Passenger Vehicle Median Crossover and Head-On Collision With Another Passenger Vehicle Linden, New Jersey May 1, 2003

Highway Accident Report

NTSB/HAR-06/02

PB2006-916202
Notation 7754

National Transportation Safety Board
Washington, D.C.

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Adopted February 7, 2006

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

National Transportation Safety Board. 2006. ***Passenger Vehicle Median Crossover and Head-On Collision With Another Passenger Vehicle, Linden, New Jersey, May 1, 2003.*** **Highway Accident Report NTSB/HAR-06/02. Washington, DC.**

Abstract: On May 1, 2003, about 2:11 a.m., eastern daylight time, a 1998 Mercedes Benz CLK320, driven by a 34-year-old off-duty police officer, was traveling southbound on U.S. Route 1 through the city of Linden in Union County, New Jersey. The vehicle was traveling in the right lane of a six-lane divided highway. The weather was clear, and the roadway was dry, except for a puddle of water adjacent to a service station on the west side of the roadway. Near milepost 41.4, the Mercedes, traveling 48 to 62 mph, hit the curb on the west side of the road and swerved to the left. The Mercedes crossed the other two southbound lanes; mounted and crossed an 11.5-foot-wide, 6-inch-high raised concrete curb median; and entered the northbound lanes, where it collided head on with a 1986 Ford Taurus traveling in the left northbound lane. The Mercedes rolled up and over the Ford and landed on its roof. The Mercedes slid approximately 80 feet across the northbound lanes and struck a wooden utility pole next to the east side of the roadway, where it came to rest straddling the right northbound lane and the grassy area to the east of the roadway. Following the collision, the Ford remained upright, rotated about 163 degrees counterclockwise, and slid about 50 feet, where it came to rest in the right northbound lane. The Ford was occupied by a 33-year-old driver and four passengers ranging in age from 18 to 31. The drivers of both vehicles and three of the four Ford Taurus passengers died at the scene. The fourth Ford passenger died several hours later in a hospital.

Major safety issues identified in this report are alcohol impairment, speed enforcement, and evaluative criteria for median barrier installation. As a result of its investigation, the Safety Board makes safety recommendations to the Federal Highway Administration, the city of Linden, and the American Association of State Highway and Transportation Officials. The Safety Board also reiterates a previously issued recommendation to the State of New Jersey.

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.

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Contents

Acronyms and Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
ADT	average daily traffic
AERF	Alcohol Education and Rehabilitation Fund
ASOS	Automated Surface Observing System
ATTF	Auto Theft Task Force
BAC	blood alcohol concentration
CAMI	Civil Aeromedical Institute
DOT	U.S. Department of Transportation
DWI	driving while impaired/intoxicated
FARS	Fatality Analysis Reporting System
FHWA	Federal Highway Administration
Green Book	*A Policy on Geometric Design of Highways and Streets*
IDRC	Intoxicated Driver Resource Center
I-278	Interstate 278
LPD	Linden Police Department
MP	milepost
NHS	National Highway System
NHTSA	National Highway Traffic Safety Administration
NIAAA	National Institute on Alcohol Abuse and Alcoholism
NJDOT	New Jersey Department of Transportation
U.S. 1	U.S. Route 1

Executive Summary

On May 1, 2003, about 2:11 a.m., eastern daylight time, a 1998 Mercedes Benz CLK320, driven by a 34-year-old off-duty police officer, was traveling southbound on U.S. Route 1 through the city of Linden in Union County, New Jersey. The vehicle was traveling in the right lane of a six-lane divided highway. The weather was clear, and the roadway was dry, except for a puddle of water adjacent to a service station on the west side of the roadway.

Near milepost 41.4, the Mercedes, traveling 48 to 62 mph, hit the curb on the west side of the road and swerved to the left. The Mercedes crossed the other two southbound lanes; mounted and crossed an 11.5-foot-wide, 6-inch-high raised concrete curb median; and entered the northbound lanes, where it collided head on with a 1986 Ford Taurus traveling in the left northbound lane. The Mercedes rolled up and over the Ford and landed on its roof. The Mercedes slid approximately 80 feet across the northbound lanes and struck a wooden utility pole next to the east side of the roadway, where it came to rest straddling the right northbound lane and the grassy area to the east of the roadway. Following the collision, the Ford remained upright, rotated about 163 degrees counterclockwise, and slid about 50 feet, where it came to rest in the right northbound lane.

The Ford was occupied by a 33-year-old driver and four passengers ranging in age from 18 to 31. The drivers of both vehicles and three of the four Ford Taurus passengers died at the scene. The fourth Ford passenger died several hours later in a hospital.

The National Transportation Safety Board determines that the probable cause of this accident was the Mercedes driver's loss of control of the vehicle due to alcohol impairment. Contributing to the severity of the accident were the lack of barriers separating traffic in the northbound and southbound traffic lanes and the failure of the Mercedes driver to wear his seat belt.

Major safety issues identified in this accident are alcohol impairment, speed enforcement, and evaluative criteria for median barrier installation. As a result of this accident, the Safety Board makes safety recommendations to the Federal Highway Administration, the city of Linden, and the American Association of State Highway and Transportation Officials. The Safety Board also reiterates a recommendation to the State of New Jersey.

Factual Information

Accident Narrative

On May 1, 2003, about 2:11 a.m., eastern daylight time, a 1998 Mercedes Benz CLK320 (Mercedes), driven by a 34-year-old off-duty police officer, was traveling southbound on U.S. Route 1 (U.S. 1) through the city of Linden in Union County, New Jersey. The vehicle was in the right lane of a six-lane divided highway. The weather was clear, and the roadway was dry, except for a puddle of water adjacent to a service station on the west side of the roadway.

Near milepost (MP) 41.4, the Mercedes, traveling 48 to 62 mph,[1] hit the curb on the west side of the road and swerved to the left. The Mercedes crossed the other two southbound lanes; mounted and crossed an 11.5-foot-wide, 6-inch-high raised concrete curb median; and entered the northbound lanes, where it collided head on with a 1986 Ford Taurus (Ford) traveling in the left northbound lane. The Mercedes rolled up and over the Ford and landed on its roof. The Mercedes slid approximately 80 feet across the northbound lanes and struck a wooden utility pole next to the east side of the roadway, where it came to rest straddling the right northbound lane and the grassy area to the east of the roadway. Following the collision, the Ford remained upright, rotated about 163 degrees counterclockwise, and slid about 50 feet, where it came to rest in the right northbound lane. (See figure 1.)

The Ford was occupied by a 33-year-old driver and four passengers ranging in age from 20 to 31, who were returning home from work at a local restaurant. The drivers of both vehicles and three of the four Ford passengers died at the scene. The fourth Ford passenger died several hours later in a hospital.

Preaccident Events

On Monday evening, April 28, the driver of the Mercedes played in a softball game that ended at about 9:00 p.m.[2] According to the driver's brother, he remained at the softball field for about an hour following the game and then went to his girlfriend's house. The driver's girlfriend said the driver left her residence at 2:00 a.m. and then called her at 2:15 a.m. on Tuesday, April 29, from his residence.

[1] The vehicle's speed was calculated based on the roadway pavement surface, pavement age, and roadway usage. Additional information on speed calculation is contained in the "Analysis" section of this report.

[2] Information detailing the activities of the Mercedes driver before the accident was obtained from interviews conducted with family members, the driver's supervisor, softball teammates, and a friend.

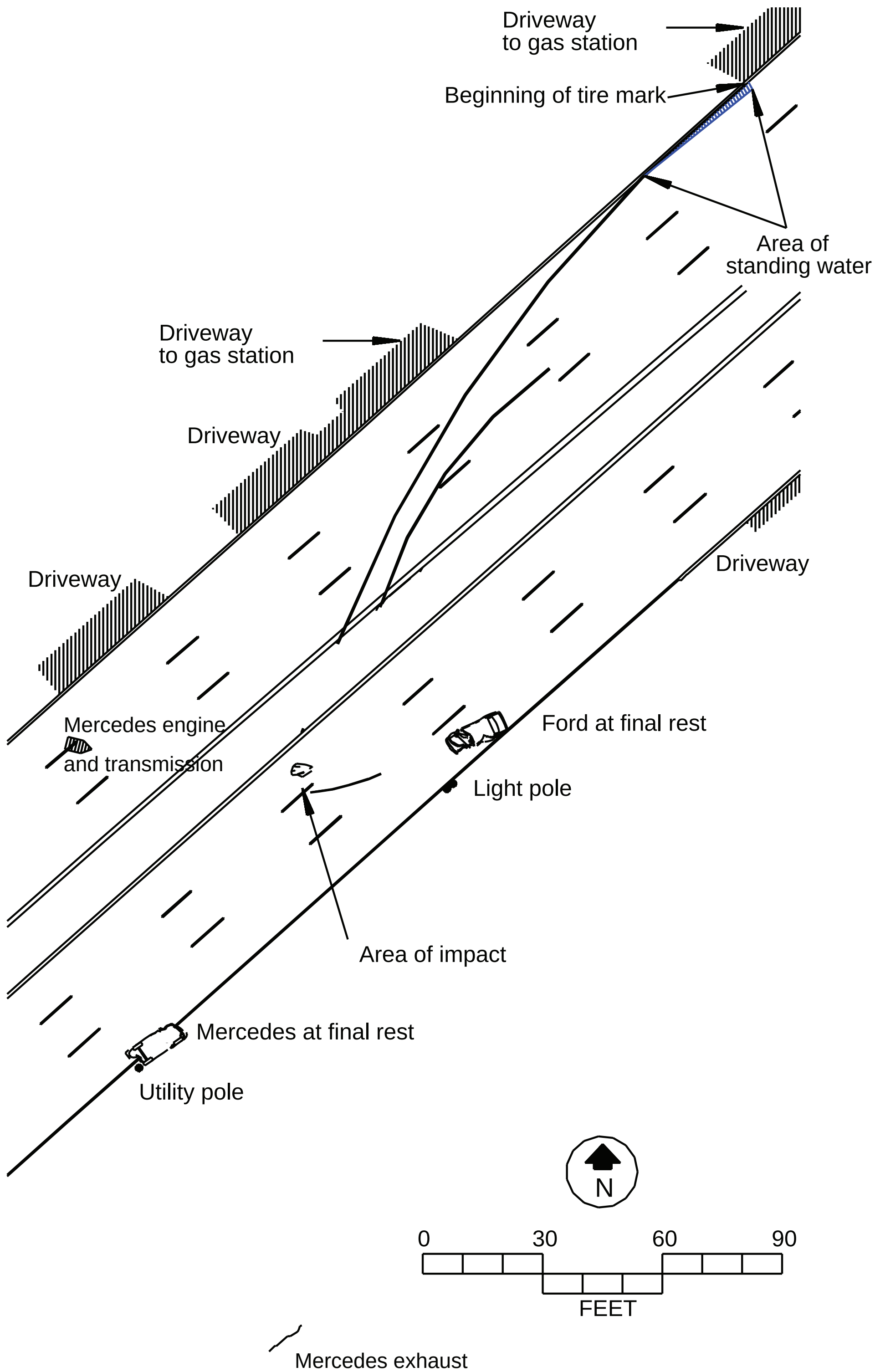

Figure 1. Linden, New Jersey, accident scene.

