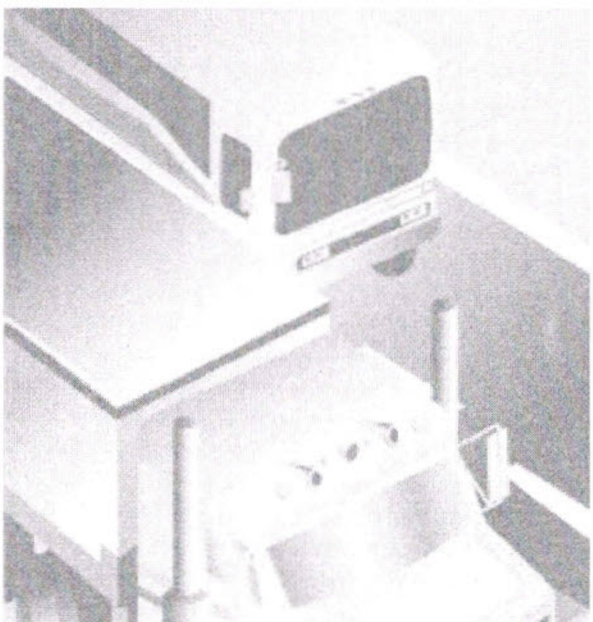
IE 2062 30517 Report

15-Passenger Child Care Van Run-Off-Road Accident Memphis, Tennessee April 4, 2002



Highway Accident Report

NTSB/HAR-04/02

PB2004-916202
Notation 7623

National Transportation Safety Board
Washington, D.C.

Highway Accident Report

15-Passenger Child Care Van Run-Off-Road Accident Memphis, Tennessee April 4, 2002

NTSB/HAR-04/02
PB2004-916202
Notation 7623
Adopted April 7, 2004

National Transportation Safety Board
490 L'Enfant Plaza, S.W.
Washington, D.C. 20594

National Transportation Safety Board. 2004. ***15-Passenger Child Care Van Run-Off-Road Accident, Memphis, Tennessee, April 4, 2002.*** **Highway Accident Report NTSB/HAR-04/02. Washington, DC.**

Abstract: On April 4, 2002, about 8:19 a.m., a 15-passenger Ford E-350 van, driven by a 27-year-old driver and transporting six children to school, was southbound in the left lane of Interstate 240 in Memphis, Tennessee. The van was owned and operated by Tippy Toes Learning Academy, a private child care center. A witness driving behind the van stated that the vehicle was traveling about 65 mph when it drifted from the left lane, across two other lanes, and off the right side of the roadway. She said that she did not see any brake lights. The van then overrode the guardrail and continued to travel along the dirt and grass embankment until the front of the van collided with the back of the guardrail and a light pole. The rear of the van rotated counterclockwise and the front and right side of the van struck the bridge abutment at the Person Avenue overpass before coming to rest. The driver was ejected through the windshield and sustained fatal injuries. Four of the children sustained fatal injuries, and two were seriously injured.

The major safety issues discussed in this report are day care transportation oversight and highway barrier design. As a result of this investigation, the Safety Board makes recommendations to child care transportation oversight agencies in the 50 States and the District of Columbia, the State Departments of Transportation, the National Association for the Education of Young Children, and the American Association of State Highway and Transportation Officials. The Safety Board also reiterates a recommendation to 39 States and the District of Columbia.

The National Transportation Safety Board is an independent Federal agency dedicated to promoting aviation, railroad, highway, marine, pipeline, and hazardous materials 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 Safety Board makes public its actions and decisions through accident reports, safety studies, special investigation reports, safety recommendations, and statistical reviews.

Recent publications are available in their entirety on the Web at <http://www.ntsb.gov>. Other information about available publications also may be obtained from the Web site or by contacting:

National Transportation Safety Board
Public Inquiries Section, RE-51
490 L'Enfant Plaza, S.W.
Washington, D.C. 20594
(800) 877-6799 or (202) 314-6551

Safety Board publications may be purchased, by individual copy or by subscription, from the National Technical Information Service. To purchase this publication, order report number **PB2004-916202** from:

National Technical Information Service
5285 Port Royal Road
Springfield, Virginia 22161
(800) 553-6847 or (703) 605-6000

Contents

Acronyms and Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
ABS	antilock braking system
DHHS	U.S. Department of Health and Human Services
ECS	electronic crash sensor
EDSMAC4	Engineering Dynamics Corporation Simulation of Automobile Collisions
EDCRASH	Engineering Dynamics Corporation Reconstruction of Accident Speeds on the Highway
FARS	Fatality Analysis Reporting System
FHWA	Federal Highway Administration
Ford	Ford Motor Company
HbA1c	hemoglobin A1c
HVE	Human Vehicle Environment
I-240	Interstate 240
MADYMO	MAthematical DYnamical MOdels
MFSAB	multifunction school activity bus
µg/ml	micrograms per milliliter
MPD	Memphis Police Department
NAEYC	National Association for the Education of Young Children
NHTSA	National Highway Traffic Safety Administration
SIMON	Simulation Model Non-linear
THC	tetrahydrocannabinol
THC-COOH	tetrahydrocannabinol carboxylic acid
TDHS	Tennessee Department of Human Services
TDOT	Tennessee Department of Transportation
Tippy Toes	Tippy Toes Learning Academy

Executive Summary

On April 4, 2002, about 8:19 a.m., a 15-passenger Ford E-350 van, driven by a 27-year-old driver and transporting six children to school, was southbound in the left lane of Interstate 240 in Memphis, Tennessee. The van was owned and operated by Tippy Toes Learning Academy, a private child care center. A witness driving behind the van stated that the vehicle was traveling about 65 mph when it drifted from the left lane, across two other lanes, and off the right side of the roadway. She said that she did not see any brake lights. The van then overrode the guardrail and continued to travel along the dirt and grass embankment until the front of the van collided with the back of the guardrail and a light pole. The rear of the van rotated counterclockwise and the front and right side of the van struck the bridge abutment at the Person Avenue overpass before coming to rest. The driver was ejected through the windshield and sustained fatal injuries. Four of the children sustained fatal injuries, and two were seriously injured.

The Safety Board determines that the probable cause of this accident was the absence of oversight by Tippy Toes Learning Academy and the driver's inability to maintain control of his vehicle because he fell asleep, quite likely due to an undiagnosed sleep disorder; the driver's marijuana use may also have had a role in the accident. Contributing to the accident was the Tennessee Department of Human Services' lack of oversight of child care transportation. Contributing to the severity of the injuries were the use of a 15-passenger van to transport pupils, the nonuse of appropriate restraints, and the design of the roadside barrier system.

The major safety issues discussed in this report are child care transportation oversight and highway barrier design.

As a result of this investigation, the Safety Board makes recommendations to child care transportation oversight agencies in the 50 States and the District of Columbia, the State Departments of Transportation, the National Association for the Education of Young Children, and the American Association of State Highway and Transportation Officials. The Safety Board also reiterates a recommendation to 39 States and the District of Columbia.

Factual Information

Accident Narrative

On April 4, 2002, about 8:19 a.m., a 15-passenger Ford E-350 van, driven by a 27-year-old driver transporting six children to school, was southbound in the left lane of Interstate 240 (I-240) in Memphis, Tennessee. (See figure 1.) The van was owned and operated by Tippy Toes Learning Academy (Tippy Toes), a private child care[1] center. A witness driving behind the van stated that it was traveling about 65 mph when it drifted from the left lane, across two other lanes, and off the right side of the roadway. (See figure 2.) She said that she did not see any brake lights. The van then overrode the guardrail and continued to travel along the dirt and grass embankment until the front of the van collided with the back of the guardrail and a light pole. The rear of the van rotated counterclockwise and the front and right side of the van struck the bridge abutment at the Person Avenue overpass before coming to rest. (See figure 3.) The distance traveled by the accident van from the point where it left the shoulder of the roadway to the final collision with the bridge abutment was approximately 189 feet. The driver was ejected through the windshield and sustained fatal injuries. Four of the children sustained fatal injuries, and two were seriously injured.

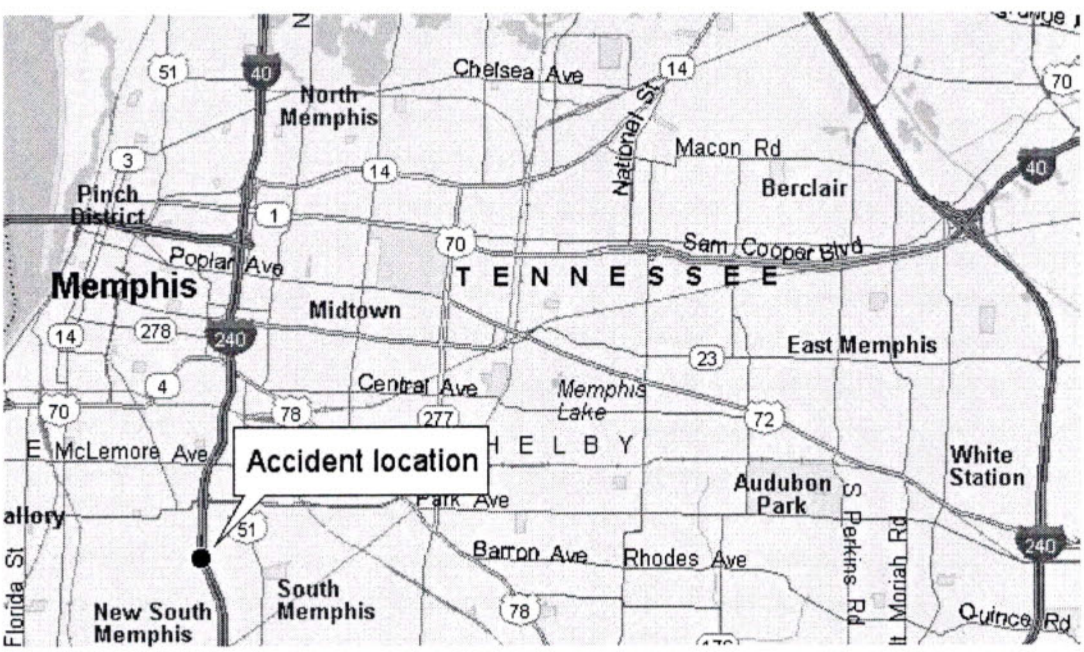


Figure 1. Area map.

[1] Child care includes both day care (preschool age children) and before- and after-school care. It does not include home-based child care or Head Start.

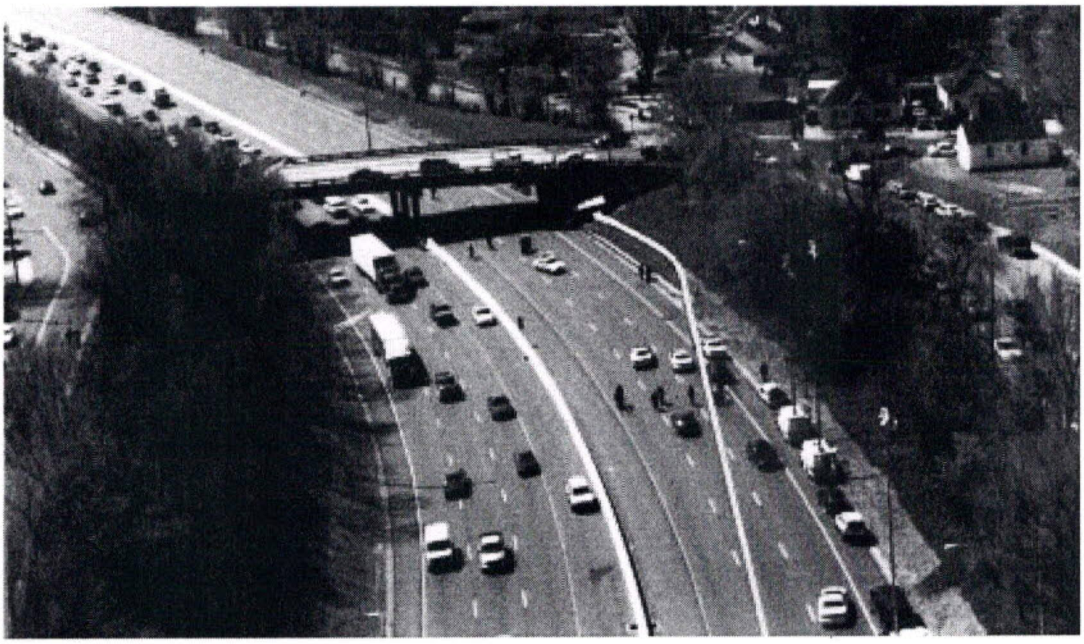


Figure 2. Approximate path of van, indicated by the arrow (the roadway continues to curve beyond the bottom of the picture, where the van began its departure).

Figure 3. Van at final rest.

Injuries

Table 1. Injuries.[2]

Injuries	Driver	Passengers	Total
Fatal	1	4	5
Serious	0	2	2
Minor	0	0	0
None	0	0	0
Total	1	6	7

Medical and Pathological Information

The driver sustained multiple fractures to left ribs 1 through 9, skull fractures, a shear injury to the brain stem, internal injuries, a fractured right ulna, and multiple abrasions to the whole body. As for the fatally injured children, the 6-year-old girl lap/shoulder belted in the right-front seat (see figure 4) sustained depressed skull fractures, fractures of the lower extremities, and multiple contusions, lacerations, and abrasions to the head and lower extremities. The unrestrained 8-year-old boy seated in the center of the first row sustained a depressed fracture to the occipital bone, a right femur fracture, and multiple abrasions and contusions. The unrestrained 6-year-old girl seated on the right side of the first row sustained open, depressed skull fractures, a cervical fracture, and multiple abrasions to her extremities. The unrestrained 9-year-old boy seated in the center of the second row[3] sustained skull fractures, a left rib fracture, a fracture to the right upper extremity, and multiple abrasions.

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

[3] The exact seating position of this passenger could not be determined. He had been in the center of the second row prior to dropping off a passenger before the accident. After the drop-off, he may have moved over, between seating positions 7 and 8 (figure 4). For the simulation, he was placed in the center seat.

Seat	Age	Belt Use	Injury
1	27	None	Fatal
2	6	Lap/shoulder	Fatal
3	10	None	Serious
4	8	None	Fatal
5	6	None	Fatal
6	10	None	Serious
7	9	None	Fatal

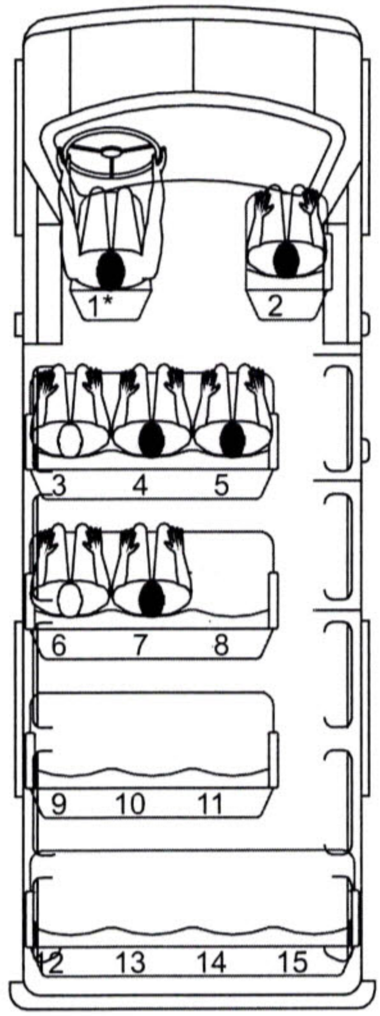


Figure 4. Seating chart (*ejected; shading indicates fatal injury).

Two other children sustained serious injuries. An unrestrained 10-year-old boy seated on the left side of the first row sustained upper torso fractures, internal injuries, and facial lacerations and abrasions. Another unrestrained 10-year-old boy seated on the left side of the second row sustained brain and lung injuries.

Survival Aspects

Intrusion and Restraints

The driver was not wearing his lap/shoulder belt and was ejected during the impact with the bridge abutment. The impact with the light pole and bridge abutment pushed the dashboard into the right-front passenger's seat, so that part of the dashboard was touching the right front of the passenger's seat cushion. The A-pillar was pushed rearward into the passenger compartment to a point 12 inches from the right-front passenger's seatback. The floor pan under the right-front seat was deformed so that it also compromised the right-front passenger's leg room. The right-side sliding door was crushed inward about 12 inches. Because the van was configured so that the first three rows of rear seats were not adjacent to the right side of the van, occupant space for the passengers in the rear was not compromised.

The vehicle had four rows behind the two front seats: three 3-passenger bench seats followed by a 4-passenger bench seat. All seating positions were equipped with passenger restraints: lap/shoulder belts in the front seats and outboard seating positions and lap belts only in the center seating positions. Only the passenger in the right-front seat was wearing a seat belt. The lap and shoulder portion of the seat belt had to be cut during the emergency response. Both the driver and the passenger side had front airbags, which deployed during the collision.

Emergency Response

An off-duty police sergeant witnessed the accident from the northbound lanes of I-240. He stated that he immediately pulled onto the shoulder and ran across the southbound lanes to the van. At 8:19 a.m., he notified the police traffic dispatcher via radio to send emergency rescue equipment to the scene. The first police unit arrived at 8:21 a.m., and the first fire and rescue unit arrived at 8:27 a.m.; rescue and extrication efforts were completed by 8:47 a.m. The first ambulance departed the scene at 8:53 a.m., and three other ambulances departed within the next 3 minutes. All four ambulances arrived at the hospital between 9:03 a.m. and 9:08 a.m. A total of 23 police cars, 4 motorcycle units, and 23 firefighters and emergency medical technicians were deployed to the scene.

Toxicological Tests

Preliminary autopsy results for the driver indicated a positive screening test for tetrahydrocannabinol (THC),[4] the chief intoxicant in marijuana. The Civil Aeromedical Institute conducted further toxicological testing on a sample of the driver's blood, which revealed the presence of THC and THC carboxylic acid (THC-COOH).[5] The sample was negative for alcohol and other illicit drugs or prescription medication.

Driver Information

The 27-year-old driver held a valid Type D Tennessee driver's license with an F endorsement. The Type D license permitted him to operate vehicles weighing less than 26,000 pounds or carrying fewer than 16 occupants (including the driver); the F endorsement, obtained on November 6, 2001, allowed the driver to transport passengers

[4] 0.0602 μg/ml (micrograms per milliliter).

[5] 0.0445 μg/ml. THC-COOH is the primary inactive metabolite of THC.

for compensation. The driver's record showed three registration violations in 1994. His criminal record showed an arrest for disregarding a stop sign and possession of a controlled substance on November 28, 2000. In connection with this arrest, the driver pled guilty in December 2001 to possession of a controlled substance.

The driver applied to work at Tippy Toes as a driver on September 18, 2001, and began work shortly thereafter. He did not submit a medical examination, and Tippy Toes did not conduct a criminal background check, even though the Tennessee Department of Human Services (TDHS) required both actions. Tippy Toes's driver employment application did not request information on previous arrests or convictions.

According to the driver's fiancée, with whom the driver lived, he had gone to bed the previous evening about 8:30 p.m. and awoke on the morning of the accident at approximately 4:30 a.m. He normally went to bed between 8:00 and 9:00 p.m. and awoke about 4:00 a.m. because he had to be at the child care director's home at 5:00 a.m. to pick up the van. He usually returned home shortly after 9:00 a.m., ate breakfast, and then took a nap before leaving about 1:00 p.m. to pick up the van and complete the afternoon route. Friends and coworkers described the driver as a "nice guy" who loved children.

The driver's fiancée stated that the driver had been treated in the emergency room for a cold several months before the accident and was tested for diabetes as part of his followup care. The results were negative. The driver had no medical insurance, and, according to his fiancée, only sought treatment for acute medical problems. An entry in the driver's May 2001 medical records, made when the driver was treated for gastroenteritis, also documented substance abuse. The driver's glucose levels in May 2001 and at a followup in June 2001 were within normal limits. Postmortem blood tests indicated an elevated hemoglobin A1c (HbA1c) level.[6] HbA1c level correlates with average blood glucose levels over several months and is frequently used to monitor diabetes. The driver was obese.[7] He was not taking any prescription medications at the time of the accident.

According to the driver's cousin (who was also a driver for Tippy Toes), the driver was a regular marijuana user who often smoked before retiring for a nap between his morning and afternoon runs. Several parents of children who rode in the van told investigators that they had complained to the child care director that the driver had been smoking marijuana in the van in the children's presence. A 12-year-old boy who had departed the van prior to the collision told investigators that the driver had smoked marijuana in the van in the past but had not done so in his presence on the day of the accident. One of the two surviving children on the van told the Memphis Police Department (MPD) that the driver did smoke a marijuana cigarette while he was driving on the morning of the accident. The child also said the driver had smoked them on previous occasions, and the child thought the owner of the child care center was aware of

---

[6] The driver's HbA1c level was 8.6 percent. The normal range is 4.3 to 6.1 percent.

[7] According to the National Institutes of Health, obesity is defined as a body mass index (the ratio of weight to height squared times a constant factor) greater than 30; morbid obesity is defined as a body mass index greater than 39. The driver was 6 feet 1 inch tall and weighed 380 pounds, corresponding to a body mass index of 50.

it. The owner/director of the child care center declined to be interviewed. Interviews conducted by the MPD and Safety Board investigators indicated that the driver's marijuana use was well known to friends and coworkers, who nicknamed him "Smoky." Neither the child care center nor the TDHS had any record of complaints about the driver's performance during the 6 months he had been employed by Tippy Toes.

An 11-year-old who regularly rode the van also told investigators that he had seen the driver nod off while driving in the past. A day care worker who rode with the driver for the first portion of the morning route as an attendant, starting between 6:00 and 6:30 a.m. and getting off the van at the child care center at 8:00 a.m., told investigators that the driver occasionally "zoned out" and also nodded off when stopped at traffic lights. The attendant believed that in addition to helping the children get settled in the van, "keeping Smoky awake" was her primary responsibility. The driver's cousin acknowledged that the driver frequently nodded off at red lights, but stated that he had not seen the driver fall asleep while driving. Another witness told investigators that when she went to the child care center, she sometimes saw the driver seated in the van asleep and snoring. The surviving child interviewed by the MPD said that the driver sometimes had a hard time staying awake while driving and recalled trying to wake him.

Vehicle and Wreckage Information

The accident vehicle was a 1999 Ford Motor Company (Ford) E-350, 15-passenger Club Wagon. Tippy Toes purchased the van with the intent of transporting children to and from school and to and from home. The van had a gross vehicle weight rating of 9,100 pounds, an original wheelbase of 132 inches, and an overall length of 232 inches. The vehicle's odometer read 98,860 miles. The van was powered by a 5.4-liter V-8 fuel-injected gasoline engine with a 4-speed automatic transmission and equipped with 4-wheel antilock braking system (ABS), power steering, and cruise control.

Safety Board investigators examined the brakes and found that the right-rear inner brake pad was below Ford's recommended wear limits and the corresponding brake rotor was grooved. All other brake components were within recommended limits. The hydraulic brake line and ABS sensor wire to the right-front brake were severed, consistent with accident damage. The brake fluid in the reservoir was about 1 inch below the "full" mark.

The three rear brake light assemblies (left, center, and right) were removed and the bulbs examined by Safety Board investigators. No sign of filament deformation was present in any of the bulbs. The bulbs were reinstalled and the brake lights tested by depressing the brake pedal. All brake light bulbs illuminated.

Both front tires and the left-rear tire had cuts and were deflated. The right-rear tire was inflated to 55 psi. The label on the driver's doorsill recommended 55 psi for the front tire and 80 psi for the rear.

The steering wheel was not deformed and rotated freely, moving the left-front tire (investigators found the right drag link disconnected, so the right-front tire did not move).

Due to the severity of the accident damage, investigators were unable to determine whether the cruise control was on at the time of the accident.

Investigators extracted diagnostic codes from the van's electronic crash sensor (ECS), antilock brake module, and powertrain module. The codes that registered were consistent with the crash event, according to Ford personnel. Siemens (the ECS manufacturer) further analyzed the ECS because it has the capability of recording a crash pulse. However, battery power to the ECS had been cut off before a complete crash pulse could be written to the ECS. Five milliseconds of data were recorded; the remaining 65 milliseconds that are typically written were blank. No useful data could be extracted to determine the crash pulse.

The van's exterior had direct impact damage to the front, including the bumper, grill, hood, lights, right-front fender, and a broken windshield. (See figure 5.) The base of the right A-pillar was bent backwards approximately 15 inches to within 12 inches of the front seat. The right side also had impact damage to both doors and the wheel well area. The maximum crush to the right side was about 24 inches at the roofline. The direct damage extended about 195 inches from the right-front fender to the right-rear quarter panel. The left side had a bent driver doorframe and body wrinkles in the front and rear wheel well areas. The front of the roof was bowed upward. No damage occurred to the rear of the van. The wheelbase was 133 inches on the left and 124 inches on the right. The overall length of the van was 232 inches on the left; this length was reduced to 224 inches on the right.

Figure 5. Van damage.

The interior damage generally corresponded to the exterior damage along the right side of the van. The front and side of the van intruded into the front seat passenger's space. (See figure 6.) The lateral floor weld behind the front seats on the passenger side separated and buckled upward.

Figure 6. Front passenger seat intrusion.

Highway Information

The accident events originated in the southbound lanes of I-240 in southwest Memphis and concluded approximately 189 feet later on the north side of the Person Avenue overpass. (See figure 7.) I-240 is an urban principal arterial highway and, in the vicinity of the accident site, was a six-lane divided highway with concrete pavement. Each side of the highway consisted of a 2.5-foot wide concrete drainage channel, an 8-foot-wide outside shoulder, three 12-foot-wide travel lanes, and a 13-foot-wide inside shoulder. All pavement markings met the requirements specified in the *Manual on Uniform Traffic Control Devices*.[8]

[8] U.S. Department of Transportation, Federal Highway Administration, *Manual on Uniform Traffic Control Devices* (Washington, DC: FHWA, 2000).

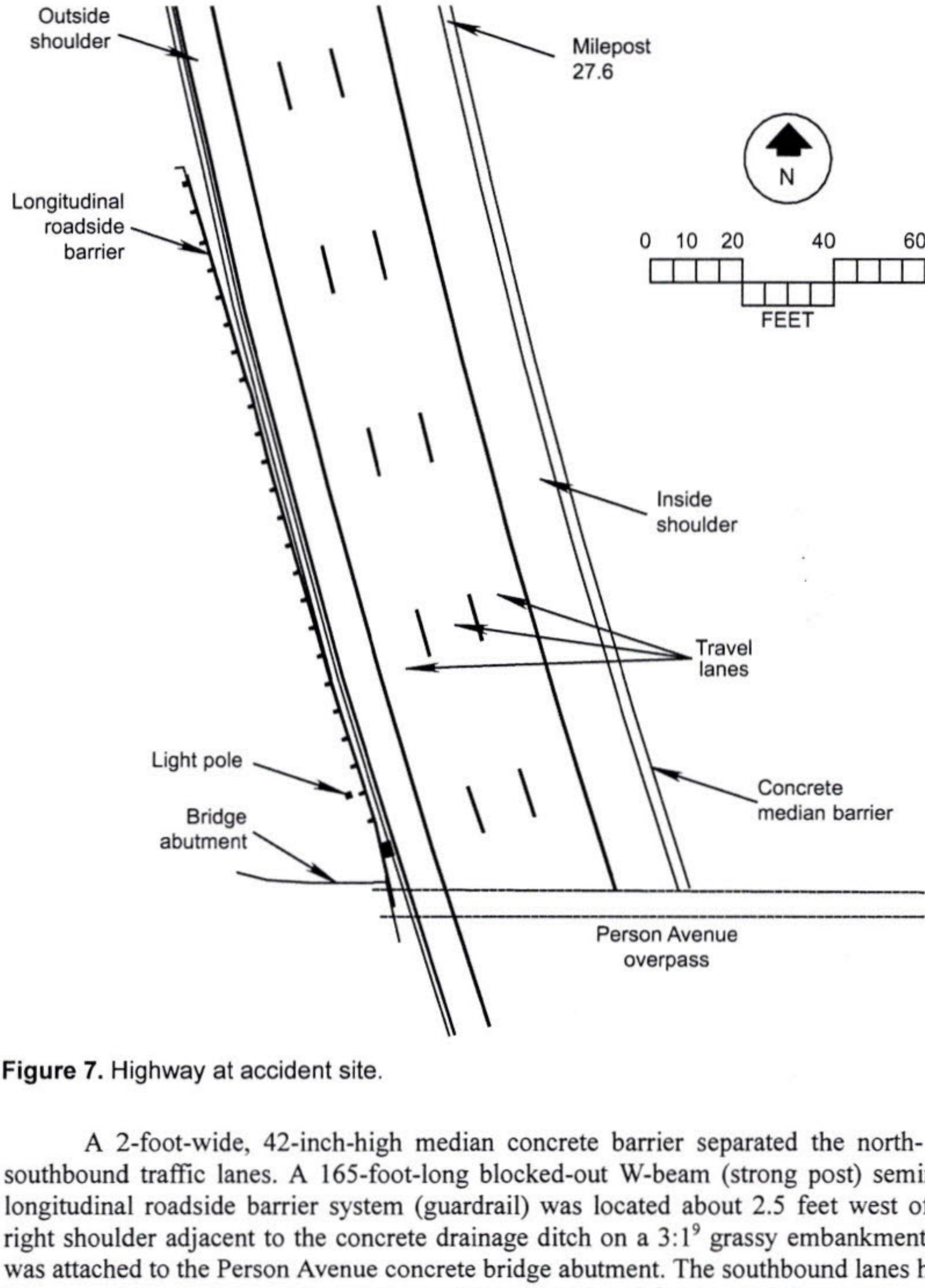


Figure 7. Highway at accident site.

A 2-foot-wide, 42-inch-high median concrete barrier separated the north- and southbound traffic lanes. A 165-foot-long blocked-out W-beam (strong post) semirigid longitudinal roadside barrier system (guardrail) was located about 2.5 feet west of the right shoulder adjacent to the concrete drainage ditch on a 3:1[9] grassy embankment and was attached to the Person Avenue concrete bridge abutment. The southbound lanes had a 2.5-percent descending grade and the roadway transitioned from a straight alignment to a 3-degree horizontal left curve at a point 440 feet north of the beginning of the barrier. (See

[9] The embankment rose 1 foot for every 3 lateral feet away from the roadway.

figures 8 and 9.) A 38-foot-high aluminum light pole on a breakaway base was approximately 20 feet north of the bridge abutment and about 4 feet west of the guardrail.

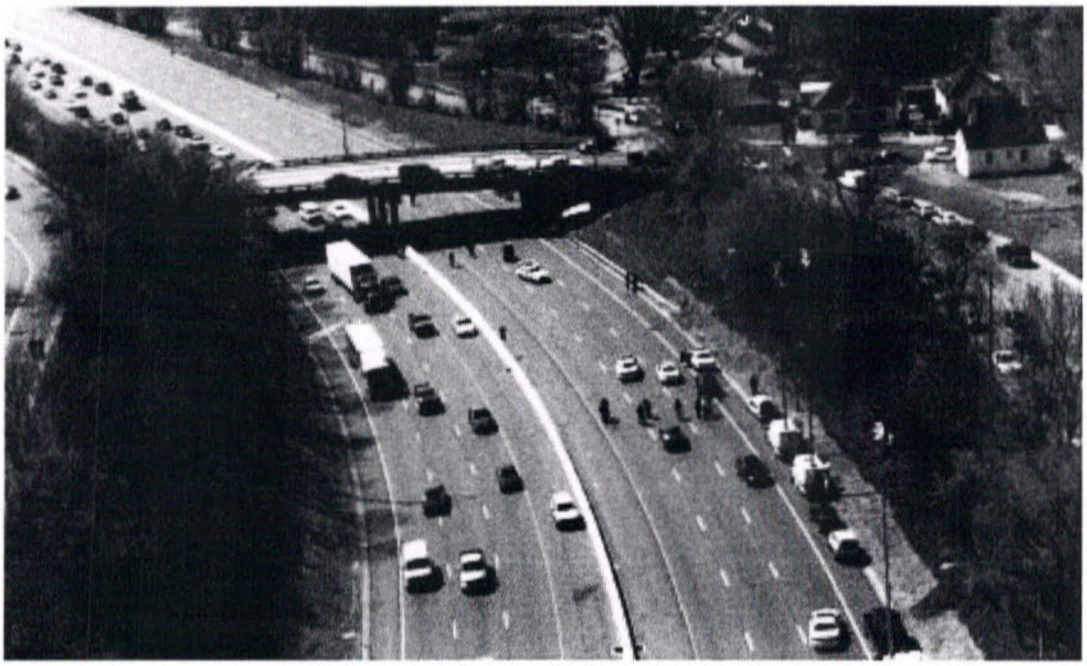


Figure 8. Overhead view of roadway curvature.