According to his family, the Mercedes driver had originally been scheduled to work his assigned shift from 8:00 p.m. to 6:00 a.m. at the Union/Essex Auto Theft Task Force (ATTF)[3] on Tuesday, April 29, and Wednesday, April 30, but took the days off from work to replace or repair a damaged contact lens. The driver's girlfriend said he visited her at her workplace during the day on Tuesday and left about 5:30 p.m. to run some errands. His family said he stayed overnight Tuesday night at a friend's house.

On Wednesday, April 30, the Mercedes driver's sister-in-law said she saw the driver at home sometime in the morning, as she was leaving to run errands, and again at 3:00 p.m., when she returned home. At 6:30 p.m., the driver and his brother left in separate cars for a softball game. Before arriving at the game, the Mercedes driver stopped at a local bar and bought a round of drinks for the bar; the bartender/manager stated that the driver did not drink at this time. The Mercedes driver played in a softball game that began about 7:30 p.m. and ended about 9:30 p.m. Following the game, he stayed at the field with several teammates. Although some team members said that they drank beer after the game, none said that they remembered seeing the driver consuming alcohol. The bartender/manager said the driver returned to the local bar between 11:00 p.m. and midnight but was not sure whether the driver had any alcohol during this visit.

About 2:00 a.m. Thursday morning, May 1, the Mercedes driver left the bar and was driving toward U.S. 1, when he met a friend. The Mercedes driver and his friend stopped to talk; they were about 850 feet from the bar. The friend said the driver did not appear intoxicated and that the driver told him he was heading home. The driver traveled about 3.35 miles before the accident occurred at 2:11 a.m. Figure 2 shows the location of the accident site, the driver's home, the softball field, and the local bar visited by the Mercedes driver; table 1 provides approximate distances between locations.

[3] Essex and Union County police officers rotate into the task force for 30 to 60 days and then return to normal duty.

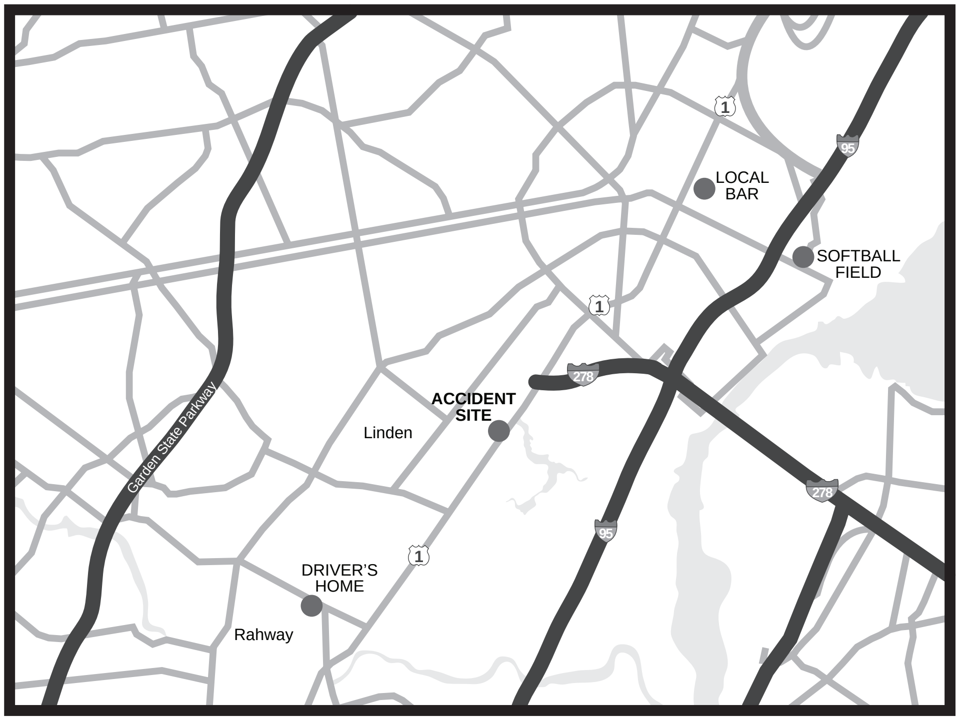

Figure 2. Locations of interest.

Table 1. Approximate distances between locations of interest.

From	To	Distance
Driver's home	Softball field	7.44 miles
Softball field	Local bar	1.44 miles
Local bar	Accident site	3.35 miles
Accident site	Driver's home	2.79 miles
Local bar	Driver's home	6.14 miles

Injuries

According to the Union County Medical Examiner, the 34-year-old driver of the Mercedes died from multiple blunt-force injuries. The driver sustained blunt-force trauma to the head, chest, abdomen, and lower-left extremity. He was partially ejected from the vehicle.

All four occupants of the Ford were fatally injured. The 33-year-old male driver of the Ford died of multiple blunt-force injuries to his head, blunt-force trauma to his chest and abdomen, and fractures to his left arm and leg. The 20-year-old female front-seat passenger sustained injuries to her head, chest, and abdomen. The left-rear passenger was a 31-year-old male, who sustained blunt-force trauma to his head, neck, and abdomen and fractures to his ribs, arms, and legs. The 20-year-old male seated in the center-rear seat sustained blunt-force trauma to the neck and face. The 22-year-old male right-rear passenger was transported to the hospital, where he was pronounced dead approximately 3.5 hours after the accident. He sustained multiple blunt-force trauma injuries to the head, chest, abdomen, and lower extremities.

Table 2 is based on the International Civil Aviation Organization's injury criteria, which the National Transportation Safety Board uses in accident investigation reports.

Table 2. Injuries.*

Injury type	Drivers	Passengers	Others	Total
Fatal	2	4	0	6
Serious	0	0	0	0
Minor	0	0	0	0
None	0	0	0	0
Total	2	4	0	6

*Title 49 *Code of Federal Regulations* Part 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.

Emergency Response and Survival Aspects

The Linden Fire Department arrived at the accident scene at 2:15 a.m. At 2:19 a.m., the Rahway Volunteer Ambulance responded to the scene and transported a Ford passenger to the University of Medicine and Dentistry of New Jersey, Newark campus.

The Mercedes sustained extensive contact damage to the right front and left rear of the vehicle. The driver's seat was equipped with a three-point restraint system, which was found in the retracted position. When extended, the belt webbing was clean and without visible evidence of loading. Dirt was found within the driver's seat belt latchplate and latchplate receiver. Dirt was also found within the occupant compartment, which investigating law enforcement personnel believed to have entered the vehicle during the rollover. The driver-side air bag deployed.

Restraint usage for the driver and the four passengers of the Ford is unknown; lap/shoulder belts were available at four seating locations, and a lap belt was available at the rear-center seat. The Ford did not have air bags.

Toxicological Information

The New Jersey State Toxicology Laboratory and, at the request of the National Transportation Safety Board, the Federal Aviation Administration's Civil Aeromedical

Institute (CAMI), conducted toxicological testing on the driver of the Mercedes. Two samples were collected from the driver postmortem by the Union County Medical Examiner and transferred to the New Jersey State Toxicology Laboratory and CAMI, which reported, respectively, blood alcohol concentrations (BACs) of 0.351 and 0.326.[4] (See table 3 for test results.) In New Jersey, drivers with a BAC of 0.08 or greater are considered impaired.

Table 3. Toxicological information for the Mercedes driver.

	New Jersey State Toxicology Laboratory	CAMI
Blood	Ethanol (alcohol), 0.351 percent; pseudoephedrine, 0.27 mg/L.	Ethanol (alcohol), 326 mg/dlL, mg/hg (0.326 percent); pseudoephedrine detected.
Urine	None of tested drugs detected.[a]	Ethanol (alcohol),379 mg/dL, mg/hg (0.379 percent); acetaldehyde, 8 mg/dL, mg/hg.
Vitreous humor	Ethanol (alcohol), 0.268 percent.	Ethanol (alcohol), 210 mg/dL, mg/hg (0.210 percent); acetaldehyde,1 mg/dL, mg/hg.
Brain	Ethanol (alcohol), 0.287 percent.	Not tested.
Liver	Pseudoephedrine, 11.0 mg/kg.	Not tested.
Stomach content[b]	Ethanol (alcohol), 0.680 percent; pseudoephedrine, 110 mg/kg; pill containing phenmetrazine.	Fexofenandine, in a brown tablet marked “Allegra D”; pseudoephedrine, in a brown tablet marked “Allegra D.”
Nasal swab	None of tested drugs[c] detected.	Not tested.

[a]Tested for barbiturates, benzodiazepines, cannabinoids, cocaine metabolites, methadone, opiates, phencyclidine (PCP), phenytoin, propoxyphene, and TCAntidepressants.

[b]The Union County Medical Examiner found two tablets marked “Allegra” in the driver’s stomach.

[c]Tested for cocaine metabolites and opiates.

Toxicological tests for the driver of the Ford, conducted by the New Jersey State Toxicology Laboratory, were negative for alcohol and illicit drugs.

Physical Evidence

Safety Board investigators observed multiple tire scuff marks and scrapes along both the vertical and horizontal faces of the concrete curb on the southbound side of the median.[5] An additional tire scuff mark and scrape were noted on the top of the concrete curb adjacent to the northbound side of the roadway. The diagonal distance between the

[4] Differences in testing equipment, specimens, or procedures could account for the discrepant results. This report uses the more conservative BAC of 0.326 reported by CAMI.

[5] The Linden Police Department (LPD) documented two tire marks in the southbound lanes of the roadway, which were not visible when Safety Board investigators arrived at the accident location because, before the roadway reopened, a motorized street sweeper had cleaned the area. The Safety Board incorporated the evidence previously mapped by the LPD on May 1 into its documents. Assisted by the LPD, Safety Board investigators electronically mapped additional points at the accident location on May 4.

last tire scuff mark on the southbound side of the median and the tire scuff mark adjacent to the northbound side of the median was about 23 feet.

During its investigation, the LPD observed a puddle of water adjacent to the north driveway of the gas station that was not present when Safety Board investigators arrived at the accident location. Using LPD postaccident photographs,[6] Safety Board investigators estimated that the area of water extended from a point about 1 foot north of the curb of the gas station's driveway to an area about 34 feet south of the curb. (See figure 1.) A drop inlet[7] was located north of the puddle. The water was primarily contained along the west curb of the driveway. At the driveway, the water extended about 2 to 3 feet into the right southbound lane and tapered off toward the curb as it transitioned to the south. The water's depth was not measured. The puddle may have resulted from a hosing down of the gas station driveway by an attendant before the accident. The puddle that appeared in postaccident photographs may have been larger than the one encountered by the Mercedes driver due to rainfall or water applied by fire and rescue equipment. In addition, Safety Board investigators noted one scar at the nose of the driveway curb and another that started about 3 feet south of the first one. Both scars were adjacent to the tire mark produced by the Mercedes as it struck the curb and veered across the two southbound lanes.

Driver Information

General

The driver of the Mercedes was a 34-year-old male. At the time of the accident, the driver held a valid class "D" New Jersey driver's license with no endorsements and a corrective lenses restriction. The National Driver Register showed no current or pending suspensions for the Mercedes driver. The driver's motor vehicle history showed three accident reports (July 9, 1988; July 25, 1993; and July 31, 1993), a report of consuming alcoholic beverages as a passenger in a motor vehicle (November 26, 1993), and failure to appear for unpaid parking tickets (April 16, 1995).

The Mercedes driver was a Union County police officer. About 3 weeks before the accident, the Mercedes driver had been assigned to the ATTF. He had been driving for about 1 week with the ATTF since completing his training. The driver's supervisor described the driver as being "very sharp" and characterized his attitude as "positive" and "upbeat." The supervisor did not know whether the driver was experiencing personal problems.