Figure 9. Roadway curvature from ground level.

The posted speed limit on I-240 was 55 mph. When originally constructed, the design speed of the highway was 50 mph; in 1993, the design speed was increased to 55 mph. No speed surveys had been conducted on I-240 in the vicinity of the accident site between 1993 and the time of the accident. At the Safety Board's request, the Tennessee Department of Transportation (TDOT) conducted a speed survey in the vicinity of the Person Avenue overpass on July 9, 2003, with six speed-monitoring stations (three in each direction). The survey found that the 85th percentile speed was 70 mph, and the median speed was 65 mph.

The average daily traffic count for I-240 in both the north- and southbound traffic lanes was nearly 105,000 in 2001.

Barrier System

When I-240 was constructed in 1963 as a divided six-lane highway, no roadside barriers existed at the Person Avenue overpass. A 1977 highway rehabilitation project added a 150-foot-long guardrail along the interstate to shield the Person Avenue bridge abutment from errant traffic. The barrier system included the use of an anchored-in-backslope terminal. In 1993, this guardrail at the Person Avenue overpass was replaced. Since 2001, the roadside barrier adjacent to the Person Avenue overpass has been repaired several times. Records from TDOT indicated that because of collision damage, the entire barrier was replaced on May 29, 2001 (see *Accident History* section below), and again on August 9, 2002, due to collision damage from this accident.

At the time of the accident, the barrier consisted of a terminal unit, a longitudinal section, and a transition section between the longitudinal section and the abutment. Located 3.5 feet from the drainage ditch, the terminal unit was an anchored-in-backslope design consisting of a 36-inch-wide by 24-inch-long by 36-inch-deep concrete block buried so that the top was almost at grade with the backslope. (See figure 10.) About 1 foot of the W-beam guardrail was affixed to the anchor block, of which about 5 inches was exposed above ground. The W-beam guardrail's end treatment flared[10] away from the edge of the drainage channel, where the guardrail was 26 inches above ground. Despite the apparent differences in height of the W-beam guardrail, the guardrail was horizontal (parallel to the roadway surface) because of the backslope. The guardrail did not reach its full height of 26 inches above the ground until it reached the drainage channel, 57 feet beyond the terminal.

[10] A roadside barrier is "flared" when it does not run parallel to the edge of the roadway. The design of the anchored-in-backslope terminal necessitates the use of a flare to route the terminal into the backslope.

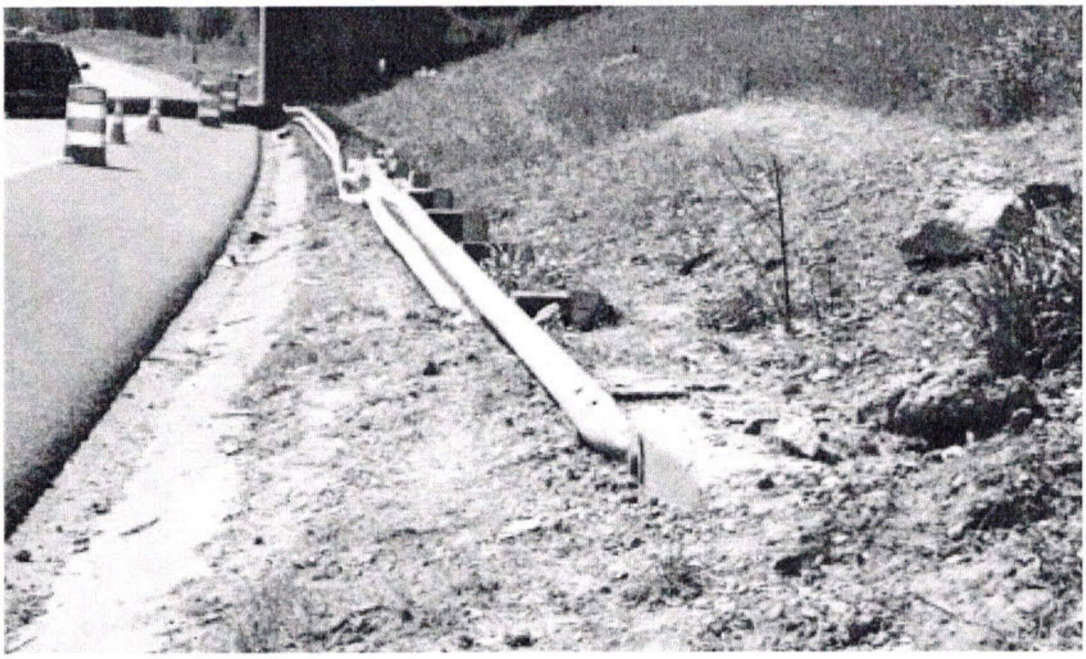


Figure 10. Guardrail and terminal unit.

The longitudinal section consisted of a 165-foot single W-beam guardrail; the effective length was 160 feet, since 5 feet was attached to the bridge abutment. Metal posts with wooden blockouts supported the W-beam guardrail.[11] The posts were approximately 75 inches apart along the semirigid portion. The section prior to the bridge abutment provided for the transition from a semirigid longitudinal section to a rigid section to prevent pocketing.[12] The posts along the rigid section of the barrier were closer together (approximately 36 inches apart).

Accident History

TDOT and the MPD provided accident records for the section of I-240 near the accident scene. For an area about 0.5 miles on either side of the accident location, TDOT reported 1 fatal accident resulting in 1 fatality, 48 injury accidents resulting in 85 injuries, and 91 accidents resulting in property damage only between 1997 and 2001. Of these accidents, 43 (31 percent) involved collisions with fixed objects. The MPD accident data, which encompassed an area at or near the accident site,[13] reported a total of 34 accidents between 1997 and 2001, 25 of which occurred in the southbound lanes. The MPD data showed two fatal accidents similar to this accident. One occurred in 1998, when the driver

[11] A blockout offsets the W-beam from the vertical post and prevents vehicles from snagging on the vertical posts.

[12] Pocketing occurs when a vehicle makes sufficient encroachment into a barrier system to become trapped instead of redirected.

[13] Most of the accidents were less than one-tenth of a mile from the accident location, with the furthest occurring one-quarter mile away.

left the right side of the highway about 325 feet north of the Person Avenue overpass, became trapped behind the roadside barrier, struck a light pole, and then struck the bridge abutment. The second similar accident occurred in 2002. MPD records revealed two other accidents in which the vehicle departed the right side of the highway and traveled behind the roadside barrier. In both cases, the drivers were able to stop before colliding with the bridge abutment.

Physical Evidence

No physical evidence was found in the roadway leading up to the van's impact with the roadside barrier. The first impact on the barrier's W-beam guardrail occurred 7 feet south of the terminal end of the W-beam guardrail. Adjacent to the first impact point was a 21-foot-long tire furrow located in the grass median at a 6-degree angle from the interstate's right shoulder. (See figure 11.) The damage extended along the top of the guardrail for about 1.5 feet. About 16 feet south of the first contact point was a series of scrapes along the W-beam guardrail, extending about 14 feet. The guardrail became increasingly deformed, bent, and torn moving south along the guardrail. Other points of damage along the guardrail included black discoloration, bends, and other damage.

Two additional tire furrows began about 4 feet west of the barrier and continued south about 100 feet. Initially, the tire furrows were 8 inches apart, but at the point they terminated they were 4.5 feet apart. A 15-foot section of the barrier adjacent to the termination of the tire furrows had contact damage along the backside of the W-beam guardrail. The support posts and blockouts were bent in a southerly direction, and the attachment hardware had been pulled through the back of the W-beam guardrail. (See figure 12.)

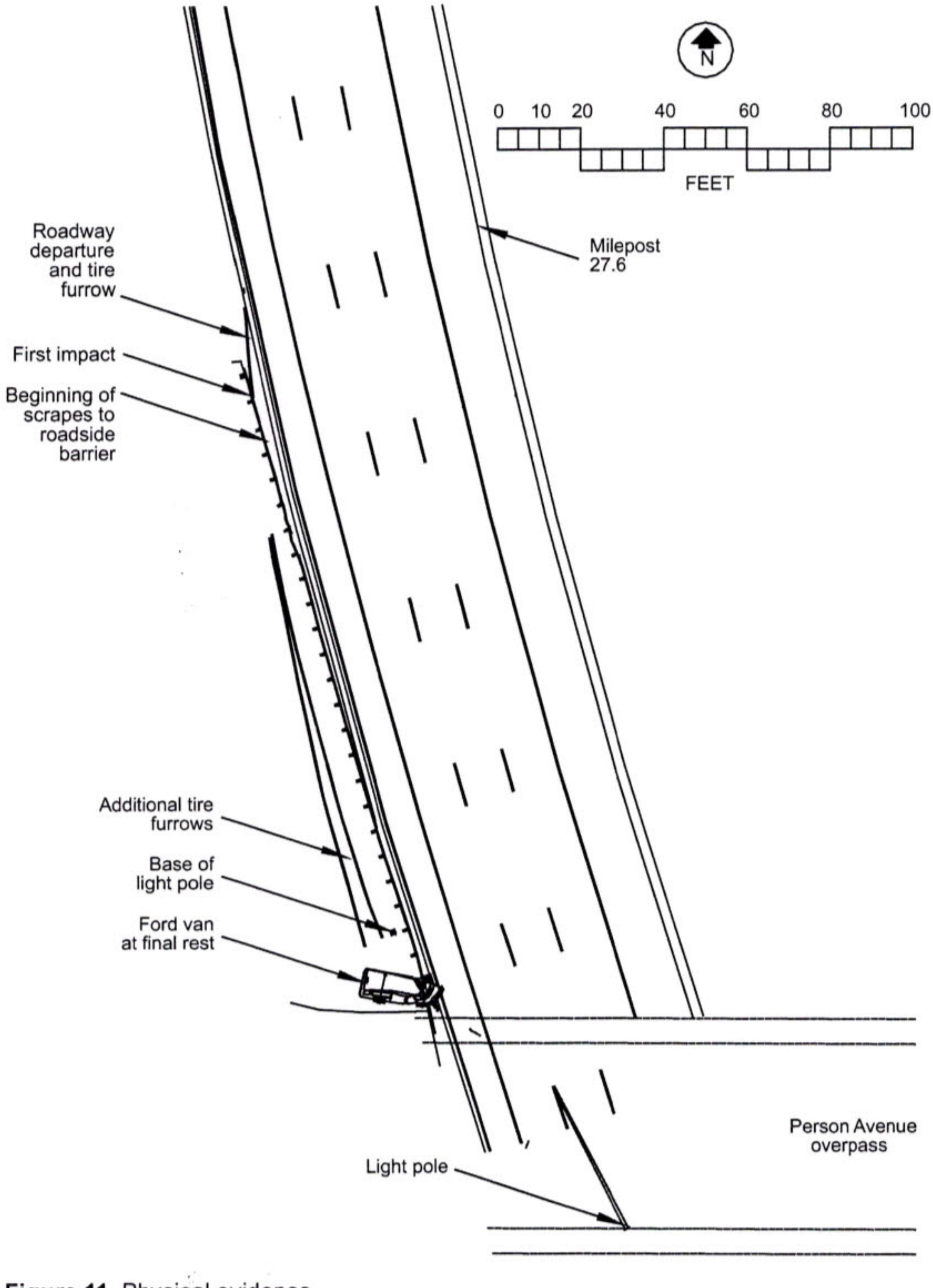


Figure 11. Physical evidence.

Figure 12. Guardrail damage, light pole base (indicated by arrow), and bridge abutment scrapes.

The 38-foot light pole was mounted on a 14-inch-square breakaway base[14] located at ground level. The light pole's mounting plate was connected to the breakaway base by four 4.5-inch-long vertical nut and bolt assemblies. (See figure 13.) After the accident, the light pole came to rest in the center lane of southbound I-240. The base of the breakaway fixture was still in the ground; three of the four mounting nuts were still attached to the base, but the mounting nuts had fractured as designed, separating the light pole's mounting plate from the breakaway base. (See figure 14.) An indentation was noted 17.5 inches above the pole's mounting plate; scrapes and paint transfers extended from the mounting plate to 57 inches above the plate.

[14] A breakaway base is used so that if the object is struck, it moves instead of acting as a rigid barrier, which could potentially cause more damage.

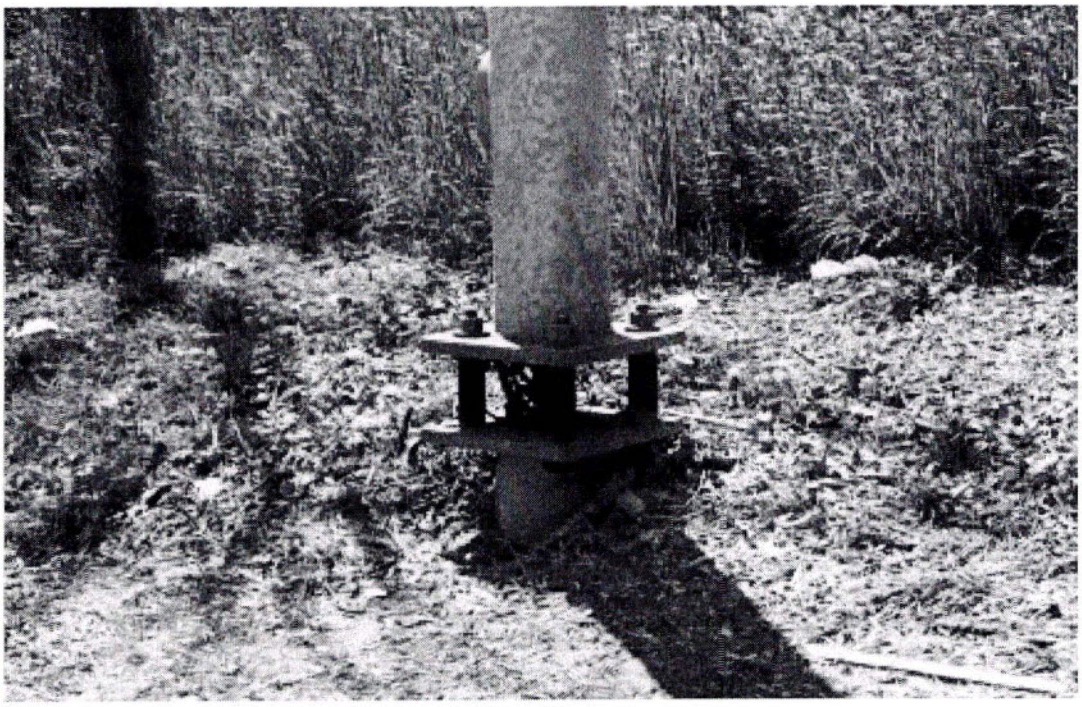


Figure 13. Exemplar light pole plate and breakaway base.