The driver's family said that the driver was in "good health." The family further noted that the driver suffered from allergies but did not know whether he was taking medication. The family indicated that the driver did not regularly take prescription or over-the-counter

[6] Since the original photographs did not allow for sufficient examination of the scene details, the brightness and contrast of the photographs were digitally enhanced.

[7] A *drop inlet* is a heavy steel grid or grate flush with the roadway's surface. Located at a low point along the road, it is intended to collect and drain storm water from the roadway surface.

drugs, did not smoke, and only drank "socially" (with his brother, on weekends, or when not working). The family said the driver was "upbeat" and described him as "strictly business on duty, focused on friends when off duty." According to medical records, the driver had a left knee injury in 2000 and a right knee injury in 2002. His 1998 preemployment physical showed that he had 20/20 vision in his right eye and 20/30 vision in his left eye when wearing contacts. The preemployment physical also indicated he had no hearing problems.

Awake/Asleep Schedule

Information on the Mercedes driver's sleep schedule for the 72 hours before the accident, developed from interviews conducted with members of his family, his supervisor, softball teammates, and friends, is shown in figure 3. During this period, the Mercedes driver slept for at least 17 hours; the driver's sleep activities the day before the accident are unknown.

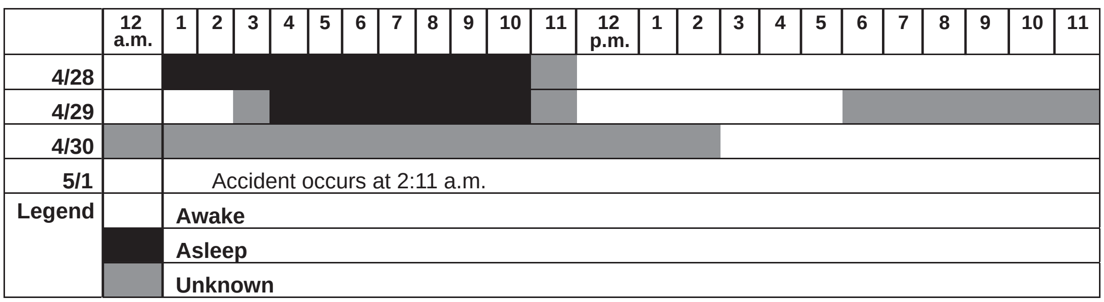

Figure 3. Mercedes driver's awake/asleep schedule.

Vehicle and Wreckage Information

Mercedes Benz CLK320

The 1998 Mercedes Benz CLK320 coupe, 2-door model, was 180 inches long, 68 inches wide, and 54 inches tall, and had a curb weight[8] of 3,240 pounds. The Mercedes had a manual 5-speed transmission. It did not have event-recording capabilities.

The vehicle sustained extensive contact damage, which was concentrated in the right front and left rear of the vehicle (see figures 4 and 5). The right-front body panels and hood had been crushed diagonally in the direction of the vehicle's left rear. An indentation matching the shape and dimension of the Ford's A-pillar[9] was located on the side of the right-front fender, about 1 foot forward from the Mercedes' firewall. The hood had fully opened and had been

[8] Refers to the weight of a vehicle without passengers or cargo but including all fluids (oil, gas, and coolant) and equipment specified as standard.

[9] A slender vertical structure supporting an automobile's roof. The A-pillar is located on both sides of the windshield; the B-pillar is located between the front and rear windows; and the C-pillar is located on both sides of the trunk.

Figure 4. 1998 Mercedes Benz CLK320.

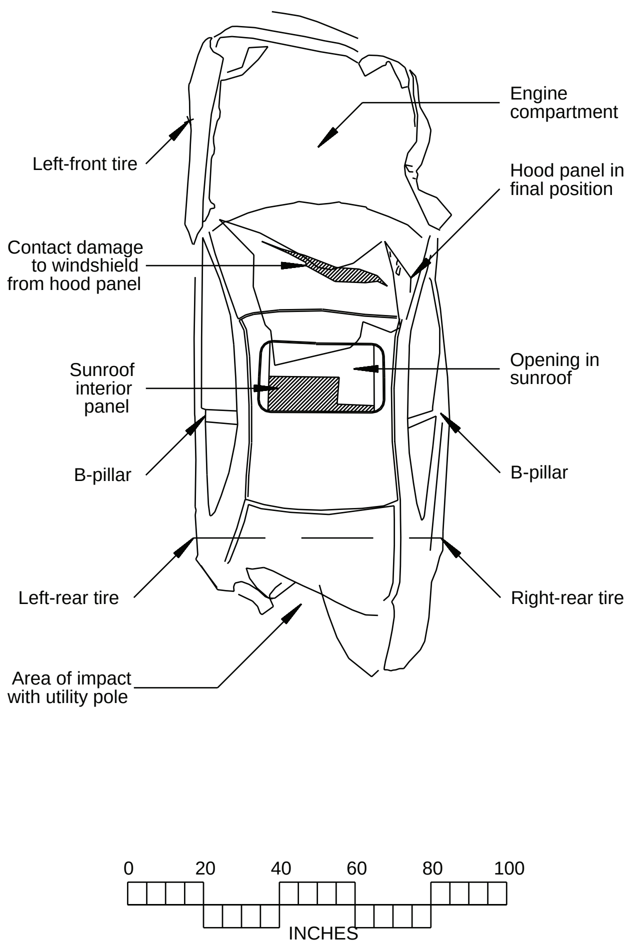

Figure 5. Crash profile of 1998 Mercedes Benz CLK320.

driven into the windshield. The impact to the left rear of the vehicle resulted from the subsequent collision with a wooden utility pole. The contact damage was semicircular in shape and extended about 2 feet into the trunk. In addition to the heavy contact damage, the roof of the Mercedes sustained some deformation, scrapes, and multiple scratches.

During the accident sequence, the right-front wheel and related suspension components became detached from the vehicle. The vehicle's engine and transmission became detached, as well, and were found in the southbound lanes approximately 77 feet from the Mercedes' final resting place. The exhaust system also became detached and was found approximately 92 feet from the Mercedes in the northbound lanes. Postaccident examination of the Mercedes detected no mechanical deficiencies.

Ford Taurus

The 1986 Ford Taurus, 4-door model, with automatic transmission, was 189 inches long, 71 inches wide, and 54 inches high, and had a curb weight of 2,865 pounds. Postaccident examination of the Ford detected no mechanical deficiencies.

Contact damage to the Ford was observed along the left side of the vehicle beginning on the left side of the front grill assembly (see figures 6 and 7). Additionally, the radiator core support was pushed in, and components on the top and left side of the engine also received contact damage. The most substantial impact to the left front was in the area of the wheel assembly. The entire left-front tire had been displaced rearward about 2 feet, and the wheel assembly had a circumferential indentation resulting from contact.

Figure 6. 1986 Ford Taurus.

The contact damage along the left side extended across both doors and terminated just forward of the left-rear wheel. Deformation to the A-pillar was semicircular and directed inward toward the passenger compartment of the vehicle. The leading edge of the roof panel was pushed rearward and crushed down into the passenger compartment. The steering wheel received substantial deformation damage, and the steering column was fractured. In addition to the contact damage from the accident, the vehicle had extensive damage and other contact damage resulting from extrication efforts.

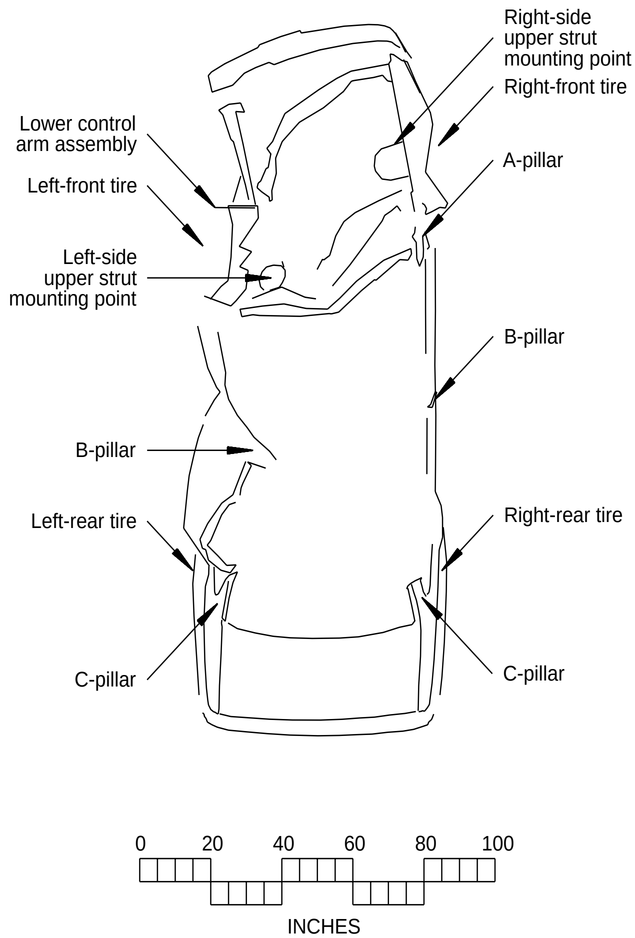

Figure 7. Crash profile of Ford Taurus.

Highway Information

Design

The accident occurred on U.S. 1 near MP 41.4 in the city of Linden, Union County, New Jersey. This section of U.S. 1 is a divided, two-way, six-lane asphalt-paved roadway (three lanes designated for northbound traffic and three lanes designated for southbound traffic), extending in a northeast/southwest direction. Slightly north of the accident site, the southbound lanes transitioned from four lanes to three.

White retroreflective lane lines mark the individual travel lanes. The left edges of the northbound and southbound travel lanes are marked with solid, yellow, retroreflective edge lines delineating the median boundaries. The width between the yellow line in the northbound travel lane to the yellow line in the southbound travel lane is 13.5 feet. Roadway dimensions are provided in table 4.

Table 4. U.S. 1 lane width (measured near MP 41.4).

	Left lane	**Center lane**	**Right lane**
Northbound	10.23 feet	10.45 feet	12.35 feet
Southbound	14.48 feet	11.77 feet	12.50 feet

The northbound and southbound lanes are divided by an 11.5-foot-wide raised median with 6-inch-high Portland cement concrete curbing. (See figure 8.) The median is backfilled with asphaltic concrete. The distance from the face of the vertical curb wall to the yellow edge lines is 1 foot. The cross section consists of a curb and gutter.

Figure 8. Raised curbed median near accident location.

There was no median barrier at the accident site. A New Jersey-type median barrier[10] begins about 200 feet north of the accident site and continues north toward the Interstate 278 (I-278) interchange. This barrier was installed during the construction of the I-278 interchange in the late 1960s. Another median barrier was installed south of the accident location beginning at MP 39.4 in the town of Rahway. Black tire rubber smears and metallic scrapes were found on both median barriers during the Safety Board's

[10] Refers to a barrier wall cross section developed by the State of New Jersey for use on its facilities. Widely used in the United States and other countries for median and roadside barriers, it is commonly referred to as a *New Jersey barrier*.

investigation. The segment of U.S. 1 that passes through the city of Linden is the only segment of U.S. 1 without a median barrier from Newark Airport to the Garden State Parkway, a distance of about 11 miles. The New Jersey Department of Transportation (NJDOT) offered a number of possible reasons for the lack of a median barrier at the accident site: the segment's straightness, the difficulty in safely terminating the segment's barrier ends, and the lack of recent reconstruction projects in the area.

Roadway Classification

The NJDOT describes the accident segment of U.S. 1 as a "land service highway."[11] It is also a part of the Federal Highway Administration's (FHWA's) National Highway System (NHS).[12]

Construction

The NJDOT built the accident segment of U.S. 1 in 1960. NJDOT records indicate a gradual upgrading of the original roadway through a sequence of reconstruction projects; the last project completed was one for pavement rehabilitation in September 1991. Several reconstruction projects involved changes to the median islands.

Speed Limit

According to the construction plans, the design speed for the accident segment of U.S. 1 was 45 mph. The posted speed limit is 40 mph; 40-mph signs[13] were placed on both the northbound (near MP 41.2) and southbound (near MP 41.6) approaches to the accident area.

Other than a 1965 NJDOT memorandum authorizing the 40-mph speed limit, the NJDOT had no records regarding speed limits on U.S. 1 in the city of Linden or any record indicating that a speed survey had ever been conducted in that area. The month after the accident, Safety Board investigators recorded the speeds of 102 vehicles on U.S 1, MP 41.4, from 9:45 p.m. to 12:15 a.m. The 85th percentile speed was 72 mph, and the median speed was 62 mph. Of the 102 vehicles measured, only 2 were traveling at or below the posted speed limit and 6 were measured to be traveling at speeds of 80 mph or greater, more than twice the speed limit. Seventy percent of the vehicles were traveling between 50 and 70 mph. At the request of the Safety Board, the NJDOT conducted two spot-speed studies near the accident location. Those studies, conducted during daytime hours for northbound vehicles only, yielded 85th percentile speeds of 58 mph and 52 mph.

Traffic signals along the entire accident segment of U.S. 1 are coordinated with a progression speed of 40 mph. In areas where traffic signal frequency is high, running

[11] An arterial or collector highway on which access to abutting property is permitted. On arterial highways and major collector roads, such access is usually regulated to protect the public safety and maintain the efficiency of the highways.

[12] The NHS comprises approximately 160,000 miles of roadway important to the Nation's economy, defense, and mobility.

[13] U.S. Department of Transportation (DOT), Federal Highway Administration, *Manual on Uniform Traffic Control Devices,* Section 2B-10, Speed Limit Sign (R2-1) (Washington, DC: FHWA, 2003).

speeds are consistent with the posted and signal progression speeds. Vehicles traveling southbound on U.S. 1 encounter a traffic signal 1/2 mile north of the accident location. The next signal is a "stop and go" signal slightly less than a 1/2 mile south of the accident location. Thus, vehicles can travel approximately 1 mile without encountering a traffic signal. Additionally, traffic from I-278 exits onto U.S. 1 just before the signal north of the accident location. The speed limit on I-278 is 50 mph.

LPD officials noted that they were aware of the high frequency of speeding on U.S. 1 in the vicinity of the accident but had not conducted directed speed limit enforcement there because of limited resources.[14] The LPD was unable to provide the number of traffic citations issued on U.S. 1 because the department's database could not accommodate such a query.

Lighting

During nighttime hours, artificial lighting illuminated the roadway. Thirteen overhead streetlights were located in the vicinity of the accident: seven on the eastern right-of-way and six on the western right-of-way. During the on-scene investigation, none of the lights on the west (southbound side) of the roadway were working, and three of the seven lights on the east (northbound side) of the roadway were working. The gas station located on the western right-of-way provided additional lighting. According to NJDOT officials, on State routes, the local power company maintains street lighting mounted on timber poles.

Average Daily Traffic Count on U.S. 1

Over the course of a year, the NJDOT conducts traffic counts at 1,000 selected sample sites on all types of public roads for a 48-hour period. In 2003, the average daily traffic (ADT) count at MP 41.85 of U.S. 1 was 69,635. Table 5 shows ADT counts for 1998 through 2003.

Table 5. Average daily traffic counts for U.S. 1 between MPs 41 and 42.

Year	Count	Distance from accident location
2003	69,635	0.45 mile north
2002	66,238	0.05 mile south
2001	50,531	0.66 mile south
2000	Not available	—
1999	82,014	0.45 mile north
1998	48,836	0.25 mile south

Accident History

Table 6 presents the accident history for U.S. 1 between MPs 41 and 42.[15] In 2001, one nonfatal median crossover accident occurred on U.S. 1 near the accident location. A review of LPD reports revealed that of the fatal accidents that occurred on U.S. 1 in Linden from 2000 through 2003, only the accident discussed in this report involved a median

[14] As of August 18, 2005, the LPD consisted of some 136 officers. The patrol division is responsible for traffic law enforcement.

[15] NJDOT Crash Records and Statistics <www.nj.gov/transportation/refdata/accident>.

crossover. The 2003 accident rate for the accident segment of U.S. 1 was 2.25 per 1 million vehicle miles driven, as compared to the Statewide accident rate for that period of 3.73 per 1 million vehicle miles driven on urban arterials with four or more lanes and raised medians.

Table 6. Accident Information for U.S. 1 between MPs 41 and 42.

Year	Total accidents	Fatal	Injury	Property damage
2003	154	2	53	99
2002	144	2	44	98
2001	147	1	56	90
2000	192	1	62	129

Inspection of the Linden segment of U.S. 1 revealed little or no evidence of vehicle incursions on the barrier curb faces or on the asphaltic concrete backfill forming the median.[16] There was evidence of run-off-the-road events.

Meteorology

The Newark Automated Surface Observing System (ASOS) is located approximately 6 miles northeast of Linden, and the Somerville ASOS is about 22 miles west of Linden. Neither station reported the presence of rain, mist, or fog during the 24 hours before the accident.

Other Information

Pavement Friction Tests

Skid resistance tests were conducted at the accident location to determine the pavement friction on the northbound and southbound travel lanes of U.S. 1 between MPs 41.3 and 41.9.[17] A trailer-mounted friction-testing device was towed behind a vehicle in each of the three northbound and southbound dry traffic lanes.[18] Southbound lanes had an average skid number of 78, and northbound lanes had an average skid number of 80.[19]

[16] Such evidence would include tire rubber scrub marks on the vertical faces of median curbs and tire marks on the median's top surface.

[17] Skid resistance tests were conducted on May 4, 2003, by NJDOT personnel from the Pavement Management Division in Trenton.

[18] American Society for Testing and Materials standard E274-97 utilizes a measurement representing the steady-state friction force on a locked test wheel as it is dragged over a wetted pavement surface under constant load and at a constant speed while its major plane is parallel to its direction of motion and perpendicular to the pavement. Because it was known the accident occurred on a dry roadway, a dry surface was tested.

[19] A *skid number r*epresents the frictional properties of the pavement. These numbers are used to evaluate the skid resistance of the pavement relative to other pavements and/or to evaluate the change in skid resistance of the pavement with time. Skid numbers of 78 and 80 are considered high, indicative of new pavement in good condition.

Video Surveillance Tape and Logs From Gas Station

The gas station located on the western right-of-way operated 24 hours per day. The gas station had a surveillance system consisting of four cameras, a multiplexer, and a recorder. One of the cameras was positioned so as to capture a partial view of U.S. 1. No imagery of the accident sequence or potential witness vehicles could be identified.

The gas station logs record all sales and significant events, such as safe drops, vendor payouts, and driveaways. The logs show no activity between 1:33 a.m. and 5:28 a.m. on May 1, 2003.

Alcohol Impairment

After alcohol is consumed, it passes from the stomach and the intestines into the blood.[20] The alcohol is then metabolized.[21] Most of the alcohol consumed is metabolized in the liver; however, a small amount of alcohol escapes metabolism and is excreted in the breath and urine. Until all of the alcohol is metabolized, it is distributed throughout the body, affecting the brain and other tissues. The liver can metabolize only a certain amount of alcohol per hour, regardless of the amount that has been consumed. Alcohol is metabolized more slowly than it is absorbed;[22] therefore, consumption must be controlled to prevent accumulation in the body and intoxication. In general, after the consumption of one standard drink,[23] the amount of alcohol in the drinker's blood (BAC) peaks within 30 to 45 minutes.[24]

Reductions in attention, judgment, and control can be observed at a BAC as low as 0.02, and many individuals with a BAC of 0.25 or greater experience confusion, vomiting, loss of consciousness, and even death.[25,26] Driving performance is substantially impaired in almost everyone at BACs of 0.08 or greater, but impaired driving behaviors can be seen at lower BACs.[27,28]

Fatality Analysis Reporting System (FARS) data show that, in 2004, 58,156 drivers were involved in fatal accidents on U.S. roadways. About 25 percent (14,259) of those drivers had a BAC greater than 0.01. Specifically, 2,264 drivers involved in fatal accidents (3.9 percent) had a BAC between 0.01 and 0.07; 4,062 drivers (7.0 percent)

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[20] This process is referred to as *absorption*.

[21] *Metabolism* occurs when the body converts ingested substances to other compounds. Metabolism involves a number of processes, one of which is *oxidation*. Through oxidation, alcohol is detoxified and removed from the blood, preventing the alcohol from accumulating and destroying cells and organs.

[22] Several factors influence alcohol absorption, including gender and the presence of food in the stomach.

[23] A standard drink is defined as 12 ounces of beer, 5 ounces of wine, or 1.5 ounces of 80-proof distilled spirits, all of which contain 1 ounce of alcohol.

[24] National Institutes of Health, National Institute on Alcohol Abuse and Alcoholism (NIAAA), *Alcohol Metabolism,* Alcohol Alert No. 35, PH 371 (Washington, DC: NIAAA, 1997).

[25] K.M. Dubowski, *Acute Alcohol Influence*, National Commission Against Drunk Driving (Washington, DC: NHTSA, 1997).

[26] National Highway Traffic Safety Administration, *The ABCs of BAC, A Guide to Understanding Blood Alcohol Concentration and Alcohol Impairment*, DOT HS 809 844 (Washington, DC: NHTSA, 2005).

[27] H. Moskowitz and D. Fiorentino, *A Review of the Literature on the Effects of Low Doses of Alcohol on Driving-Related Skills* (Washington, DC: NHTSA, 2000).

[28] DOT HS 809 844.

had a BAC between 0.08 and 0.14; 7,195 drivers (12.4 percent) had a BAC between 0.15 and 0.29; and 737 drivers (1.3 percent) had a BAC greater than 0.30 (see figure 9).[29]

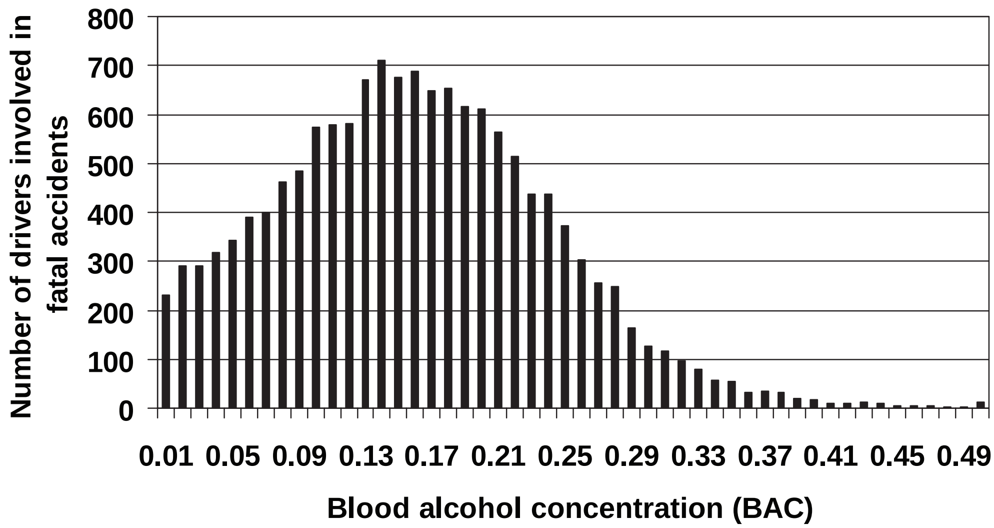

Figure 9. BACs of drivers involved in fatal accidents (FARS 2004).