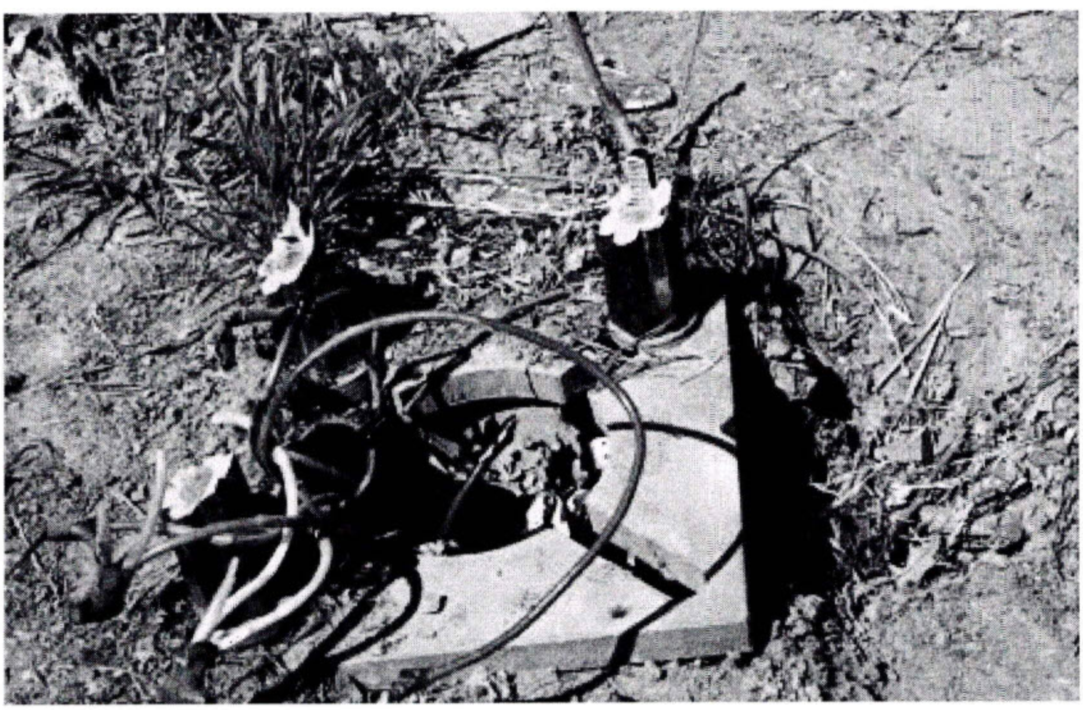


Figure 14. Light pole breakaway base mounting plate with fractured mounting nuts.

The north face of the bridge abutment had contact damage encompassing an area 8 feet high by 16 feet wide. At the base of the abutment, the earthen backslope was scarred, and dirt was thrown against the abutment; dirt was compressed into the surface of the concrete. Investigators observed a circular scrape mark 17 inches in diameter at the bottom of the abutment about 18 inches west of the bridge's northeast corner.

Weather Information

Observations from the Memphis International Airport, located approximately 4 miles southeast of the accident location, were clear with a temperature of between 43 and 46 degrees Fahrenheit and winds of about 15 mph from the northeast.

Operational Information

Tippy Toes Learning Academy was a TDHS-licensed child care provider for children ages 6 weeks to 12 years. To supplement child tuition, Tippy Toes received money from the TDHS, some of which was from the U.S. Department of Health and Human Services (DHHS) for temporary assistance to needy families.[15] The TDHS license permitted transportation for local and intrastate travel. Students were typically transported from their homes to Tippy Toes, from Tippy Toes to and from school, and from Tippy Toes to home.

Tippy Toes began operations in October 2000. On April 9, 2002, 5 days after the accident, Tippy Toes ceased operation and voluntarily surrendered its license.

Tippy Toes's TDHS application identified a Dodge and two Fords as the vehicles used for student transportation. The TDHS requires child care providers only to identify vehicles by make. Tippy Toes purchased the 1999 accident van from a used car dealer on October 4, 2001. No vehicle maintenance records or vehicle repair records were on file at Tippy Toes, although both were required by TDHS regulation.

On its TDHS application, Tippy Toes identified three regular drivers and one bus attendant. The accident driver's file included his September 18, 2001, application for employment; the child care facility owner's December 27, 2001, evaluation of the driver;[16] a copy of his driver's license; and a February 23, 2002, certificate of training issued by the TDHS for attending a 3-hour course on transportation rules and regulations, as was required for all child care drivers. No records of a medical examination or a criminal background check were found, even though the TDHS requires both. Further, these items were never submitted to the TDHS, as was also required.

---

[15] From the time Tippy Toes began operation in October 2000, until the time it ceased operation shortly after the accident, Tippy Toes received $516,919 from the TDHS, $54,368 of which was allocated for child transportation.

[16] This document stated that the driver's "...evaluation went very well. He is aware of the rules and policies, as far as he continuously to work in this facilities. [*sic*]"

The TDHS requires that any child care center providing transportation maintain, for 1 year, a passenger log showing the location and time at which a child was picked up or dropped off and indicating the person present with or waiting for the child. Tippy Toes maintained such a passenger log. The TDHS also required that a vehicle used to transport children carry a fire extinguisher, emergency reflective triangles, a first aid kit, and a bloodborne pathogen kit; none of these items were found in the accident van. Additionally, the TDHS requires that staff responsible for regularly transporting children practice emergency exiting procedures with the children.

As part of its oversight, the TDHS conducted at least six child care center site visits per year to ensure compliance with all TDHS rules and regulations. If a child care center is in violation of TDHS rules, the TDHS can require the center to enter into a Plan of Corrective Action. The TDHS may also impose civil penalties and/or probation, deny the application for licensure or relicensure, or suspend or revoke all or any part of the license to operate.

Tippy Toes received five on-site inspections during the time in which the accident driver was employed.[17] The transportation operation was examined during the January 3, 2002, inspection. The TDHS inspection report indicated that the transportation logs were reviewed with the director of Tippy Toes. No violations or discrepancies were noted in this report.

Simulations

Vehicle Dynamics Simulation

Safety Board staff conducted a simulation[18] of the van's dynamics during the accident sequence to estimate the van's speed and crash pulse and to determine where the van departed the roadway. Based on witness statements, the van drifted off the roadway with no steering or braking input. To match the physical evidence adjacent to the roadway, the van was placed in the left lane near the beginning of the horizontal curve, with an initial speed of 65 mph. In the simulation, the van traveled without added steering or braking along the roadway in a path tangent to the curve, until the curvature and elevation of the roadway caused the van to depart the left lane and cross two other lanes and the shoulder. The simulation showed that based upon the van's roadway departure when starting in the left lane, the guardrail would have had to have been about 40 feet longer with the same end treatment in order to redirect the van as it drifted off the roadway.

In the simulation, the van was traveling approximately 63 mph as it departed the roadway. The van's speed decreased as it interacted with the guardrail end treatment and traveled along the grass; immediately before impacting the backside of the guardrail posts

[17] These inspections, which were performed by different people, occurred between December 18, 2001, and March 7, 2002.

[18] The Human Vehicle Environment (HVE), Simulation Model Non-linear (SIMON), Engineering Dynamics Corporation Simulation of Automobile Collisions (EDSMAC4), and Engineering Dynamics Corporation Reconstruction of Accident Speeds on the Highway (EDCRASH) software programs were used for the simulation.

and light pole, the van was traveling about 56 mph. According to the Insurance Institute for Highway Safety,[19] most frontal airbags will deploy in crashes when the longitudinal change in velocity is 16 mph or more. Upon impact with the bridge, the van's speed decreased another 30 mph, with some residual velocity remaining as the van continued to rotate and rebound off the abutment. Simulation results showed the instantaneous deceleration was 12.4 g during impact with the guardrail posts and light pole and 31.1 g during impact with the bridge abutment.

Occupant Kinematics Simulation

The Safety Board conducted a simulation of the occupant movement within the vehicle to determine the possible kinematics that led to injury and ejection and to compare the effect of the use of restraints among occupants. The simulation used output from the vehicle dynamics simulation to establish the crash pulse and the position-time history and deformations of the van. The MAthematical DYnamical MOdels (MADYMO)[20] program was used to determine occupant kinematics and predicted injuries. Each simulation began immediately prior to impact with the guardrail and light pole and continued until the van rebounded from the bridge abutment.

The driver was simulated using a 95th percentile Hybrid III dummy,[21] while each child was represented by a 6-year-old Hybrid III dummy.[22] Three simulations were performed:

- Actual restraint condition (simulates the 6-year-old in the front seat being restrained by the lap/shoulder belt);
- Available restraint condition (simulates restraints available in the accident van: lap/shoulder belts for the outboard seats and lap belts only for the center seating positions); and
- Recommended restraint condition, first bench seat only (simulates booster seats[23] for the 6-year-old and 8-year-olds and lap/shoulder belt use for the 10-year-old).[24]

---

[19] <http://www.highwaysafety.org/safety_facts/qanda/airbags.htm>.

[20] TNO MADYMO Automotive, MADYMO version 6.1.

[21] The 95th percentile Hybrid III dummy, the largest validated dummy available for simulation, is 6 foot 2 inches tall and weighs 223 pounds, significantly less than the driver's weight of 380 pounds.

[22] While some of the children were larger than the 6-year-old dummy, the Hybrid III 10-year-old dummy has not yet been included in Federal regulations. The currently available 10-year-old dummy does not have the additional measurement capabilities that the Hybrid III 6-year-old dummy has and thus was not used.

[23] The simulated booster seat was developed and validated by the University of Virginia Center for Applied Biomechanics: L. Van Rooij, C. Sherwood, J. Crandall, K. Orzechowski, and M. Eichelberger, Society of Automotive Engineers, *The Effects of Vehicle Seat Belt Parameters on the Injury Risk for Children in Booster Seats*, 2003-01-0500 (Warrendale, PA: Society of Automotive Engineers, 2003).

[24] The 6-year-old occupant in the front passenger seat was not simulated in a booster seat because children 12 and under should not sit in the front seat.

In the actual restraint condition, the occupants initially traveled forward and laterally toward the left as the front of the van impacted the light pole and guardrail posts and rotated counterclockwise, moving the occupants out of their normal seating positions. During the impact with the bridge abutment, the occupants moved forward, then laterally toward the right side of the van, impacting the intruded side, as the van rotated about the front axle and impacted the abutment along the right side. The driver was ejected during the impact with the bridge abutment.

In the available restraint condition, the occupants did not move as much as during the actual restraint condition, but the type of restraint available affected their motion during the impact with the guardrail and light pole. For lap/shoulder-belted occupants on the left side of the van, the shoulder harness restrained their upper bodies, but began to ride along the neck for the smaller occupants. For those in the center, where only lap belts were available, the upper body was free to rotate forward and to the left. The same was true for the occupants in the right side of the vehicle, whose upper bodies slid out of the harnesses as they moved forward and toward the left. During the impact with the bridge abutment, simulated passengers on the right and in the center were out of position from the initial impact and traveled a greater distance toward the right side, as compared with their initial positions, before impacting the intruding sidewall and window structure.

In the recommended restraint condition, only the 6- and 8-year-old occupants in the first bench seat were simulated in booster seats using 6-year-old Hybrid III dummies, as they were the only passengers, based on age and weight, recommended to use booster seats.[25] The booster functioned as intended, helping to position the lap and shoulder belt on the occupant and helping the restraint remain in position during the crash sequence. (See figure 15.) Furthermore, the booster helped reduce the lateral motion of the occupants during the initial phase of the crash. As a result, the upper body did not have as far to travel to the right during the impact with the bridge abutment, reducing the severity of the impact with the intruding sidewall and windows. Without the booster seats, the location of the attachment points for the lap/shoulder belts positioned the shoulder harness higher on the 6-year-old torso. (See figure 15, right dummy.)

To provide a comparison of the shoulder belt positioning on a 10-year-old, the currently available 10-year-old dummy was placed in the MADYMO model and fitted with the lap/shoulder belt in the manner simulated for the Hybrid III 6-year-old dummy in the front seat. (See figure 16.)

[25] (a) National Transportation Safety Board, *Analysis*, Vol. 1 of *The Performance and Use of Child Restraint Systems, Seatbelts, and Airbags for Children in Passenger Vehicles*, Safety Study NTSB/SS-96/01 (Washington, DC: NTSB, 1996), 2 Vols. (b) <http://www.nhtsa.dot.gov/CPS/>.

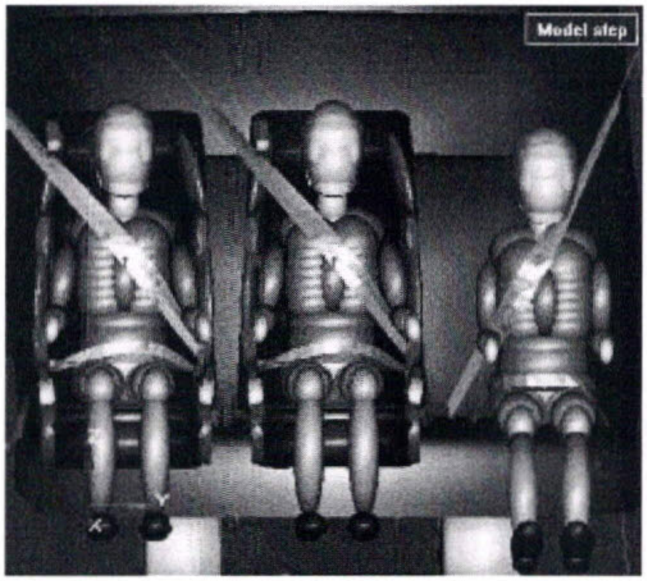


Figure 15. Seat belt position with and without a booster seat (6-year-old Hybrid III dummy).

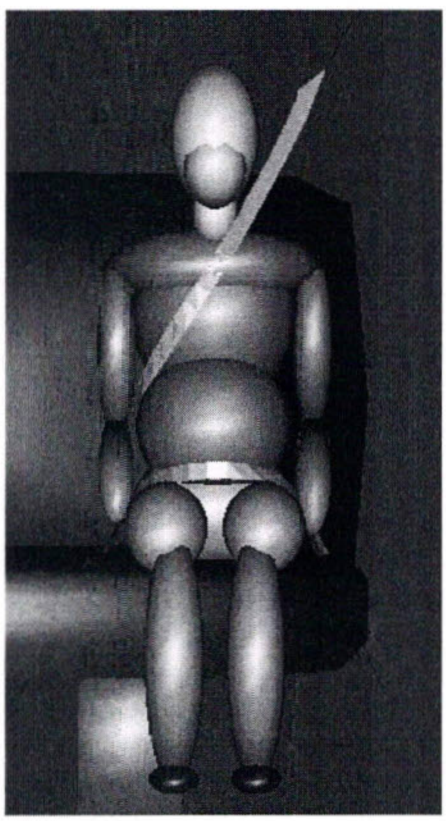


Figure 16. 10-year-old dummy with lap/shoulder belt.

Bus Definitions

School Bus

The *Federal Motor Vehicle Safety Standards* define school bus as a vehicle that carries more than 10 people, including the driver, that is used primarily to transport children to or from school. In the early 1970s, the Federal Government developed additional design standards for school buses specifically addressing occupant protection, joint strength of the body panels, and roof rollover protection. The stricter occupant crash protection standards for school buses assure their passengers a higher degree of safety than do Federal standards for other types of vehicles, including 15-passenger vans. Small school buses (those with gross vehicle weight ratings of less than 10,000 pounds) must meet the same structural standards as large school buses and, in addition, must be equipped with lap or lap/shoulder belts at all passenger seating positions.

Multifunction School Activity Bus

On July 31, 2003, the National Highway Traffic Safety Administration (NHTSA) established a new school bus classification, the multifunction school activity bus (MFSAB), for use on trips other than between home and school. This new classification provides entities other than schools, such as child care centers or Head Start centers, with an alternative to 15-passenger vans. The MFSAB is built to the same crashworthiness and occupant protection standards as a school bus, but is not required to have flashing lights or stop arms since most MFSABs drop off and pick up passengers at the destination rather than in the street.

School Bus Fatality Data

The Safety Board examined Fatality Analysis Reporting System (FARS)[26] data for school buses and large (12- and 15-passenger) vans. The data showed that from 1993 through 2002, 57 fatalities occurred among occupants younger than age 19 in school buses and 574 fatalities occurred among occupants younger than age 19 in large vans (12- and 15-passenger vans). More than 435,000 school buses[27] and about 500,000 15-passenger vans are on the road.[28]

[26] FARS, maintained by NHTSA, is a census of all crashes involving a motor vehicle traveling on a traffic way customarily open to the public that result in the death of a person (occupant or nonmotorist) within 30 days of the accident.

[27] *School Transportation News*, <www.stnonline.com>.

[28] National Transportation Safety Board, *Evaluation of the Rollover Propensity of Fifteen-Passenger Vans*, Safety Report NTSB/SR-02/03 (Washington, DC: NTSB, 2002).

Child Care Transportation Laws and Guidance

Over 117,000 child care centers[29] in the United States[30] provide care for millions of children from ages 0 to 13 on a full-time or part-time basis. These child care centers must meet regulations established by their respective States. In Tennessee, 4,908 child care providers care for over 300,000 children. Among the 3,553 child care centers in Tennessee, 1,328 provide transportation, the majority of which occurs between the centers and schools.[31]

The Federal Government funds over $4.8 billion[32] annually to the States to help subsidize child care for low-income families.