Drivers With High BACs. In 2000, the Safety Board released a report on the hard core drinking driver.[30] In its report, the Safety Board defined a hard core drinking driver as a repeat offender (that is, an offender with more than one conviction or arrest for driving while impaired/intoxicated [DWI] within the past 10 years) or a high BAC offender (BAC of 0.15 or greater).

Although impairment from alcohol is pronounced in most individuals at a BAC of 0.15 or greater, some can function and even drive a vehicle at higher BAC levels.[31] In a study[32] of 81 drinking drivers in Sweden with high BACs (BAC greater than or equal to 0.400), it was concluded that attempting to drive a motor vehicle with a high BAC indicates "an exceptionally high cellular tolerance to the impairment caused by this drug. The alcohol burn-off rate was relatively high in these heavy drinkers (0.023 percent per hour),[33] which probably reflects the development of metabolic tolerance as well."

[29] Numbers and percentages were calculated using imputed data.

[30] National Transportation Safety Board, *Actions to Reduce Fatalities, Injuries, and Crashes Involving the Hard Core Drinking Driver*, Safety Report NTSB/SR-00/01 (Washington, DC: NTSB, 2000).

[31] DOT HS 809 844.

[32] A.W. Jones, "The Drunkest Drinking Driver in Sweden: Blood Alcohol Concentration 0.545 Percent w/v.," *Journal of Studies on Alcohol,* Vol. 60, No. 3 (1999): 400-06. (Abstract only.)

[33] According to the National Highway Traffic Safety Administration (NHTSA), the average metabolism rate for moderate drinkers produces a 0.017 per hour decline in BAC level. For further information, see National Highway Traffic Safety Administration, *Computing a BAC Estimate* (Washington, DC: NHTSA, 1994) <www.nhtsa.gov/people/injury/alcohol/BACreport.html>.

Individuals who are able to function at high BAC levels, which in others would be incapacitating or even fatal, have very likely developed a tolerance to alcohol. Tolerance to alcohol can be displayed in two ways: the effect of a given dose of alcohol decreases as tolerance develops, and a greater dose of alcohol is required to produce a given effect. Consuming alcohol in the same environment or under the same cues can develop or accelerate alcohol tolerance.[34] Learned tolerance, where the repeated practice of a task in association with alcohol consumption leads to the development of tolerance, can reduce the alcohol-induced impairment that would ordinarily accompany the performance of that task.[35] However, the tolerance acquired in a certain environment or for a specific task is not readily transferred to new or different situations. A driver who has developed behavioral tolerance to driving a familiar car over a particular route under routine circumstances may drive without being involved in an accident despite the consumption of substantial amounts of alcohol. However, a driver who encounters a novel environment would be at the same elevated risk for an accident as a new driver with the same BAC because of the lack of prior learning opportunities for the new situation.[36]

Several studies show that the drivers with high BACs are at a greater risk of being involved in a fatal accident than zero-BAC drivers.[37] The 2000 Safety Board report cited research by the Insurance Institute for Highway Safety that estimated the relative fatality risk for drivers in single-vehicle accidents with high BACs to be 385 times that of a zero-BAC driver. The Traffic Injury Research Foundation estimated that high-BAC drivers were more than 200 times more likely to be involved in a fatal accident than a nondrinking driver.

NHTSA research shows that some impaired drivers may not be arrested or involved in an accident. NHTSA reports that "on average, a driver can drive [impaired] 5,000 miles before being arrested for a DUI [driving under the influence] offense."[38] Other research found that, on average, 1 arrest occurs per 88 episodes of driving over the legal limit and per 6 stops for suspicion of driving under the influence.[39] More recent research has shown that drivers with very high BACs were far more likely to be described as having histories suggestive of problem drinking than other fatally injured drivers; nonetheless, a substantial proportion were not described as having drinking histories.[40]

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[34] National Institutes of Health, National Institute on Alcohol Abuse and Alcoholism, *Alcohol and Tolerance,* Alcohol Alert No. 28, PH 356 (Washington, DC: NIAAA, 1995).

[35] National Institutes of Health, National Institute on Alcohol Abuse and Alcoholism, *Drinking and Driving,* Alcohol Alert No. 31, PH 362 (Washington, DC: NIAAA, 1996).

[36] Alcohol Alert No. 31.

[37] NTSB/SR-00/01.

[38] National Highway Traffic Safety Administration, *Alcohol and Highway Safety 1984: A Review of the State of the Knowledge* (Washington, DC: NHTSA, n.d.) 56.

[39] P. Zador, S. Krawchuck, and B. Moore, *Drinking and Driving Trips, Stops by Police, and Arrests: Analyses of the 1995 National Survey of Drinking and Driving Attitudes and Behavior,* DOT HS 809 184 (Washington, DC: NHTSA, 2001).

[40] S.P. Baker, E.R. Braver, L.H. Chen, G. Li, and A.F. Williams, "Drinking Histories of Fatally Injured Drivers," *Injury Prevention*, Vol. 8 (September 2002): 221-26.

The Safety Board concluded in its 2000 report[41] that the elevated accident risk and potential for recidivism of high-BAC (0.15 or greater) drivers constitute a safety problem that warrants State legislation to create a high-BAC "aggravated" alcohol offense. The Safety Board outlined a model program (see figure 10) to reduce hard core drinking driving that incorporates several elements, including vehicle sanctions to restrict or separate hard core drinking drivers from their vehicles, and frequent, well-publicized sobriety checkpoints. The Safety Board model program also recommends that the States pass legislation that defines a high BAC (0.15 or greater) as an "aggravated" DWI offense requiring strong intervention similar to that ordinarily prescribed for repeat DWI offenders.

State Laws. In all 50 States and the District of Columbia, a driver with a BAC level of 0.08 or greater is considered to be impaired. A majority of States have also established laws that reflect the need for additional penalties or countermeasures when drivers have BACs of 0.15 or greater.[42]

In New Jersey, effective January 20, 2004, a person with a BAC of 0.08 or greater who operates a vehicle is considered to be driving under the influence.[43] New Jersey's law pertaining to drivers with a 0.10 BAC, which was the legal limit before 2004, also remains in effect. Penalties for driving while impaired in New Jersey are shown in table 7.

[41] NTSB/SR-00/01.

[42] For higher BACs, the following States mandate education, assessment, and/or increased penalties or consider the BAC an aggravating factor: Arizona, Arkansas, California, Georgia, Indiana, Iowa, Louisiana, Maine, Missouri, Oklahoma, Rhode Island, South Carolina, Texas, Virginia, and Washington, for a BAC of 0.15; Alaska, Connecticut, Delaware, Illinois, Montana, Nebraska, New Hampshire, New Mexico, North Carolina, Pennsylvania, and Utah, for a BAC of 0.16; Ohio, South Dakota, and Wisconsin, for a BAC of 0.17; Kentucky, Nevada, and North Dakota, for a BAC of 0.18; and Colorado, District of Columbia, Florida, Idaho, Massachusetts, Minnesota, and Tennessee, for a BAC of 0.20. For further information, see the *Mothers Against Drunk Drivers (MADD)* Web site: <www3.madd.org/laws/law.cfm?LawID=HBAC>.

[43] The Department of Transportation Appropriation Act for fiscal year 2001 (H.R. 4475) included a provision that the States must enact 0.08 BAC per se laws by 2004 or begin losing Federal highway construction funds.

Model Program Elements

1. Frequent and well-publicized statewide sobriety checkpoints that include checking for valid driver's licenses. Checkpoints should not be limited to holiday periods. **[P]**
2. Vehicle sanctions to restrict or separate hard core drinking drivers from their vehicles, including license plate actions (impoundments, confiscation, or other actions); vehicle immobilization, impoundment, and forfeiture; and ignition interlocks for high-BAC first offenders and repeat offenders. **[P]**
3. State and community cooperative programs involving driver licensing agencies, law enforcement officers, judges, and probation officers to enforce DWI suspension and revocation. **[P]**
4. Legislation to require that DWI offenders who have been convicted or administratively adjudicated maintain a zero BAC while operating a motor vehicle. **[P]**
5. Legislation that defines a high BAC (0.15 or greater) as an "aggravated" DWI offense that requires strong intervention similar to that ordinarily prescribed for repeat DWI offenders. **[P]**
6. As alternatives to confinement, programs to reduce hard core drinking driver recidivism that include home detention with electronic monitoring and/or intensive probation supervision programs. **[S]**
7. Legislation that restricts the plea bargaining of a DWI offense to a lesser, non-alcohol-related offense and that requires the reasons for DWI charge reductions be entered into the public record. **[S]**
8. Elimination of the use of diversion programs that permit erasing, deferring, or otherwise purging the DWI offense record or that allow the offender to avoid license suspension. **[P]**
9. Administrative license revocation for BAC test failure and refusal. **[P]**
10. A DWI record retention and DWI offense enhancement look-back period of at least 10 years. **[S]** (*Note:* When determining whether a person is a repeat DWI offender, States establish look-back periods. Offenses that pre-date the look-back period will not be considered.)
11. Individualized sanction programs for hard core DWI offenders that rely on effective countermeasures for use by courts that hear DWI cases. **[S]**

To determine a State's progress in addressing hard core drinking drivers through the hard core model program, staff has prioritized the above elements as follows:

Primary elements [P]. Elements that research indicates will directly reduce fatalities such as sobriety checkpoints (1), vehicle sanctions (2), "hot sheet" programs (3), zero BAC restrictions (4), increased penalties for high-BAC offenders (5), diversion elimination (8), and administrative license revocation (9).

Secondary elements [S]. Elements that staff concludes will help the DWI countermeasure system function more efficiently such as alternatives to jail incarceration (6), plea bargaining restrictions (7), 10-year look-back and records retention period (10), and individualized sanction programs (11).

Figure 10. National Transportation Safety Board model program to reduce hard core drinking driving.

Table 7. New Jersey penalties for impaired driving (alcohol or drug related).

	BAC greater than or equal to 0.08 but less than 0.10	**BAC greater than or equal to 0.10**	**Second offense within 10 years of first offense**	**Third offense within 10 years of second offense**
License loss	3 months	7 months–1 year	2 years	10 years
Fines, fees, and surcharges	-$250–$400 fine -$75 per day IDRC fee -$100 drunk driving fund -$100 Alcohol Education and Rehabilitation Fund (AERF) -$1,000 a year for 3 years surcharge -$75 Safe Neighborhood Services Fund	-$300–$500 fine -$75 per day IDRC fee -$100 drunk driving fund -$100 AERF -$1,000 a year for 3 years surcharge -$75 Safe Neighborhood Services Fund	-$500–$1000 fine -$100 per day IDRC fee -$100 drunk driving fund -$100 AERF -$1,000 a year for 3 years surcharge -$75 Safe Neighborhood Services Fund	-$1,000 fine -$100 per day IDRC fee -$100 drunk driving fund -$100 AERF -$1,500 a year for 3 years surcharge -$75 Safe Neighborhood Services Fund
Prison term	Up to 30 days	Up to 30 days	48 hours to 90 days	180 days
Community service, Intoxicated Driver Resource Center (IDRC), or detainment	12–48 hours IDRC	12–48 hours IDRC	-30 days community service -12–48 hours IDRC	-Up to 90 days community service, which can reduce period of imprisonment -12–48 hours IDRC

Operator Fatigue and Alcohol. Operator fatigue factors, including sleep loss, the time of day at which the accident occurred, and shiftwork have been implicated as causal or contributing factors in several Safety Board investigations.[44,45] Reduced sleep can magnify the effects of low doses of alcohol.[46] Alcohol use also can impact sleep and

[44] (a) National Transportation Safety Board, *Motorcoach Run-off-the-Road and Overturn, Victor, New York, June 23, 2002,* Highway Accident Report NTSB/HAR-04/03 (Washington, DC: NTSB, 2004). (b) National Transportation Safety Board, *15-Passenger Child Care Van Run-off-Road Accident, Memphis, Tennessee, April 4, 2002,* Highway Accident Report NTSB/HAR-04/02 (Washington, DC: NTSB, 2004). (c) National Transportation Safety Board, *Single Vehicle Run-off-Road Rollover, U.S. Route 101, San Miguel, California, January 2, 2001*, Highway Accident Brief NTSB/HAB-02/01 (Washington, DC: NTSB, 2002). (d) National Transportation Safety Board, *Greyhound Motorcoach Run-off-the-Road Accident, Burnt Cabins, Pennsylvania, June 20, 1998,* Highway Accident Report NTSB/HAR-00/01 (Washington, DC: NTSB, 2000).

[45] (a) National Transportation Safety Board, *Motorcoach Run-off-the-Road Accident, Tallulah, Louisiana, October 13, 2003,* Highway Accident Report NTSB/HAR-05/01 (Washington, DC: NTSB, 2005). (b) NTSB/HAR-04/03. (c) National Transportation Safety Board, *Single-Vehicle Motorcoach Rollover Near Interstate Highway 24, Pleasant View, Tennessee, April 19, 2001,* Highway Accident Brief NTSB/HAB-02/18 (Washington, DC: NTSB, 2002). (d) National Transportation Safety Board, *Collision With School Bus, Chappell Hill, Texas, April 7, 1998,* Highway Accident Brief NTSB/HAB-02/16 (Washington, DC: NTSB, 2002).

[46] T. Roehrs, D. Beare, F. Zorick, and T. Roth "Sleepiness and Ethanol Effects on Simulated Driving," *Alcoholism: Clinical and Experimental Research,* Vol. 18, No. 1 (January/February 1994):154-58.

sleep quality, leading to daytime fatigue and sleepiness.[47,48] Alcohol consumption by nonalcoholics can induce sleep problems by disrupting the sequences and duration of sleep states and by decreasing total sleep time. It also has a sedating effect in that it decreases the time required to fall asleep. A 2000 poll conducted by the National Sleep Foundation shows that about 19 percent of individuals have taken alcohol to induce sleep, acknowledging the sedating effect of alcohol. Over time, with continued consumption of alcohol just before bedtime, alcohol's sleep-inducing effect decreases. Alcoholics experience problems falling asleep, frequent awakenings, and a decreased total sleep time, and are more likely to suffer from certain sleep disorders, including sleep apnea.[49]

Alcohol Use and Seat Belt Use. Since 1999, restraint usage increased from 67 percent to 82 percent nationwide and from 63 percent to 86 percent in New Jersey. Seat belt use among drivers involved in fatal accidents is substantially lower for drivers impaired by alcohol.[50] Safety belts were used by only 28 percent of fatally injured drivers with BACs of 0.08 or greater, as compared to 41 percent of fatally injured drivers with BACs between 0.01 and 0.07, and 57 percent of fatally injured drivers with 0.00 BACs.[51]

Lap/shoulder belts, when used, reduce the risk of fatal injury to front-seat passenger car occupants by 45 percent and the risk of moderate-to-critical injury by 50 percent.[52] Additional occupant protection is provided by air bags.[53] NHTSA analyses indicate that air bags reduced fatalities by 14 percent when no safety belt was used and by an additional 11 percent when a safety belt was used with air bags.[54]

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[47] T. Roehrs and T. Roth, *Sleep, Sleepiness, and Alcohol Use,* National Institute on Alcohol Abuse and Alcoholism <www.niaaa.nih.gov/publications/arh25-2/101-109.htm>.

[48] National Institutes of Health, National Institute on Alcohol Abuse and Alcoholism, *Alcohol and Sleep,* Alcohol Alert No. 41 (Washington, DC: NIAAA, 1998).

[49] (a) K. Brower, *Alcohol's Effects on Sleep in Alcoholics*, National Institute on Alcohol Abuse and Alcoholism. <www.niaaa.nih.gov/publications/arh25-2/110-125.htm>. (b) NIAAA Alcohol Alert No. 41.

[50] (a) National Highway Traffic Safety Administration, *Traffic Safety Facts 2004 Data: Occupant Protection,* DOT HS 809 909 (Washington, DC: NHTSA, 2005). (b) National Highway Traffic Safety Administration, *Seat Belt Use in 2005—Use Rates in the States and Territories*, DOT HS 809 970 (Washington, DC: NHTSA, 2005).

[51] National Highway Traffic Safety Administration, *Traffic Safety Facts 2004 Data: Alcohol*, DOT HS 809 905 (Washington, DC: NHTSA, 2005).

[52] National Highway Traffic Safety Administration, *Sixth Report to Congress, Fourth Report to the President, The National Initiative for Increasing Safety Belt Use,* DOT HS 809 823 (Washington, DC: NHTSA, June 2004).

[53] National Highway Traffic Safety Administration, *Third Report to Congress, Effectiveness of Occupant Protection Systems and Their Use* (Washington, DC: NHTSA, December 1996) <www.nhtsa.dot.gov/cars/rules/rulings/Index_occupprotect.html >.

[54] National Highway Traffic Safety Administration, *Traffic Safety Facts 2003 Data: Occupant Protection*, DOT HS 809 765 (Washington, DC: NHTSA, 2004).

Alcohol Use and Speeding. In 2004, 40 percent of drivers with a 0.08 or greater BAC who were involved in fatal accidents were speeding, as compared to 15 percent of drivers with a 0.00 BAC.[55]

Speed Management

Speeding[56] contributed to 30 percent of fatal accidents in 2004,[57] resulting in nearly 13,192 lives lost. Slightly less than 12 percent of all fatalities in New Jersey are speeding related.[58] Speeding reduces a driver's ability to steer safely around curves or objects in the roadway, extends vehicle stopping distance, and increases the distance a vehicle travels while the driver reacts to a dangerous situation.[59]

Speed limits are set to improve safety by reducing the risks imposed by drivers' speed choices. Generally, a balance between safety and travel efficiency (that is, minimizing travel time) is sought. Speed limits establish an upper bound on speeds, reducing the probability and severity of accidents. They also reduce speed disparities among vehicles. Established speed limits determine an enforcement standard, and effective enforcement deters unwanted driving behaviors.[60]

Typically, speed limits are enforced using traditional methods such as patrol cars with radar or other vehicle-speed measuring devices. The increasing number of vehicles, drivers, and vehicle miles driven, combined with competing demands for law enforcement personnel, have made traditional patrol car enforcement less practical and efficient; therefore, other methods of speed management and enforcement, such as speed cameras or photo radar, variable message signs, and roadway design, are being implemented. [61]

Speed cameras use radar to trigger a camera that photographs a vehicle and its license plate when the vehicle's speed exceeds a preset limit. Violation notices are usually sent to the vehicle owner.[62] Speed cameras have been successfully used in a

[55] National Highway Traffic Safety Administration, *Traffic Safety Facts 2004 Data: Speeding*, DOT HS 809 915 (Washington, DC: NHTSA, 2005).

[56] NHTSA considers an accident to be speeding related if the driver was charged with a speeding-related offense or if the officer indicated that racing, driving too fast for conditions, or exceeding the posted speed limit contributed to the accident.

[57] DOT HS 809 915.

[58] C. Liu, C. Chen, R. Subramanian,, and D. Utter, *Analysis of Speeding-Related Fatal Motor Vehicle Traffic Crashes*, DOT HS 809 839 (Washington, DC: NHTSA, 2005).

[59] DOT HS 809 915.

[60] (a) National Research Council, Transportation Research Board, *Managing Speed Review: Current Practices for Setting and Enforcing Speed Limits*, Special Report 254 (Washington, DC: National Academy Press, 1998). (b) U.S. Department of Transportation, *Speed Management Strategic Initiative* (Washington, DC: DOT, June 2005).

[61] Insurance Institute for Highway Safety, *Q&A: Speed—Law Enforcement* <www.iihs.org/research/qanda/speed_lawenf.html>.

[62] The National Committee on Uniform Traffic Laws and Ordinances has developed a model law for automated traffic law enforcement that includes a civil fine for violations.

few States[63] and in the District of Columbia, where, for example, average speeds declined 14 percent and the proportion of vehicles exceeding the speed limit by more than 10 mph declined by 82 percent.[64] Speed cameras are more widely used in countries outside of the United States as a means of speed enforcement.[65] New Jersey statute prohibits the use of speed cameras.[66] In 2004, legislation[67] was proposed to authorize the use of photo-radar devices for enforcement purposes on certain local streets. The legislature did not act on this bill.

Variable message signs that show the speed of a traveling vehicle or alert a driver to an upcoming safety situation (such as a work zone or fog) have had limited effectiveness. For example, the variable message signs or speed feedback indicators that are intended to increase awareness of excessive speeds and encourage drivers to slow down showed a 7- to 10-percent decrease in speeds in the presence of the indicator. After the indicator was removed, the speed reduction disappeared. Traffic enforcement activity prolonged the effectiveness of the indicator.[68]

Roadway design measures such as speed humps, traffic circles, and roadway markings have reduced the incidence and severity of accidents.[69] The FHWA also notes that such traffic calming projects result in reduced traffic volume, diverting potential accidents to other locations.

Median Barrier Guidelines

National Guidelines. The American Association of State Highway and Transportation Officials' (AASHTO's) *Roadside Design Guide*[70] defines median barriers as "longitudinal barriers that are most commonly used to separate opposing traffic on a divided highway." According to the *Roadside Design Guide*, median barriers should be installed only if the consequences of striking a barrier are expected to be less severe than if no barrier existed. Guidance contained in AASHTO's *Roadside Design Guide* for the installation

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[63] According to the Insurance Institute for Highway Safety, speed cameras are used in Arizona, California, Colorado, North Carolina, Ohio, Oregon, and the District of Columbia <www.iihs.org/research/topics/sc_cities.html>.

[64] (a) Insurance Institute for Highway Safety <www.iihs.org/research/qanda/speed_lawenf.html>. (b) Insurance Institute for Highway Safety, "Cameras Reduce Speeding on D.C. Streets," *Status Reports*, Vol. 37, No. 5 (May 2002).

[65] M. Peden, R. Scurfield, D. Sleet, D. Mohan, A. Hyder, E. Jarawan, and C. Mathers, eds., *World Report on Road Traffic Injury Prevention* (Geneva: World Health Organization, 2004).

[66] New Jersey Statute 39:4-103.1.