Findings of Tennessee Committee on Child Care Agency Transportation Safety

Following this accident, the Governor of Tennessee appointed a committee to assess Tennessee's child care transportation policies and to issue recommendations to improve the safety of child care transportation. The committee recommended the following:

- Require that all vehicles purchased by child care providers meet the Federal regulations for school buses and phase out the use of other vehicles by January 1, 2005;
- Require the Tennessee Department of Safety to inspect all school-bus-type vehicles used by child care centers as regular school buses;
- Require children and the driver to be secured in individual passenger restraint devices at all times and children under 4 to use child passenger restraints;
- Require child care transportation drivers to have commercial drivers' licenses;
- Require child care transportation drivers to pass a yearly physical and mental examination;
- Require prospective child care transportation drivers to have completed a criminal background check before being permitted to drive a child care vehicle; and
- Require that child care vehicles be identified with the name and phone number of the child care center, a serial number registered with the TDHS, and a TDHS number to call to make complaints.

[29] These centers do not include Head Start programs, which provide educational programs for low-income, prekindergarten children.

[30] <www.thechildrensfoundation.net>.

[31] Correspondence with TDHS Licensing Office dated February 12, 2004.

[32] <www.acf.hhs.gov>.

Child Care Transportation Laws in Tennessee

After the release of the Tennessee Governor's findings on child care agency transportation safety, Tennessee law changed as noted below:

Vehicle standards. Beginning January 1, 2007, all vehicles used for child care transportation and designed to carry more than 10 passengers must meet Federal school bus standards.

Vehicle inspection. Beginning January 1, 2004, all vehicles used for child care transportation must receive regular inspections and maintenance by a certified mechanic, and all vehicles designed to carry more than 10 passengers must have an annual safety inspection conducted by the Department of Safety. Inspection documentation must be maintained by the child care center.

Restraints. Beginning January 1, 2007, all children must be restrained in age-appropriate restraints, and children weighing 40 to 80 pounds must be in booster seats.

Driver licensing. The State reiterated the existing requirement that child care transportation drivers have a current Tennessee driver's license with an "F" (for hire) endorsement, or a license for the type of vehicle used.

Driver training. Beginning January 1, 2004, child care transportation drivers must obtain a certification document from the Department of Safety signifying that they have passed additional written or skills tests required for persons driving a vehicle transporting children enrolled in child care. Furthermore, these drivers must obtain annual school bus driver training.

Driver physical. The State reiterated the existing requirement that child care transportation drivers obtain an annual health statement signed by a physician verifying that they are physically and mentally able to transport children.

Drug testing policy. Beginning August 1, 2003, all newly hired child care transportation drivers must have a drug screen within 10 days of assuming duties and beginning January 1, 2004, all existing drivers must have a drug screen. The child care center must immediately review the results, and, if the results are positive, notify the TDHS and prohibit the individual from driving for the child care center. Further, a written plan approved by the TDHS must be established that prohibits the individual from driving until he or she passes a drug test or is approved for driving by the TDHS.

Vehicle identification. Beginning March 1, 2003, all vehicles operated by child care centers must be identified with their name, emergency contact number, and the label "Child Care Transportation Complaints," followed by the TDHS phone number. This identification must be on both sides and on the rear of the vehicle.

Child Care Transportation Laws in Other States

Safety Board staff reviewed child care transportation laws in other States to determine how they compare with Tennessee's new regulations. These laws are discussed below and summarized in table 2 at the end of this section.

Vehicle standards. Seven States require the use of school buses for at least some child care transportation:

- Hawaii requires that school buses be used for transportation to and from school;
- Indiana requires that any vehicle carrying more than 10 children be a school bus;
- Massachusetts requires that any child care vehicle carrying more than eight children to or from school be a school bus;
- New Jersey requires that school buses be used for early childhood centers if the vehicle carries more than eight passengers but allows other vehicles for school-age children;
- New York requires that any *new* vehicle to be used for carrying more than 10 children to or from school be a school bus;
- South Carolina will require, beginning January 1, 2006, that all vehicles carrying more than 10 passengers to or from school meet school bus standards; and
- Vermont requires private vehicles that are used to transport children to or from school for compensation and that carry more than 11 passengers, including the driver, be school buses. Vermont is the only State that notes in its child care center guidelines the NHTSA requirement that a vehicle used primarily for transportation to or from school must be a school bus.

Vehicle inspection. Twenty-eight States have an annual or biannual vehicle inspection program.

Restraints. Forty States specify restraint usage requirements, many of which are patterned after their child restraint laws.

Driver licensing. All State child care agencies require child care transportation drivers to hold a driver's license appropriate for the vehicle used.

Driver training. One State, Maine, requires additional child care transportation training within 6 months of employment.

Driver physical. Two States, Florida and Illinois, specifically require physical exams before employment as a child care transportation driver. Florida requires an annual physical examination that grants medical approval to a driver. Illinois requires that a driver demonstrate physical fitness by submitting a medical exam from a licensed physician; this medical form must be submitted to the Illinois Department of Children and Family Services.

Drug testing policy. Twenty-four States specifically prohibit drug use for child care transportation drivers, and Arkansas, Indiana, and Montana require testing "for cause." Only Tennessee requires preemployment drug testing for child care transportation drivers.

Vehicle identification. Oklahoma is the only State besides Tennessee that requires child care vehicles to be visibly marked with the name of the facility or sponsoring organization.

Table 2. Child care transportation laws. (Check mark indicates that the State's law addresses a particular area.)

	Vehicle standards	Vehicle inspection	Restraints	Driver licensing	Driver training	Driver physical	Drug testing policy	Vehicle identification
Alabama		✓	✓	✓				
Alaska			✓	✓				
Arizona			✓	✓			✓	
Arkansas			✓	✓			✓	
California			✓	✓				
Colorado		✓	✓	✓				
Connecticut				✓				
Delaware		✓		✓			✓	
District of Columbia				✓				
Florida		✓	✓	✓		✓	✓	
Georgia		✓	✓	✓				
Hawaii	✓	✓		✓				
Idaho				✓			✓	
Illinois		✓	✓	✓		✓		
Indiana	✓			✓			✓	
Iowa			✓	✓			✓	
Kansas		✓	✓	✓			✓	
Kentucky		✓	✓	✓				
Louisiana		✓	✓	✓				
Maine		✓	✓	✓	✓			
Maryland			✓	✓			✓	
Massachusetts	✓	✓	✓	✓			✓	
Michigan		✓	✓	✓				
Minnesota			✓	✓			✓	
Mississippi		✓	✓	✓			✓	
Missouri		✓	✓	✓			✓	
Montana			✓	✓			✓	
Nebraska			✓	✓				
Nevada				✓				
New Hampshire		✓	✓	✓			✓	
New Jersey	✓	✓	✓	✓			✓	
New Mexico			✓	✓			✓	
New York	✓	✓	✓	✓				

	Vehicle standards	Vehicle inspection	Restraints	Driver licensing	Driver training	Driver physical	Drug testing policy	Vehicle identification
North Carolina		✓		✓			✓	
North Dakota				✓			✓	
Ohio				✓				
Oklahoma			✓	✓			✓	✓
Oregon			✓	✓				
Pennsylvania		✓	✓	✓				
Rhode Island		✓		✓				
South Carolina	✓		✓	✓			✓	
South Dakota			✓	✓				
Tennessee	✓	✓	✓	✓	✓	✓	✓	✓
Texas		✓	✓	✓				
Utah		✓	✓	✓				
Vermont	✓	✓	✓	✓			✓	
Virginia		✓	✓	✓				
Washington			✓	✓			✓	
West Virginia		✓	✓	✓				
Wisconsin		✓	✓	✓				
Wyoming			✓	✓			✓	

Head Start Transportation Law

Head Start is a Federal child development program serving low-income children from birth to age 5 to increase their school-readiness. On January 18, 2001, the DHHS, which administers the program, issued a rule, partially based on a Safety Board recommendation,[33] concerning the transportation of children by Head Start agencies. Beginning January 18, 2006, Head Start agencies providing transportation to children enrolled in their programs must use school buses or allowable alternative vehicles that are equipped with height- and weight-appropriate restraint systems; these restraint systems must be used at all times. Effective January 20, 2004, one bus monitor must be on board Head Start agency vehicles at all times. Further, all drivers must possess a commercial driver's license and be examined by a licensed doctor to establish their physical ability to perform the job. Finally, all drivers and monitors must receive recurrent training in vehicle and passenger safety.

[33] Safety Recommendation H-99-20, which recommended that Head Start children be transported in vehicles built to Federal school bus structural standards or the equivalent, was classified "Closed—Acceptable Action" on April 18, 2001. For further information, see National Transportation Safety Board, *Pupil Transportation in Vehicles Not Meeting Federal School Bus Standards*, Special Investigation Report NTSB/SIR-99/02 (Washington, DC: NTSB, 1999).

National Highway Traffic Safety Administration Interpretation

All new vehicles used to transport children to or from school or school-related activities must meet the safety standards for school buses.[34] The *Federal Motor Vehicle Safety Standards* require that school buses have roof rollover protection, energy-absorbing seats, and greater body joint strength than most other types of vehicles, including 15-passenger vans.

NHTSA's Chief Counsel issued an interpretation letter[35] on August 3, 1998, in response to an inquiry for clarification from the Iowa Department of Education. In the letter, NHTSA stated that using a vehicle to pick up children from school every day, or even every other day, constitutes "significant" use of a vehicle and that such a vehicle would be considered a school bus and thus would need to comply with school bus requirements.

Booster Seats

NHTSA conducted a study[36] in 1994 that examined lap/shoulder belt fit on children. The study found that when children are seated upright, the widest part of their calves rests on the edge of the seat, putting pressure on their legs and causing discomfort. This discomfort often causes children to slouch, so that their legs hang over the edge of the seat. One of the benefits of booster seats is that they allow children to sit comfortably without slouching. Slouching can cause the lap belt to ride up on the abdomen and allow the shoulder portion of the belt to cross close to the face. NHTSA concluded that the minimum size child who could use a three-point belt alone would be 59.2 inches tall and weigh 82 pounds. NHTSA currently recommends that a belt-positioning booster seat be used for children ages 4 to 8 and under 4 feet 9 inches tall.[37] NHTSA's position is consistent with the Safety Board's 1996 research[38] and resulting recommendations described in Appendix B, *Previous Recommendations*.

Roadside Barrier Guidelines

TDOT has adopted the American Association of State Highway and Transportation Officials' (AASHTO's) guidelines for terminal requirements and "length of need"[39] for roadside barriers. According to AASHTO's *Roadside Design Guide*,[40] when

[34] Title 49 *United States Code* 30112.

[35] < http://www.nhtsa.dot.gov/cars/rules/interps/files/17730.drn.htm>.

[36] U.S. Department of Transportation, National Highway Traffic Safety Administration, *Study of Older Child Restraint/Booster Seat Fit and NASS Injury Analysis*, DOT HS 808 248 (Washington, DC: NHTSA, 1994).

[37] <www.nhtsa.dot.gov/CPS>.

[38] NTSB/SS-96/01.

[39] "Length of need" is the length of barrier needed to protect an errant vehicle from impacting a roadside hazard.

[40] American Association of State Highway and Transportation Officials, *Roadside Design Guide*, (Washington, DC: AASHTO, 1989), pages 5-32 – 5-39.

determining a barrier's length of need, several factors should be considered, the primary ones being the lateral distance of the hazard from the edge of the traveled way[41] and the theoretical distance that a vehicle leaving the roadway would need to come to a stop.[42] In the *Roadside Design Guide*, AASHTO notes that the equation for length of need is intended for use on straight or nearly straight sections of roadway. The *Roadside Design Guide* also notes that a vehicle leaving the roadway on the outside of a curve would follow a tangential runout path, and in such cases, recommends that the tangent line from the curve to the outside edge of the hazard or clear zone be used in place of the theoretical runout path. TDOT guidance recommends the use of "good engineering judgment" when a hazard appears on the outside of a roadway curve and refers the designer to the AASHTO *Roadside Design Guide*.

The anchored-in-backslope terminal design was deemed acceptable for use[43] with W-beam guardrails after October 1, 1998. According to the Federal Highway Administration (FHWA), when properly designed, this type of terminal provides full shielding for the identified hazard, eliminates the possibility of an end-on impact with the barrier terminal, and minimizes the likelihood of access behind the rail.

Previous Recommendations

The Safety Board has addressed the issues of child restraints and school bus occupant protection standards in previous reports. Appendix B summarizes relevant safety recommendations that have been issued as a result of these reports and their status.

[41] Distance measured to the far side of the hazard, if the hazard is a fixed object, or distance measured to the outside edge of the clear zone, if the hazard is an embankment or if the hazard is a fixed object but extends beyond the clear zone.

[42] Referred to as "runout length," this theoretical distance is measured from the upstream extent of a hazard, along the roadway, to the point at which a vehicle is assumed to have left the roadway. The runout length varies depending on the operating speed and the available friction between the tires and the ground.

[43] FHWA Acceptance Letter CC-53 HNG-14, dated July 10, 1998.

Analysis

Introduction

This report is the Safety Board's fourth in a series of investigations to focus on 15-passenger van transportation.

The first report,[44] issued in 1999, addressed the use of vehicles that do not meet school bus structural standards, yet are used for school, Head Start, or day care transportation. The Safety Board found in the four accidents investigated, including one involving a 15-passenger van transporting children to their homes from an after-school child care program, that had school buses been used, the vehicles probably would have sustained less damage and the passengers may have suffered fewer and less severe injuries. In that report, the Board made recommendations to the States to require school buses for all pupil transportation, including child care centers. (For more information, see the *Child Care Transportation* section later in this analysis.) The Board also discussed the importance of using age-appropriate restraints for all passengers, regardless of vehicle type or use.

In 2002, the Safety Board issued a report[45] that reviewed accident data for 15-passenger vans. The Board found that 15-passenger vans have a greater propensity for rollover than passenger cars, particularly when loaded with 10 or more passengers. The Safety Board recommended that technologies to prevent rollovers, such as electronic stability control, be developed and installed in 15-passenger vans. Additionally, the Board recommended that 15-passenger vans be rated on their rollover propensity.

In 2003, the Safety Board issued a report[46] on 15-passenger vans based on two accidents involving church groups. The Board found that the vans handle differently than passenger cars and require additional skills and knowledge to operate, particularly in emergency situations. Additionally, the Board found that the vans are not built to the same structural standards as school buses or even some passenger cars. The report also discussed the importance of regular maintenance and the benefits of using seat belts to prevent ejection.

In part, as a result of the Safety Board's efforts, the public is more aware of the safety shortcomings of 15-passenger vans. Head Start is phasing out use of the vans. Several States already prohibit or have introduced legislation either prohibiting the use of vans for school transportation or requiring drivers to obtain specific training for the vans.

[44] NTSB/SIR-99/02.

[45] NTSB/SR-02/03.

[46] National Transportation Safety Board, *15-Passenger Van Single-Vehicle Rollover Accidents, Henrietta, Texas, May 8, 2001, and Randleman, North Carolina, July 1, 2001*, Highway Accident Report NTSB/HAR-03/03 (Washington, DC: NTSB, 2003).

Some insurance companies are no longer insuring the vans for use by churches. General Motors Corporation and Ford Motor Company have equipped their 15-passenger vans with electronic stability control. NHTSA has developed an action plan for 15-passenger vans that focuses on the vans' rollover propensity, construction, seat belts, statistics, training, and consumer information. Finally, some groups that use 15-passenger vans, such as churches, day care associations, and youth organizations, have issued press releases to their members describing the problems associated with 15-passenger vans and possible solutions, including phasing out their use.

The analysis that follows will first exclude factors not causal to the accident and then describe the accident sequence. The remainder of the analysis will examine the driver's physical condition, child care oversight in Tennessee and throughout the country, and barrier design guidelines.

Accident Discussion

The weather was clear and the roadway dry. Safety Board investigators found no mechanical defects on the van that would have contributed to the accident. The first responder arrived at the accident scene within 2 minutes of the accident, and rescue and extrication efforts were completed within 30 minutes of the accident. Therefore, the Safety Board concludes that neither the weather nor the mechanical condition of the van contributed to the accident and that the emergency response was timely and appropriate.