[67] Assembly Bill No. 2369, February 23, 2004.

[68] S.M. Casey and A.K. Lund, "The Effects of Mobile Roadside Speedometers on Traffic Speeds," *Accident Analysis and Prevention*, Vol. 25, No. 5 (1993): 627-34.

[69] Federal Highway Safety Administration, *Synthesis of Safety Research Related to Speed and Speed Management,* FHWA-RD-98-154 (Washington, DC: FHWA, 1998).

[70] American Association of State Highway and Transportation Officials, *Roadside Design Guide* (Washington, DC: AASHTO, 2002).

of barriers on high-speed,[71] controlled-access roadways that have relatively flat, traversable medians is based on a combination of ADT and center median widths. The *Roadside Design Guide* suggests that the need for median barriers be evaluated on roadways where the ADT is at least 20,000 vehicles and the median width is less than 10 meters (32.8 feet). Barriers are optional for roadways where the median width is less than 10 meters and the ADT is 30,000 or fewer vehicles. Barriers are also considered optional for median widths between 10 and 15 meters (41.2 feet), regardless of the ADT. Barriers are not normally considered for medians 15 or more meters wide.

The *Roadside Design Guide* states that median barriers are sometimes used on high-volume, non-access-controlled roadways. It also notes that terminating such barriers can be difficult, and sight distance may be a significant problem at intersections. AASHTO's *A Policy on Geometric Design of Highways and Streets* (Green Book) further explains,

> Careful consideration should be given to the installation of median barriers on multilane expressways or other highways with partial control of access. Even medians that are narrow permit inadvertent encroachments with a chance of recovery and can also include geometric features to accommodate crossing or left-turn traffic. With the addition of barriers, barrier ends at median openings present formidable obstacles. Crash cushions, although needing maintenance and imposing a high initial cost, may be needed to shield an errant motorist from the barrier ends. Consequently, an evaluation of the number of median openings, crash history, alignment, sight distance, design speed, traffic volumes, and median width should be conducted prior to installation of median barriers on non-freeway facilities.[72]

AASHTO's Green Book states that on low-speed urban arterial streets, a raised curb median may be used. The *Roadside Design Guide* defines a vertical curb as a curb having a vertical or nearly vertical face of 6 inches or higher. These types of curbs are intended to discourage motorists from deliberately leaving the roadway.

The Green Book[73] notes that raised curb medians are desirable for preventing midblock left turns and can also provide a refuge for pedestrians and space for signs and other appurtenances. However, the same guidance warns that raised curb medians do not prevent pedestrian or cross-median accidents unless a median barrier is present, noting the raised curb may cause drivers to lose control of their vehicles if struck. The *Roadside Design Guide* states that raised curb medians are generally not desirable for high-speed roadways because, if an errant vehicle became airborne, the change in the bumper height

[71] Both AASHTO's *A Policy on Geometric Design of Highways and Streets* and the FHWA's *Manual on Uniform Traffic Control Devices* use the terms "low speed" and "high speed" but do not define them. Interviews with veteran traffic engineers indicate that 45 mph is widely considered to be the boundary between low- and high-speed facilities. For further information, see American Association of State Highway and Transportation Officials, *A Policy on Geometric Design of Highways and Streets* (Washington, DC: AASHTO, 2004) and U.S. Department of Transportation, Federal Highway Administration, *Manual on Uniform Traffic Control Devices* (Washington, DC: FHWA, 2003).

[72] *A Policy on Geometric Design of Highways and Streets,* 2004, chapter 4.

[73] *A Policy on Geometric Design of Highways and Streets,* 2004, chapter 7.

could become crucial if a secondary accident occurs. The Green Book further notes that these types of medians can be difficult to see at night without appropriate lighting or delineation.[74]

New Jersey Median Barrier Guidelines. The NJDOT has adopted AASHTO median barrier warrants as part of the State's *Roadway Design Manual*. However, AASHTO guidelines do not always accommodate New Jersey requirements; where discrepancies exist, the NJDOT guidelines are followed for all roadways except interstate highways. NJDOT guidelines state that the number of crossovers, accident history, alignment, sight distance, design speed, traffic volume, and median width should be evaluated before median barriers are installed on noninterstate highways.[75] As a practice, the NJDOT does not place median barriers on nonfreeway roadways that permit left turns.

The NJDOT's *Roadway Design Manual* also suggests that a number of factors be considered before installing median barriers on highways with partial control of access, in part, because of potential problems at each intersection or median crossover where the median barrier must be terminated. Safety Board staff observed numerous median barrier wall terminations on U.S. 1, which varied from elaborate crash cushions to no end treatment.

In October 2002, the NJDOT developed the "Cross Median Crash Reduction Program," which evaluates the accident history of roadway segments to help determine where to install median barriers. The program identified an initial list of freeway segments for further consideration. Because the program did not evaluate nonfreeway segments, U.S. 1 was not considered as a possible location to place a barrier. The NJDOT expects the program to be expanded, pending future funding, to include the entire State roadway network.

[74] *A Policy on Geometric Design of Highways and Streets,* 2004*,* chapter 7.

[75] New Jersey Department of Transportation, *Roadway Design Manual*, Section 8, "Guidelines for Guide Rail Design and Median Barriers."

Analysis

This analysis first discusses the factors and conditions the Safety Board was able to exclude as neither causing nor contributing to the accident. It then provides a brief overview of the accident events and discusses the safety issues relevant to this accident: alcohol impairment, speed enforcement, and evaluative criteria for median barrier installation.

Exclusions

At the time of the accident, no rain or fog was reported and the roadway was dry, except for the puddle of water in the right southbound lane of U.S. 1 observed by the LPD. Mechanical inspection of both vehicles failed to detect any mechanical defects that would have affected the drivers' ability to control their respective vehicles. The damage to the vehicles was consistent with impact. The Linden Fire Department arrived at the accident site in about 4 minutes, and an ambulance arrived approximately 8 minutes after the accident. The roadway was appropriately marked with maximum speed signs (40 mph), and the travel lanes of the roadway were well marked with solid, yellow, retroflective lines designating the edges of the travel lanes and dashed, white, retroflective lines indicating individual travel lanes. Although the roadway lighting was in poor condition, it was supplemented by lighting from the gas station.

The Union County Medical Examiner's report on the Mercedes driver noted two intact tablets in the driver's stomach marked "Allegra." Testing conducted by the CAMI indicated the tablet was composed of pseudoephedrine (a nasal decongestant) and fexofenadine (an antihistamine), a combination commonly known as "Allegra-D."[76,77] Pseudoephedrine is a mild stimulant that is not typically expected to result in impairment.

[76] Allegra-D is a prescription drug used to relieve the symptoms of seasonal allergic rhinitis in adults and children over 12.

[77] Toxicological testing performed by the New Jersey State Toxicology Laboratory reported phenmetrazine in a pill in the Mercedes driver's stomach, but the autopsy report noted that tablets removed from the driver's stomach were marked "Allegra." The toxicological report notes only pseudoephedrine, alcohol, and acetaldehyde (a metabolite of alcohol) in the driver's blood and tissues. Phenmetrazine was marketed in the United States under the brand name Preludin as a weight control pill, which the manufacturer ceased making in 1991. Chemically, phenmetrazine and pseudoephedrine are similar substances. The tablets in the driver's stomach were most likely Allegra-D (pseudoephedrine and fexofenadine), not phenmetrazine.

Fexofenadine has been demonstrated to be free of performance impairment during psychomotor tests and actual driving performance, when taken at typical doses, alone or with alcohol.[78]

The Safety Board therefore concludes that the weather, the mechanical condition of the vehicles, the roadway markings, the roadway lighting, and the driver's use of prescription drugs neither caused nor contributed to the accident. The Safety Board further concludes that the emergency response was timely and adequate.

LPD officers noted that, upon arriving at the accident scene, they observed a puddle of standing water, 2 to 3 feet at the widest part, which extended about 35 feet in the right southbound traffic lane adjacent to the north driveway of the gas station. (See figure 1, top-right corner of diagram.) A drop inlet located north of the puddle and intended to drain that area did not function as designed because it was no longer at the lowest point in the gutter, allowing a pool of water to collect. Variances in the thickness of the asphaltic concrete surface quite likely occurred the last time the roadway was resurfaced. The LPD accident report indicated that the puddle could have caused the vehicle to hydroplane.[79] However, the Safety Board's analysis of the physical evidence shows that hydroplaning was not a factor in the accident sequence.

The origin of the tire marks produced by the Mercedes indicates that the vehicle was already traveling toward the west curb of the roadway as it approached the area of standing water. The scars and scuff mark observed on the nose of the curb were most likely produced by the right-front tire and wheel rim of the Mercedes. Given the diameter of the tire, as the leading edge made contact with the curb, the portion of the tire in contact with the pavement would have been trailing behind and would not yet have entered the water adjacent to the curb's nose. In other words, the front of the tire would have struck the curb before any other portion could have encountered the puddle. The impact of the tire and wheel rim with the curb would have contributed to the vehicle's loss of control.

As the vehicle's right-side tires departed the curb, the limited amount of water on the roadway would have precluded more than one tire at a time from rolling through the water. With one tire in the puddle and three tires on dry pavement, the vehicle would have

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[78] (a) F. Ridout, Z. Shamsi, R. Meadows, S. Johnson, and I. Hindmarch, "A Single-Center, Randomized, Double-Blind, Placebo-Controlled, Crossover Investigation of the Effects of Fexofenadine Hydrochloride 180 mg Alone and With Alcohol, With Hydroxyzine Hydrochloride 50 mg as a Positive Internal Control, on Aspects of Cognitive and Psychomotor Function Related to Driving a Car," *Clinical Therapeutics*, Vol. 25, No. 5 (May 2003): 1518-38. (b) P.C. Potter, J.M. Schepers, and C.H. Van Niekerk, "The Effects of Fexofenadine on Reaction Time, Decision-Making, and Driver Behavior," *Annals of Allergy, Asthma, and Immunology,* Vol. 91, No. 2 (August 2003): 177-81. (c) J.M. Weiler, J.R. Bloomfield, G.G. Woodworth, A.R. Grant, T.A. Layton, T.L. Brown, D.R. McKenzie, T.W. Baker, G.S. Watson, "Effects of Fexofenadine, Diphenhydramine, and Alcohol on Driving Performance, A Randomized, Placebo-Controlled Trial in the Iowa Driving Simulator," *Annals of Internal Medicine*, Vol. 132, No. 5 (March 2000): 354-63. (d) A. Vermeeren and J.F. O'Hanlon, "Fexofenadine's Effects, Alone and With Alcohol, on Actual Driving and Psychomotor Performance," *The Journal of Allergy and Clinical Immunology,* Vol. 101, No. 3 (March 1998): 306-11.

[79] *Hydroplaning* refers to the separation of a tire from the road surface by a layer of water, which reduces available friction, causing the tire to slide.

maintained its frictional adhesion to the roadway, and the small amount of water would have had no significant effect on vehicle control. Moreover, given the size of the puddle and the vehicle's speed, the tire would have been in contact with the water for less than one wheel revolution and for only a fraction of a second—approximately 0.005 second—further supporting an insignificant impact on vehicle control. Therefore, the Safety Board concludes that the Mercedes' contact with the puddle in the southbound lanes of U.S. 1 was of insufficient extent and duration to have caused the vehicle to hydroplane and did not contribute to the accident.