Just before the accident, the van had been traveling in the left lane of three lanes on the southbound side of I-240. No other vehicles or obstacles were in the roadway that would have caused the driver to depart his lane and begin moving toward the right shoulder across two other lanes at a shallow angle. The roadway curved toward the left, whereas the van continued in a straight path, departing the roadway at an approximate 6-degree angle. (See figure 2 at the beginning of this report.) Physical evidence indicated no skid marks from the van as it left the roadway.

The van traveled across the right shoulder, through the drainage channel, and onto the grassy backslope. (See figure 17, location 1.) The right-front tire rolled over the W-beam guardrail of the roadside barrier system, approximately 8.5 feet south of the barrier's buried-in-backslope terminal; at this location, the W-beam guardrail was about 5 inches above the ground. The van continued over the top of the barrier system (location 2) and traveled about 40 feet, when the left-front tire rolled over the top of the W-beam guardrail (location 3); the height of the guardrail at that point was about 14 inches.[47] The vehicle also began to rotate to the left, as evidenced by the two right tire furrows in the grass, offset by 8 inches, and then began to roll toward its left side. The van continued for about 85 feet parallel to the roadway (location 4). The 3:1 slope of the grassy backslope caused the van to be redirected back toward the roadside barrier, such that the left-front of the van contacted the back of the barrier system about 133 feet south of the barrier terminal. The

[47] Its final height was 26 inches above the roadway.

van had rotated approximately 19 degrees toward the right and collided with the light pole affixed to a breakaway base unit (location 5). This collision caused the van to rotate further, such that it was oriented about 45 degrees from the initial direction of travel when it struck the bridge abutment, about 20 feet beyond the light pole (location 6). The front right side of the van sustained the greatest amount of damage due to the force of the collision. Because the van had begun to roll back toward the right after the collision with the light pole, the upper portion of the right side body panels incurred the greatest impact deformation.

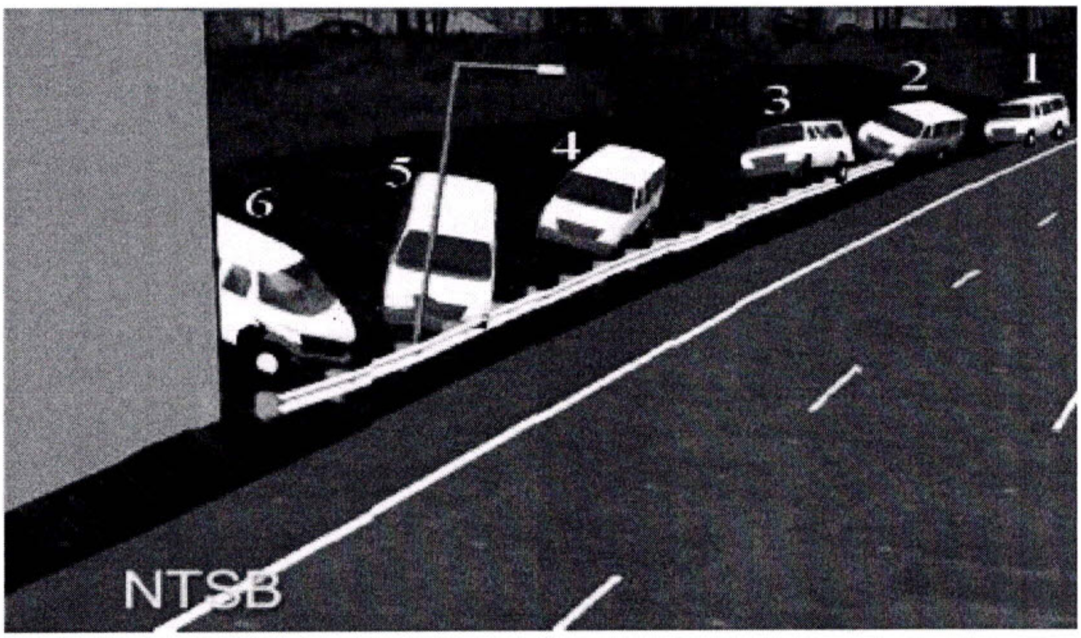


Figure 17. Path of van.

Driver's Condition

The driver's condition was evaluated to determine the role that it played in the accident. The driver's postaccident toxicological tests indicated that he had used marijuana recently; based on the concentration of THC and THC-COOH in the driver's blood, the estimated time of marijuana consumption was anywhere from 13 minutes to 3 hours before the accident.[48] Since THC begins to metabolize almost immediately after use, the presence of THC in the driver's blood indicated that the hallucinogenic compound of marijuana had not completely metabolized and was still influencing the driver's performance.

[48] Based on data in M.A. Huestis, J.E. Henningfield, E.J. Cone, "Blood Cannabinoids II. Models for the Prediction of Time of Marijuana Exposure from Plasma Concentrations of Δ^9-tetrahydrocannabinol (THC) and 11-nor-9-carboxy-Δ^9-tetrahydrocannabinol (THCCOOH)," *Journal of Analytical Toxicology,* Vol. 16 (1992): 283-290.

Witness statements further support marijuana use. An attendant said she boarded the van between 6:00 and 6:30 a.m. and left the van at about 8:00 a.m. and during that time did not see the driver smoke. Therefore, the driver most likely smoked the marijuana either before picking up the attendant or after dropping her off. Furthermore, one of the surviving passengers told police that the driver was smoking marijuana while driving that morning. Therefore, the Safety Board concludes that the driver consumed marijuana on the morning of the accident and was under the influence of the drug at the time of the crash.

THC acts within the central nervous system and can result in mood changes and disturbances in time perception.[49] THC decreases dynamic visual acuity,[50] reduces eye-hand and hand-hand coordination, increases reaction times, causes incorrect reactions,[51] can result in incorrect estimates of time and distance, and can increase brake time.[52]

According to the driver's fiancée, the driver slept his usual amount, about 8 hours, on the night before the accident. He also routinely napped for a few hours at midday. Witnesses told investigators that the accident driver sometimes dozed off when stopped at traffic lights and was seen sleeping in his van while parked outside the child care center. One witness said she could hear him snoring loudly from outside the van when it was parked outside the day care center. Research suggests that napping is a common practice among individuals with severe sleep apnea,[53] a common disorder in which breathing stops during sleep for 10 seconds or more, sometimes more than 300 times a night. Because of these disruptions to normal sleep patterns, individuals with sleep apnea tend to suffer from excessive daytime sleepiness, no matter how much sleep they obtain during any period.

A study of 384 patients with sleep apnea syndrome identified situations that have a high tendency to induce sleep in these individuals.[54] Riding in a car was reported as likely to induce sleep in 71 percent of individuals with sleep apnea syndrome, and 50 percent reported "driving" as being sleep-inducing. Thirty-two percent of the apneic patients reported falling asleep while waiting for a red light.

Another study[55] compared 78 morbidly obese people without obstructive sleep apnea with 40 healthy weight subjects and found that sleep problems were significantly

[49] T.H. Barnes, *Drug Use and Driving* (Toronto: Addiction Research Foundation, 1974).

[50] B. Brown, A.J. Adams, and G. Haegerstrom-Portnoy, "Effects of Alcohol and Marijuana on Dynamic Visual Acuity," *Perception and Psychophysics*, Vol. 20, No. 2 (1975): 119-124.

[51] P. Kielholz, V. Hobi, D. Ladewig, P. Miest, and R. Richter, "An Experimental Investigation About the Effect of Cannabis on Car Driving Behavior," *Pharmakopsychiatrie Neuro-Psychopharmakologie*, Vol. 6, No. 2 (1973): 91-103.

[52] B.J. Rafaelsen, P. Bech, and L. Rafaelsen, "Simulated Car Driving Influenced by Cannabis and Alcohol," *Pharmakopsychiatrie Neuro-Psychopharmakologie*, Vol. 6, No. 2 (1973): 71-83.

[53] R. Rosenthal, C. Bishop, P. Guido, M. L. Syron, T. Helmus, F. M. Rice, and T. Roth, "The Sleep/Wake Habits of Patients Diagnosed as Having Obstructive Sleep Apnea," *Chest*, Vol. 111, No. 6 (1997): 1494-1499.

[54] T. Roehrs, M. A. Carskadon, W. C. Dement, and T. Roth, "Daytime Sleepiness and Alertness," eds. M. H. Kryger, T. Roth, and W. C. Dement, *Principles and Practice of Sleep Medicine*, 3rd ed. (Philadelphia: W. B. Saunders Co., 2000): 43-52.

more frequent in the obese people. Excessive daytime sleepiness was reported by 34.7 percent of the obese patients and by 2.7 percent of the normal weight subjects.

Sleep apnea is characterized by excessive daytime sleepiness, despite an apparently sufficient period of night sleep.[56] The driver's obesity[57] and snoring are both risk factors for a sleep disorder, which can cause excessive daytime sleepiness. Furthermore, diabetes has been linked to obstructive sleep apnea,[58] and, while undiagnosed, the driver had elevated HbA1c levels that would indicate a diabetic condition. The driver had never undergone a formal evaluation for a sleep disorder; however, he exhibited the symptoms and risk factors for a sleep disorder.

The driver of the Tippy Toes van was transporting child care children to school on the day of the accident. He had been driving for Tippy Toes for just over 6 months without a record of complaints about his performance on file with the day care center, despite the fact that several parents said they had complained to the director of Tippy Toes about the driver's marijuana use. Two children who rode with the driver regularly, another child care worker (the attendant), and the driver's cousin, who was also employed as a driver by Tippy Toes, told Safety Board investigators that the driver nodded off while stopped at traffic lights. The attendant also said that coworkers and friends were well aware of the driver's marijuana use and that she believed the owner and director of the child care center were aware as well.

A witness behind the van reported the absence of illuminated brake lights as the van departed its travel lane, crossed the center and right lanes, and left the roadway. The van departed at a shallow angle from the roadway, and no skid marks or other evidence of braking or steering could be found. Further, the bulbs in the rear brake light assemblies showed no sign of filament deformation, indicating that the brake lights were not on at the time of the crash, consistent with the driver not reacting to the roadway departure. Based on the simulation, more than 3 seconds elapsed from the time the van departed the left lane to the time the van was on the grass, sufficient time[59] for the driver to notice the lane departure and react by either steering or braking.

---

[55] O. Resta, M.P. Foschino-Barbaro, P. Bonfitto, T. Giliberti, A. Depalo, N. Pannacciulli, and G. De Pergola, "Low Sleep Quality and Daytime Sleepiness in Obese Patients Without Obstructive Sleep Apnea Syndrome," *Journal of Internal Medicine*, Vol. 253, No. 5 (2003): 536-543.

[56] C. Guilleminault, "Clinical Features and Evaluation of Obstructive Sleep Apnea," eds. M. Kryger, T. Roth, and W.C. Dement, *Principles and Practice of Sleep Medicine*, 2nd ed. (Philadelphia: W.B. Saunders Co., 1994).

[57] The driver's height and weight (6 foot 1 inch tall, 380 pounds) meet the clinical criteria for morbid obesity.

[58] M.S. Ip, B. Lam, M.M. Ng, W.K. Lam, K.W. Tsang, and K.S. Lam, "Obstructive Sleep Apnea is Independently Associated with Insulin Resistance," *American Journal of Respiratory and Critical Care Medicine*, Vol. 164, No. 5 (2002): 562-563.

[59] Driver perception reaction time ranges from 0.9 to 2.1 seconds. From Thomas A. Dingus, Steven K. Jahns, Abraham D. Horowitz, and Ronald R Knipling, "Human Factors Design Issues for Crash Avoidance Systems," eds. Woodrow Barfield and Thomas A. Dingus, *Human Factors in ITS* (New Jersey: Lawrence Erlbaum Associates, 1998).

The driver's history of difficulty maintaining wakefulness, the van's lack of brake light illumination, and the gradual drifting of the van off the roadway are consistent with a driver who has fallen asleep. The Safety Board concludes that the driver fell asleep before departing the roadway, probably due to an undiagnosed sleep disorder.

Child Care Transportation

Vehicle

In this accident, the children were being transported to school from Tippy Toes, their child care center, in a 15-passenger van. Because of the severity of this crash, most of the passengers would have sustained injuries, whether restrained or not, due to the speed at which the van struck the bridge abutment and the intrusion into the occupant compartment. However, the injuries would have been less severe for the passengers in the rear of the van had they been restrained. Because of the intrusion into the front-right passenger area, the front-seat passenger had little survivable space, regardless of restraint usage. The other fatally injured occupants were either thrown out of their seating area due to the impact forces or were thrown into the intruding sidewall as the van impacted the bridge abutment. The two passengers who survived the accident probably did not sustain fatal injuries because they were farthest from the impact and intrusion and were quite likely shielded by the other van occupants.

As a result of a 1999 special investigation report,[60] which discussed four accidents involving nonconforming vehicles used for pupil transportation, the Safety Board recommended that the 50 States and the District of Columbia:

> H-99-22
>
> Require that all vehicles carrying more than 10 passengers (buses) and transporting children to and from school and school-related activities, including but not limited to, Head Start programs and day care centers, meet the school bus structural standards or the equivalent as set forth in 49 *Code of Federal Regulations* Part 571. Enact regulatory measures to enforce compliance with the revised statutes.

Only 11 States have implemented this recommendation. The Safety Board remains firmly convinced that the safest way to transport children to or from school or school-related activities is in a vehicle built to school bus standards. From 1993 through 2002, fatalities to children within school buses averaged just over 5 per year; yet, in that same timeframe, fatalities to children in 15-passenger vans averaged 57. Further, a *School Transportation News* study[61] found that the cost per road mile of a 15-passenger school bus is actually less than the cost of a 15-passenger van, due to the greater life span of a school bus and reduced maintenance costs.[62]

---

[60] NTSB/SIR-99/02.

[61] *School Transportation News*, <www.stnonline.com>.

School buses are built using a design concept known as compartmentalization;[63] a vehicle so constructed would have kept the children within their seating area during the initial impact with the light pole instead of being thrown from their seating positions during this initial impact, as predicted by the Safety Board's accident simulation. The intrusion into the seating compartment may also have been lessened because of the school bus's greater joint strength. The Safety Board found in its 1999 study[64] that school buses provide better crashworthiness and occupant protection. The study concluded that had the vehicles involved in these accidents had equivalent occupant crash protection, they probably would have sustained less damage, and the passengers might have suffered fewer and less severe injuries. The same can be said for the van and passengers in the Memphis accident. The Safety Board therefore concludes that had Tippy Toes used a vehicle built to school bus standards to transport the children to and from school, rather than a 15-passenger van, the resulting injuries might have been less severe. The Safety Board continues to urge the 39 States that have not done so, and the District of Columbia, to include child care centers in their requirement that school buses or buses built to school bus standards be used for the transportation of children to or from school or school-related activities and therefore reiterates Safety Recommendation H-99-22.

Restraint Usage

The driver was not restrained, which led to his ejection and fatal injuries. Even if he had been restrained, his weight and the forces from the crash might have prevented the restraint system (lap/shoulder belt and airbag) from fully protecting him, resulting in possible chest injuries. While the driver was not ejected in the Board's simulation, it cannot be determined whether the lap/shoulder belt and airbag would have been able to restrain someone of the accident driver's size, which was at the upper limit for which restraints are effective.[65] Even assuming the lap/shoulder belt could have prevented the driver from being ejected, he may have suffered chest injuries, most likely due to contact with the steering wheel.[66]

Although the Safety Board believes that children should be transported to and from school or day care in a school bus, we understand that child care centers will continue to use other vehicles to transport children as school buses and MFSABs are phased into use. The continued use of non-school bus vehicles makes the use of restraints

[62] Maine Bureau of Highway Safety, *15-Passenger Van Training Program* (Augusta, Maine: Bureau of Highway Safety, 2003).

[63] In school buses, compartmentalization is used to protect passengers from crash impacts. This is accomplished by having the seats closely spaced together, with the seat cushions and high seatbacks covered in an energy-absorbing material. The entire seat structure is designed to absorb energy and to dissipate through deformation the energy of the crash away from the passenger and into the surrounding compartment. In addition to using compartmentalization, small school buses are equipped with lap belts because their size can lead to more passenger movement in a collision.

[64] NTSB/SIR-99/02.

[65] Federal Motor Vehicle Safety Standard 571.208 only requires that a 50th percentile adult male dummy be used in the frontal barrier tests of seat belts and airbags.

[66] Correspondence with Dr. Jeff Crandall, University of Virginia Center for Applied Biomechanics, December 15, 2003.

even more important because the restraints at least offer some measure of protection. In the Safety Board's simulations, use of available restraint systems was estimated to reduce the overall occupant motion and the potential for ejection and injuries from occupant-to-occupant contacts. Further, the simulations showed that, had the children been restrained in age-appropriate restraints, they probably would have received even less severe injuries. The predicted injuries of the two children who should have been in booster seats (the 6- and 8-year-olds) were estimated to be greatly decreased in the simulation when they were placed in booster seats. This is because the seats provide the proper positioning of the seat belts on smaller children. (See figure 15 earlier in this report.) An additional benefit of the booster seats used in the simulation, high-backed boosters with sides, was that they further contained the occupants within their seating area, reducing potential injuries that would have been caused by contacting other surfaces within the van.

The 6-year-old who was not placed in a booster seat in the simulation experienced additional predicted injuries due to improper belt placement. The location of the attachment points for the lap/shoulder belts and the shoulder attachment caused the shoulder harness to ride up the torso in the simulation, so that the belt contacted the occupant's neck. (See figure 15 earlier in this report.) Even though the children in seats 3 and 6 were old enough (both were 10 years old) that they were not recommended to use booster seats, the shoulder harness of their lap/shoulder belts quite likely would also have been ill-fitting, crossing the children at the neck due to the location of the upper anchorages. (See figure 16 earlier in this report.) Ill-fitting lap/shoulder belts can lead to further injuries, such as increased risk of fractures to the spine and serious abdominal injuries.[67,68] The Safety Board has recommended to manufacturers of 15-passenger vans that these lap/shoulder belts be adjustable in 15-passenger vans[69] because, as currently configured, these vans locate the shoulder belt upper anchorage high and aft of the passenger, creating a situation where the belt fits poorly.

The 9-year-old passenger in center seat 7 only had the option of using a lap belt. The Safety Board has long advocated use of lap/shoulder belts in all seating positions because they greatly reduce a passenger's risk of injury during a collision. Restrained by lap belts only, passengers sometimes sustain increased abdominal, head, and neck injuries as a result of pivoting about the lap belt or due to excessive upper body motion. Both General Motors Corporation and Ford Motor Company (the current manufacturers of 15-passenger vans) plan to install lap/shoulder belts at all seating positions by September 2007; General Motor's belts will be adjustable.

Driver Fitness

During the course of the investigation, investigators found other issues associated with Tippy Toes's child transportation program that contributed to this accident. Despite the

---

[67] C. Gotschall, A. Better, D. Blaus, M. Eichelberger, F. Bents, and M. Warner, "Injuries to Children Restrained in 2- and 3-Point Belts," *42nd Annual Proceedings of the Advancement of Automotive Medicine*, 1998.

[68] J. Garrett and P. Braunstein, "The Seat Belt Syndrome," *Trauma,* Vol. 2 (1962): 220.

[69] For more information on Safety Recommendation H-03-25, see appendix B.

TDHS requirements, Tippy Toes had not conducted a background check on or medical examination of the driver. A background check would have revealed the driver's marijuana possession arrest, and a medical examination might have identified the driver's marijuana use and possible sleep apnea. Drug testing also would quite likely have identified the driver's marijuana use. Although Tippy Toes's employees knew of and thought the owners were aware of the driver's marijuana use, nothing was done to prevent him from driving children to and from the child care center. Because Tippy Toes did not forward the driver's application to the TDHS, as required, the TDHS had no record of this driver being employed by Tippy Toes or knowledge that the driver had not been given a background check or medical examination. Reviewing the driver's file would have been one opportunity for the TDHS to identify this driver and ensure he had been properly screened. Even though TDHS personnel had another chance to review the driver's file at Tippy Toes, they failed to note the lack of a background check or medical examination. The Safety Board concludes that because Tippy Toes did not comply with State law and because the TDHS provided inadequate oversight of Tippy Toes's operations, the accident driver was able to transport children, even though he had not had a background check or medical examination.

The accident driver was a known frequent marijuana user and, according to children and parents, had sometimes smoked marijuana while driving the child care van. Because marijuana can affect a driver's perception and reaction, riding with this driver was dangerous. Although the TDHS did not require preemployment drug testing for child care center drivers at the time of the accident, the agency now requires an initial drug screening and prohibits those who test positive from driving for a child care center. The TDHS still does not require random drug tests. The Safety Board concludes that had drug testing been conducted, the accident driver's drug use would quite likely have been detected and he may have been prohibited from transporting children. All highway transportation providers in the United States, from school bus drivers to motorcoach drivers to truck drivers, must submit to both preemployment and random drug testing. Child care transportation providers, who transport young children on a daily basis, should be held to at least the same strict standards as other commercial drivers.

Child Care Transportation Oversight

Public schools currently require that school buses be used to transport children to or from school and that all drivers hold a commercial driver's license and have a medical examination. Beginning in 2006, the Head Start program will require its centers to use vehicles built to school bus standards, restrain children in age-appropriate restraints, and require drivers to hold a commercial driver's license and have a medical examination. Children being transported to and from child care centers deserve the same level of protection as their siblings and neighbors being transported to Head Start or to public elementary or high schools.

Tippy Toes's owner did not conduct a background check on the driver, did not inquire about previous traffic or drug convictions, and did not require that the driver complete a medical examination. Moreover, not only was the owner aware of the driver's marijuana use, and did nothing to restrict or stop him from driving children to or from school, she apparently was also aware that two of the attendants believed that one of their primary responsibilities was to keep the driver awake. Furthermore, the owner allowed children to be transported without seat belts or child restraints, thereby violating the State restraint laws. Had the owner fulfilled any of her responsibilities regarding the transportation of children, this accident may not have occurred or the consequences may have been less severe. Therefore, the Safety Board concludes that the complete absence of driver and transportation operations oversight on the part of Tippy Toes's owner led to this accident.

Following this accident, Tennessee established stricter requirements for child care center transportation. This new law includes requirements, phased in from 2003 to 2007, for the use of vehicles built to school bus standards and age-appropriate restraints; for annual vehicle inspections; for driver background checks, drug tests, and medical examinations; for commercial driver's licenses; and for vehicle identification. Similarly, a fatal accident in South Carolina[70] prompted that State to pass a law requiring vehicles built to school bus standards, child restraints, and annual vehicle inspections. However, Tennessee and South Carolina enacted these stricter laws *only after* fatal accidents involving child care transportation. Further, based on the lack of positive response to Safety Recommendation H-99-22 to require the use of vehicles built to school bus standards and Safety Recommendation H-96-14 to require the use of booster seats, and on the lack of existing State laws implementing such safety improvements, the Safety Board does not believe that significant progress has been made nationally in child care center transportation safety. The Safety Board concludes that the absence of a comprehensive safety oversight system for child care transportation places children who are being transported to and from child care centers at risk.

A comprehensive child care transportation safety program should consist of vehicle, driver, and operational requirements. Vehicles used for child care transportation should be built to Federal school bus standards or be multifunction school activity buses because these vehicles provide greater occupant protection. In addition, as the Safety Board has advocated and as the simulation showed, children are safest when seated in properly used, age-appropriate child restraints and, therefore, child care transportation providers should require children to use such restraints when the vehicle is equipped with seat belts. Further, vehicles should be maintained and inspected routinely to ensure that they are in good working order. Although the accident van's worn brake pad, grooved brake rotor, and the low rear tire inflation pressures did not contribute to the accident, these problems are indicative of poor maintenance.

In this accident, major driver deficiencies escaped scrutiny because the driver's records were not reviewed, the driver never received a background check or a medical examination, and the driver's drug use was tolerated. Drivers employed by child care centers should undergo a criminal background check and a physical examination to detect health or other problems that would impair their driving and endanger the children's safety. Drivers should also be required to submit to preemployment and random drug testing to detect illicit drug use. Further, an oversight agency should review this driver

[70] A 15-passenger van carrying students from a private school to a swimming pool was struck by a tractor-semitrailer that failed to stop at a red light. One passenger was fatally injured and several others were seriously injured. The Safety Board did not investigate this accident.

information, to ensure that child care centers do not overlook driver violations. Finally, so that passersby can report unsafe drivers, child care vehicles should be labeled with the names and phone numbers of the child care center and pertinent oversight agency. One witness said she had seen the Memphis driver sleeping in the vehicle, but had nowhere to report this issue beyond the child care center. Further, because the driver was reported to fall asleep at red lights, others may also have noticed his habits, but had no practical means of notifying anyone of their concerns. Witnesses also stated they believed the child care operator knew of the driver's drug use but ignored it. Had these witnesses known the number of the oversight agency, they could have alerted the agency to this unsafe driver.

Based on the circumstances of this and other accidents, the Safety Board believes that the States and the District of Columbia should implement a comprehensive oversight program for child care transportation that includes the following elements: use of vehicles built to school bus standards or of multifunction school activity buses; a regular vehicle maintenance and inspection program; a requirement that occupants wear age-appropriate restraints at all times; a requirement that drivers receive a criminal background check and have a medical examination to determine fitness to drive; preemployment, random, postaccident, and "for cause" drug testing for child care transportation providers and the prohibition of anyone who tests positive for drugs from transporting children; review by an oversight agency of periodic driver background checks, medical examinations, and drug test results; and a requirement that child care vehicles be labeled with the child care center's and oversight agency's names and phone numbers.

To reinforce efforts by the States to establish comprehensive child care safety oversight programs, the Safety Board proposes that an additional transportation safety accreditation be established by the National Association for the Education of Young Children (NAEYC),[71] which administers the Nation's largest professionally sponsored, voluntary accreditation system for all types of early childhood centers and schools. Over 8,000 child care centers hold NAEYC accreditation. NAEYC's accreditation system currently addresses topics such as curriculum, staffing, child/teacher/parent interaction, health and safety, nutrition, and program administration. The Safety Board believes that NAEYC, as part of its accreditation program, should establish a transportation safety accreditation that requires applicants to implement the same oversight elements that the Safety Board proposed in its above recommendation to the States.

Another resource available to child care providers as they implement child care transportation safety oversight programs is the DHHS, which provides Child Care and Development Funds to States to "assist low-income families, families receiving temporary public assistance, and those transitioning from public assistance in obtaining child care so they can work or attend training/education."[72] In 2003, \$4.8 billion in funds were available. The child care center in this accident received funding in 2002. The DHHS does not prescribe health and safety requirements; it only requires that child care facilities

[71] Over 8,000 child care centers are accredited <www.naeyc.org>, including over 200 federally sponsored child care centers and over 800 U.S. Department of Defense child care centers <http://www.nccic.org/pubs/qcare-it/apdx-d.html> and <http://clinton3.nara.gov/WH/Work/031098.html>.

[72] <www.acf.dhhs.gov>.

receiving funds meet State requirements for health and safety. However, the DHHS does provide resource information on its Web site for child care providers, including links to NHTSA's recommendations on child restraints. The Safety Board concludes that the DHHS, which provides child care and development funds to the States, is well-positioned to supply guidance and information on the safe transportation of children to child care providers. The Safety Board will ask that the DHHS publish, distribute to local offices, and place on its Web site, information on the circumstances of this accident and the Safety Board's recommendation for a comprehensive child care transportation oversight program, as well as the Safety Board's previously published information on 15-passenger van safety.

Barrier Design

As the van departed the roadway, it drove over the top of the guardrail terminal and became trapped behind the guardrail. Because of the backslope, the guardrail at the accident location varied in height from 5 inches at the anchored-in-backslope terminal to 26 inches above ground 57 feet beyond the terminal. Yet, because of the backslope, the guardrail remained level to the pavement surface. This allowed the van to encroach on the barrier and easily mount it at its anchor point, ride over it, and continue along and behind the length of the barrier. The use of such a design resulted in a terminal configuration similar to a turned-down[73] terminal, because of the reduction from the full barrier height to ground level. The Safety Board concludes that had the barrier system in place at the accident location not tapered into the backslope and had another type of barrier terminal been used, the van would not have been able to ride over the top of the barrier's longitudinal guardrail and would probably have been prevented from becoming trapped behind the guardrail and striking the bridge abutment. While an anchored-in-backslope design can be effective, it is not a safe design for locations where design hazards exist along a steep backslope or a horizontal curve, as was true at the accident location. There, the anchored-in-backslope terminal essentially becomes a flared turned-down design, which is unsafe and no longer permitted because the turned-down design provides no protection to errant vehicles. The Safety Board believes that State and District of Columbia Departments of Transportation should identify guardrails with anchored-in-backslope terminals and eliminate any that create a situation similar to a turned-down terminal.

The roadside barrier[74] extended 160 feet from the bridge abutment. Based on a plot of the accident site, using the 21-foot clear zone and the 360-foot runout length recommended by AASHTO for design speeds of 55 mph,[75] the barrier's calculated length of need is 79 feet. As can be seen in figure 18, when the runout length is plotted, it actually intersects the roadway only 227 feet from the bridge abutment because of the roadway's curvature, so that the full 360 feet is not available for errant drivers to recover.

---

[73] A turned-down terminal is a W-beam guardrail that decreases from full height to ground level, typically over a distance of 25 feet.

[74] The barrier comprises the guardrail and the end treatment.

[75] AASHTO, *Roadside Design Guide*, 5-33.

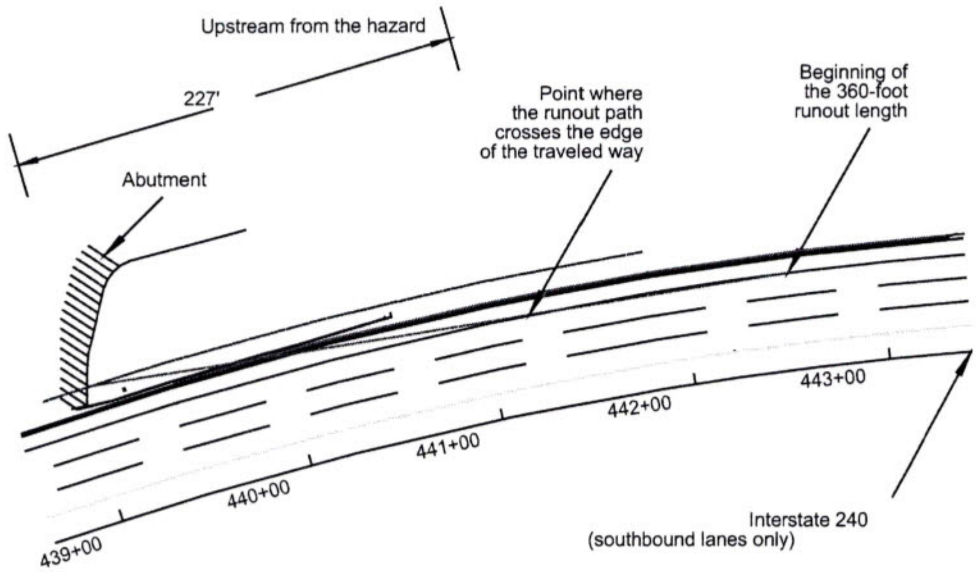


Figure 18. True runout length on curve.

Because of the horizontal curve before the bridge abutment, the length of need of the guardrail should be calculated to account for vehicles that leave the roadway tangent to the curve, as the accident vehicle did. AASHTO states in one of its design examples[76] that when a vehicle leaves the road on the outside of the curve (as in this accident), it generally follows a tangential path. In such cases, the tangent line from the curve to the clear zone or outside edge of the hazard should be used instead of the theoretical runout length.

Because of the curvature of the roadway, a vehicle can depart the roadway at a distance further from the hazard than that predicted by AASHTO's recommended runout length. When a vehicle "straightens out" the curve, it departs the roadway further from the hazard but still needs to be redirected or provided room to stop. When this occurs, the vehicle can completely miss the barrier system designed to protect against the hazard, as was the case in this accident and others. MPD records indicate three fatal (including this accident) and two property damage accidents at this location between 1997 and 2002 in which vehicles became trapped behind the guardrail.

The steep grade of the backslope and the wall of the bridge abutment, when combined with the barrier, created a trap. Once trapped behind the barrier, even had the driver tried to steer to avoid striking the abutment, he would not have been able to return to the roadway because the van was trapped between the guardrail and the backslope, effectively directing the van into the bridge abutment. However, with sufficient stopping distance, a vehicle could stop before striking the bridge abutment. Thus, the runout length of the barrier also needs to take into consideration situations in which no clear zone is available to a driver who gets trapped behind the barrier. In the simulation, the driver would have had 1.8 seconds to try to bring the vehicle under control from the time he

[76] AASHTO, *Roadside Design Guide*, 5-39.

departed the roadway. This is insufficient time to stop a vehicle, and the slope does not allow the driver to steer away from the barrier.

In the simulation, a vehicle traveling at 65 mph in the left lane and continuing in a straight path tangent to the curve, instead of following the curvature of the roadway, would need at least 40 more feet of guardrail with the same end treatment, or 10 feet more with a different end treatment, to redirect the vehicle onto the roadway. Using AASHTO's formulas and a runout length of 480 feet (based on the 85th percentile speed of 70 mph) and plotting the trajectory of a vehicle that leaves the roadway tangential to the curve, the barrier system's length of need is 293 feet, exceeding the existing barrier's length by 133 feet, not including the end treatment. (See figure 19.) By extending the barrier, the likelihood of an errant vehicle impacting the barrier system and being redirected away from the bridge abutment increases. For a driver trapped behind the barrier, the additional length would provide the opportunity to stop before colliding with the bridge abutment.

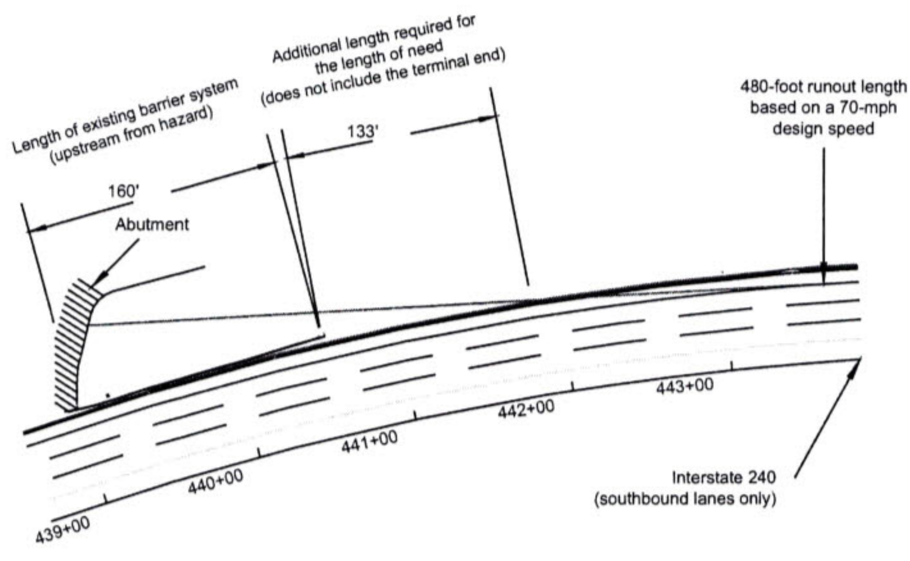


Figure 19. Length of need based on speed and roadway curvature.

The Safety Board concludes that given the roadway curvature and the lack of a clear zone, the barrier at the accident site was not long enough to prevent a vehicle that departed the roadway from going behind the barrier or to allow an errant vehicle to recover before striking the bridge abutment. AASHTO's *Roadside Design Guide* does not specifically address these types of situations or direct the highway designer to examine the need for longer runout lengths if the conditions could contribute to a vehicle becoming trapped behind the barrier or if the roadway curves. The Safety Board believes that AASHTO should modify the guidance contained in the *Roadside Design Guide* to clearly provide designers with information on the design of roadway barrier systems in situations where the roadway curves or where the terrain, hazards, and barrier system could trap an errant vehicle behind the barrier system. The Safety Board will ask AASHTO to inform its members of the circumstances of this accident and of the importance of considering roadway curvature and terrain configurations in the design of barrier systems.

Conclusions

Findings

1. Neither the weather nor the mechanical condition of the van contributed to the accident, and the emergency response was timely and appropriate.

2. The driver consumed marijuana on the morning of the accident and was under the influence of the drug at the time of the crash.

3. The driver fell asleep before departing the roadway, probably due to an undiagnosed sleep disorder.

4. Had Tippy Toes Learning Academy used a vehicle built to school bus standards to transport the children to and from school, rather than a 15-passenger van, the injuries resulting from this accident might have been less severe.

5. Because Tippy Toes Learning Academy did not comply with State law and because the Tennessee Department of Human Services provided inadequate oversight of Tippy Toes Learning Academy's operations, the accident driver was able to transport children, even though he had not had a background check or medical examination.

6. Had drug testing been conducted, the accident driver's drug use would quite likely have been detected, and he may have been prohibited from transporting children.

7. The complete absence of driver and transportation operations oversight on the part of Tippy Toes Learning Academy's owner led to this accident.

8. The absence of a comprehensive safety oversight system for child care transportation places children who are being transported to and from child care centers at risk.

9. The U.S. Department of Health and Human Services, which provides child care and development funds to the States, is well-positioned to supply guidance and information on the safe transportation of children to child care providers.

10. Had the barrier system in place at the accident location not tapered into the backslope and had another type of barrier terminal been used, the van would not have been able to ride over the top of the barrier's longitudinal guardrail and would probably have been prevented from becoming trapped behind the guardrail and striking the bridge abutment.

11. Given the roadway curvature and the lack of a clear zone, the barrier at the accident site was not long enough to prevent a vehicle that departed the roadway from going behind the barrier or to allow an errant vehicle to recover before striking the bridge abutment.

Probable Cause

The Safety Board determines that the probable cause of this accident was the absence of oversight by Tippy Toes Learning Academy and the driver's inability to maintain control of his vehicle because he fell asleep, quite likely due to an undiagnosed sleep disorder; the driver's marijuana use may also have had a role in the accident. Contributing to the accident was the Tennessee Department of Human Services' lack of oversight of child care transportation. Contributing to the severity of the injuries were the use of a 15-passenger van to transport pupils, the nonuse of appropriate restraints, and the design of the roadside barrier system.

Recommendations

New Recommendations

As a result of its investigation of the April 4, 2002, 15-passenger child care van accident, the National Transportation Safety Board makes the following recommendations:

To the State and District of Columbia Child Care Transportation Oversight Agencies:

Implement an oversight program for child care transportation that includes the following elements:

- Use of vehicles built to school bus standards or of multifunction school activity buses; (H-04-8)
- A regular vehicle maintenance and inspection program; (H-04-9)
- A requirement that occupants wear age-appropriate restraints at all times; (H-04-10)
- A requirement that drivers receive a criminal background check and have a medical examination to determine fitness to drive; (H-04-11)
- Preemployment, random, postaccident, and "for cause" drug testing for all child care transportation providers and the prohibition of anyone who tests positive for drugs from transporting children; (H-04-12)
- Review by an oversight agency of periodic driver background checks, medical examinations, and drug test results; (H-04-13) and
- A requirement that child care vehicles be labeled with the child care center's and oversight agency's names and phone numbers. (H-04-14)

To the State and District of Columbia Departments of Transportation:

Identify guardrails with anchored-in-backslope terminals and eliminate any that create a situation similar to a turned-down terminal. (H-04-15)

To the National Association for the Education of Young Children:

As part of your accreditation program, establish a transportation safety accreditation that requires applicants to implement the following elements: (H-04-16)

- Use of vehicles built to school bus standards or of multifunction school activity buses;
- A regular vehicle maintenance and inspection program;
- A requirement that occupants wear age-appropriate restraints at all times;
- A requirement that drivers receive a criminal background check and have a medical examination to determine fitness to drive;
- Preemployment, random, postaccident, and "for cause" drug testing for all child care transportation providers and the prohibition of anyone who tests positive for drugs from transporting children;
- Review by an oversight agency of periodic driver background checks, medical examinations, and drug test results; and
- A requirement that child care vehicles be labeled with the child care center's and oversight agency's names and phone numbers.

To the American Association of State Highway and Transportation Officials:

Modify the guidance contained in the *Roadside Design Guide* to clearly provide designers with information on the design of roadway barrier systems in situations where the roadway curves or where the terrain, hazards, and barrier system could trap an errant vehicle behind the barrier system. (H-04-17)

Previously Issued Recommendation Reiterated in This Report

The National Transportation Safety Board reiterates the following recommendation:

To the States (except Alaska, Delaware, Indiana, Massachusetts, Nebraska, New Jersey, New York, Pennsylvania, South Carolina, Utah, and Vermont) and the District of Columbia:

Require that all vehicles carrying more than 10 passengers (buses) and transporting children to and from school and school-related activities, including but not limited to, Head Start programs and day care centers, meet the school bus structural standards or the equivalent as set forth in 49 *Code of Federal Regulations* Part 571. Enact regulatory measures to enforce compliance with the revised statutes. (H-99-22)

Previously Issued Recommendation Classified in This Report

For the State of Vermont, the previously issued recommendation H-99-22 cited above is classified in this report:

Safety Recommendation H-99-22 (previously classified "Open—Acceptable Response") is classified "Closed—Acceptable Action."

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

ELLEN ENGLEMAN CONNERS
Chairman

MARK V. ROSENKER
Vice Chairman

JOHN J. GOGLIA
Member

CAROL J. CARMODY
Member

RICHARD F. HEALING
Member

Adopted: April 7, 2004

Appendix A

Investigation and Public Hearing

The National Transportation Safety Board was notified of the Memphis, Tennessee, accident on April 4, 2002. An investigative team was dispatched, including members from the Washington, D.C.; Arlington, Texas; Denver, Colorado; Gardena, California; and Parsippany, New Jersey, offices. Groups were established to investigate human performance; motor carrier operations; and highway, vehicle, and survival factors.

Parties to the investigation were the Tennessee Department of Human Services, Tennessee Department of Transportation, and the Memphis Police Department.

No public hearing was held.

Appendix B

Previous Recommendations

For a summary of State compliance with the Safety Board recommendations discussed below, see table B-1 at the end of this appendix.

Restraint Usage

On September 20, 1996, the Safety Board adopted a safety study on *The Performance and Use of Child Restraint Systems, Seat Belts, and Air Bags for Children in Passenger Vehicles.*[1] As a result of that study, the Safety Board issued the following safety recommendations to the governors and legislative leaders of the 50 States and U.S. Territories and to the mayor and chairman of the council of the District of Columbia:

> H-96-13 through -16
>
> Emphasize the importance of transporting children in the back seat of passenger vehicles through educational materials disseminated by the State. Consider setting aside one-tenth of 1 percent from all motor vehicle insurance premiums for policies written to establish a highway safety fund to be used for this and other safety efforts. (H-96-13)
>
> Review existing laws and enact legislation, if needed, that would:
>
> Ensure that children up to 8 years old are required by the State's mandatory child restraint use law to use child restraint systems and booster seats. (H-96-14)[2]
>
> Eliminate exemptions for children to substitute seat belts in place of child restraint systems. (H-96-15)
>
> Require children 8 years or older to use seat belts in all vehicle seating positions. (H-96-16)

The Safety Board classified Safety Recommendation H-96-13 "Closed—Acceptable Action" for all of the States and the District of Columbia.

H-96-14 is on the Safety Board's Most Wanted List of Safety Improvements. Eleven States complied with H-96-14; 17 States and the District of Columbia with H-96-15; and 45 States and the District of Columbia with H-96-16.

---

[1] NTSB/SS-96/01.

[2] This recommendation is on the Safety Board's "Most Wanted" list. For further information, see *NTSB Most Wanted Transportation Safety Improvements 2004* <www.ntsb.gov/Recs/mostwanted/index.htm>.

The Safety Board's most recent report on 15-passenger van safety[3] also addressed restraint issues. As a result of this investigation, the Safety Board recommended that the National Highway Traffic Safety Administration (NHTSA):

> H-03-15
>
> Include 12- and 15-passenger vans in your upcoming rulemaking that will require lap/shoulder belts at all center seats.

NHTSA responded on December 2, 2003, that it had issued a Notice of Proposed Rulemaking on August 6, 2003, that would require lap/shoulder belts at all front-facing seating positions other than front-center seats. Pending completion of the final rule, for which the Safety Board has encouraged the inclusion of 12- and 15-passenger vans, the Safety Board has classified Safety Recommendation H-03-15 "Open—Acceptable Response" on April 15, 2004.

The Safety Board also recommended that Ford Motor Company and General Motors Corporation,[4] the manufacturers of 15-passenger vans:

> H-03-25
>
> Voluntarily install lap/shoulder belts at all center seating positions in 12- and 15-passenger vans and make all lap/shoulder belts in outboard and center seating positions adjustable by model year 2006.

At the time of publication, the Safety Board was evaluating Ford Motor Company's and General Motors Corporation's responses, which were received November 3, 2003, and March 26, 2004, respectively.

School Bus Occupant Protection Standards

In 1998 and 1999, the Safety Board investigated four accidents involving vehicles used to transport children to or from school that were not built to school bus occupant protection standards. Three of these accidents involved 15-passenger vans. The Safety Board adopted a report and issued recommendations in 1999.[5] Most of the recommendations

---

[3] NTSB/HAR-03/03.

[4] Dodge no longer manufactures 15-passenger vans; the last model year was 2002.

[5] NTSB/SIR-99/02.

pertained to the transportation of children to or from school or school-related activities, including day care and Head Start. The Safety Board recommended that the 50 States and the District of Columbia:

> H-99-22
>
> Require that all vehicles carrying more than 10 passengers (buses) and transporting children to and from school and school-related activities, including but not limited to, Head Start programs and day care centers, meet the school bus structural standards or the equivalent as set forth in 49 *Code of Federal Regulations* Part 571. Enact regulatory measures to enforce compliance with the revised statutes.

The Safety Board classified Safety Recommendation H-99-22 "Open—Unacceptable Response" for Tennessee, because, although being phased out for day care transportation, 15-passenger vans can still be used for school transportation. Only 10 States complied with this recommendation: Alaska, Delaware, Indiana, Massachusetts, Nebraska, New Jersey, New York, Pennsylvania, South Carolina, and Utah. Consequently, the Safety Board classified Safety Recommendation H-99-22 "Closed—Acceptable Action" for those States. Information obtained during this accident investigation revealed that Vermont also complied with this recommendation and therefore, for Vermont, the Safety Board has classified Safety Recommendation H-99-22 "Closed—Acceptable Action."

Table B-1. State compliance with safety recommendations.

	H-96-13	H-96-14	H-96-15	H-96-16	H-99-22
Alabama	C				
Alaska	C			C	C
Arizona	C			C	
Arkansas	C	P	P	C	
California	C	P	P	C	
Colorado	C	P	P	C	
Connecticut	C			C	
Delaware	C	C	C	C	C
District of Columbia	C	C	C	C	
Florida	C		C	C	
Georgia	C			C	
Hawaii	C			C	
Idaho	C			C	
Illinois	C	C	C	C	
Indiana	C	C	C	C	C
Iowa	C				
Kansas	C			C	P
Kentucky	C		C	C	
Louisiana	C	P	P	C	
Maine	C	C	C	C	
Maryland	C	P	C	C	
Massachusetts	C			C	C
Michigan	C		C	C	P
Minnesota	C				
Mississippi	C				P
Missouri	C			C	P
Montana	C	P	P	C	

	H-96-13	H-96-14	H-96-15	H-96-16	H-99-22
Nebraska	C	P	P	C	C
Nevada	C	P	C	C	P
New Hampshire	C	P	C	C	P
New Jersey	C	C	C	C	C
New Mexico	C			C	P
New York	C			C	C
North Carolina	C		C	C	
North Dakota	C			C	
Ohio	C				P
Oklahoma	C			C	P
Oregon	C	P	P	C	
Pennsylvania	C	C	C	C	C
Rhode Island	C	C	C	C	P
South Carolina	C	P	P	C	C
South Dakota	C			C	
Tennessee	C	C	C	C	
Texas	C			C	
Utah	C			C	C
Vermont	C	C	C	C	C
Virginia	C	P	P	C	
Washington	C	P	P	C	P
West Virginia	C			C	
Wisconsin	C			C	
Wyoming	C	C	C	C	

C - complies with the recommendation.
P - partially complies with the recommendation.