Accident

On April 30, 2003, the driver of the 1998 Mercedes left his house about 6:30 p.m. for a softball game. On the way to the game, the driver stopped by a local bar and bought a round of drinks for the patrons. He played in a softball game, which began about 7:30 p.m. and ended at 9:30 p.m. The driver and several teammates remained at the field after the game, and some of the players consumed alcohol. About 11:30 p.m., the driver returned to the local bar, which he left about 2:00 a.m. As he left the bar, he met a friend and stopped to talk for a few minutes.

The Mercedes driver drove about 3.35 miles in the southbound lanes of U.S. 1 in Linden before the accident. Near MP 41.4, as indicated by the tire marks, the vehicle was traveling between 48 and 62 mph,[80] hit the curb on the west side of the road, swerved to the left, crossed the other two southbound lanes, mounted and crossed the 11.5-foot-wide, 6-inch-high raised curb median, and entered the northbound lanes, where it collided head on with a 1986 Ford. As the Mercedes crossed over the raised center median, the vehicle had rotated about 71 degrees counterclockwise from its original orientation in the right southbound traffic lane. (See figure 1 for a diagram of the accident scene.)

As evidenced by the vehicle damage, the initial contact between the two vehicles occurred between the right front of the Mercedes and the left front of the Ford. The Mercedes most likely began to rotate clockwise about its longitudinal axis, rolled up and over the Ford, landed on its roof, and slid about 80 feet into a wooden utility pole on the east side of the roadway. The Ford remained upright and rotated counterclockwise about 163 degrees, and then slid about 50 feet to its point of final rest in the northbound lanes of U.S. 1.

Mercedes Speed Calculation

LPD investigators documented two tire marks observed in the southbound lanes of the roadway and classified them as critical curve speed scuff marks. The properties of these marks were used to calculate the speed of the vehicle as it traversed the southbound

[80] See speed calculation section that follows.

lanes of the highway. Using 78, the skid number obtained by the NJDOT for the southbound lanes, calculations showed that the vehicle's speed would have been 62 mph as it traversed the southbound lanes.

However, this skid number was probably too high, given that the NJDOT conducted its testing on a dry road surface, whereas the testing standards are for wet surfaces. Based on the physical examination of the pavement surface, as well as consideration of the roadway's usage (ADT between 48,000 and 82,000 vehicles) and the pavement age (most recent paving project was in 1991), the traffic lanes were determined to be traffic polished. In this condition, typical skid numbers would be in the range of 45 to 65,[81] not the friction value of 78 reported by the NJDOT. Using these typical values, the Mercedes' speed was calculated to range from 48 to 57 mph.

Mercedes Driver Actions

The Safety Board's accident investigation indicated that the Mercedes was already traveling toward the curb before it approached the water puddle. The roadway and median scuff marks also showed that, after hitting the west curb, the vehicle swerved to the left across the other two southbound lanes on U.S. 1. The scuff marks at the scene suggest that the Mercedes driver initiated a significant steering maneuver to swerve the vehicle to the left across the two southbound lanes on U.S. 1. The Safety Board considered several possible explanations for the steering maneuver.

Response to Another Vehicle

Although the video surveillance tape from the gas station was not usable, gas station logs showed no activity at the pumps for approximately 30 minutes before the accident, reducing the likelihood that the Mercedes driver's maneuver was in response to a vehicle leaving the gas station.

Alcohol Consumption

CAMI testing[82] showed alcohol in the Mercedes driver's blood (0.326 percent) and other bodily fluids.[83] In the hours before the accident, the driver was at two places where alcohol was being consumed. Although no one reported seeing the driver drinking alcoholic beverages at the softball field or local bar, the driver's BAC level indicates that he had consumed significant amounts of alcohol before the accident. Several possible scenarios could explain the driver's high BAC level. In one such scenario, the driver, after having consumed alcohol most of the day, would have had a drink at the bar, followed by a couple of beers at the softball game, and then returned to the bar and continued to drink

[81] L.B. Fricke, *Traffic Accident Reconstruction, Volume 2 of the Traffic Investigation Manual* (Evanston, IL: Northwestern Traffic Institute, 1990).

[82] Testing was also performed by the New Jersey State Toxicological Laboratory, which found a 0.351 BAC. The more conservative CAMI results are used here.

[83] According to CAMI, 0.379 percent in urine and 0.210 percent in vitreous humor.

until leaving, thus consuming enough alcohol to increase his BAC before the accident. However, because the driver's specific drinking behavior—that is, what he was drinking or the time at which he started drinking—is not known, the Board calculated[84] the amount of alcohol that a sober, 230-pound male would have had to drink to reach a 0.326 BAC under various conditions.[85] Based on those calculations, a prototypical male who began drinking about 7.5 hours before reaching a 0.326 BAC (about the time the driver made his first trip to the bar) would have had to consume approximately twenty-seven 12-ounce beers.[86] The same person who began drinking about 5 hours before reaching a 0.326 BAC (about the time the driver's softball game ended) would have had to consume twenty-five 12-ounce beers or, if he began drinking about 3 hours before reaching a 0.326 BAC, twenty-three 12-ounce beers.

At a BAC of 0.326, most individuals would experience dizziness; impaired muscular coordination, including an inability to stand or walk; reduced perception and visual functions; vomiting; and, possibly, loss of consciousness. However, the driver of the Mercedes was able to talk with friends and drive for approximately 3.35 miles before becoming involved in an accident. Individuals who are able to function with high BACs have very likely developed a tolerance to alcohol and therefore need to drink more alcohol than others to produce the same effect. Practicing the same task while under the influence of low doses of alcohol can lead to successful performance of the task by such individuals, unless they encounter something unusual. The Safety Board concludes that the Mercedes driver's ability to function (that is, to talk with friends and drive his vehicle for 3.35 miles) after consuming amounts of alcohol that would have incapacitated a nontolerant individual indicates that he had probably developed a tolerance to alcohol.

In most individuals, driving impairment can appear at a BAC of 0.02. Driving performance is impaired in almost everyone at a BAC of 0.08 or greater. At a BAC of 0.08, most drivers experience increased distractibility, steering difficulties, reduced visual acuity, and affected coordination. An alcohol-tolerant driver who might otherwise be able to drive successfully at these BAC levels still has degraded driving skills and can exhibit impaired performance if something beyond his practiced behavior occurs. An unanticipated situation can place the alcohol-tolerant driver at the same risk for an accident, due to lack of prior learning opportunities for the unexpected event, as a novice driver who has the same BAC.[87] Although the Mercedes driver had very likely acquired a tolerance to alcohol, the unexpected occurrence of drifting over and hitting the curb exceeded his ability to compensate for his high BAC level. His performance would then have been comparable to that of a non-alcohol-tolerant driver in that his level of distractibility, ability to steer the vehicle, visual acuity, coordination, and reaction time, among other abilities, would have been affected. The Safety Board concludes that despite

[84] Safety Board calculations followed the guidelines contained in: *Computing a BAC Estimate* <www.nhtsa.gov/people/injury/alcohol/BACreport.html>.

[85] According to the autopsy report, the driver weighed between 220 and 230 pounds.

[86] The Safety Board stresses that these are estimates based on drinks containing 1 ounce of alcohol. Calculations also show the driver would have had to consume twenty 5-ounce glasses of wine or nineteen 1.5-ounce liquor drinks to achieve a 0.326 BAC.

[87] (a) NIAAA, Alcohol Alert No. 28. (b) NIAAA, Alcohol Alert No. 31.

the Mercedes driver's apparent alcohol tolerance, he exhibited alcohol-impaired performance in allowing his vehicle to drift over and strike the curb, steering abruptly after hitting the curb, and crossing the three lanes of traffic and the median.

The Mercedes driver's driving record did not indicate any previous violations of DWI laws. However, NHTSA research has shown that drivers can drive impaired for thousands of miles and on several occasions before being arrested for a DWI offense.[88] The Safety Board concludes that although the Mercedes driver had no record of impaired driving penalties or violations, it is very likely that a driver with such a high BAC had previously driven impaired.

The Mercedes driver's BAC indicates the driver consumed significant amounts of alcohol before the accident. It is also very likely that the driver had a problem with alcohol for a substantial period of time because his behaviors indicate he had developed a tolerance to alcohol. However, few people appeared to be aware of the driver's problem with alcohol. The driver's family and friends said that he was a social drinker, yet no one indicated that the driver was a problem drinker. Additionally, the driver of the Mercedes was a police officer and associated with other law enforcement personnel socially (for example, softball games) and through work. Drivers' histories are not always indicative of problem drinking, and people are not always aware of or do not want to acknowledge a drinking problem.[89] However, unlike the general public, police officers are responsible for enforcing impaired driving laws and frequently receive training in detecting impaired driving behaviors and signs of alcohol or drug use.[90] Some States, such as New York, provide impaired driving detection training for all of their officers; others, such as New Jersey, conduct training on this topic as requested (about a half-dozen courses each year). The Safety Board concludes that as a police officer, the driver of the Mercedes associated with and worked with other police officers who should have been able to recognize signs of excessive alcohol use and impairment. The Safety Board will inform the International Association of Chiefs of Police, the National Sheriffs' Association, and the Fraternal Order of Police of the circumstances of this accident and encourage law enforcement organizations to conduct refresher training on recognizing signs of excessive alcohol use and impairment.

The Safety Board's model program to counter the hard core drinking driver, which targets drivers with a high BAC as well as repeat offenders, has several elements, including frequent and well-publicized sobriety checkpoints, vehicle sanctions to restrict or separate hard core drinking drivers from their vehicles, State and community programs to enforce DWI suspensions, legislation that defines a high BAC (0.15 or greater) as an "aggravated" DWI offense, administrative license revocation for BAC test failure and refusal, and individualized sanction programs for repeat DWI offenders.

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[88] (a) *Alcohol and Highway Safety 1984: A Review of the State of the Knowledge*, 56. (b) DOT HS 809 184.

[89] *Injury Prevention*, Vol. 8 (September 2002): 221-26.

[90] NHTSA has developed standards for training on detecting impaired driving: DWI Detection and Standardization Field Sobriety Testing Basic Course, DWI Detection and Standardized Field Sobriety Instructor Training, DWI Detection and Standardized Field Sobriety Testing Refresher Training, and Drug Recognition Expert Training.

In 2000, the Safety Board recommended that the States and the District of Columbia establish their own DWI programs:

> H-00-26
>
> Establish a comprehensive program that is designed to reduce the incidence of alcohol-related crashes, injuries, and fatalities caused by hard core drinking drivers and that includes elements such as those suggested in the National Transportation Safety Board's Model Program.

On July 5, 2005, the State of New Jersey responded to Safety Recommendation H-00-26, indicating that it had passed legislation in 1999 giving the courts discretion to order that an interlock device[91] be installed on the motor vehicle of a first-time DWI offender and requiring that an interlock device be installed for second or subsequent offenders. New Jersey law also authorizes the arresting law enforcement agency to impound a vehicle operated by a person arrested for DWI for up to 12 hours following the arrest, if the agency determines that releasing the vehicle to the person arrested represents a threat to public safety. New Jersey permits sobriety checkpoints and, according to the New Jersey Division of Highway Traffic Safety, Linden received $10,000 in drunk driving prevention funds in 2004 (of which, $4,600 was spent on checkpoints) and $14,000 in drunk driving prevention funds in 2005. New Jersey also has alternatives to confinement, restricts plea-bargaining, and has a look-back period of at least 10 years.

However, New Jersey has not initiated many of the other elements of the model program: laws addressing administrative license revocation, zero BAC restriction for DWI offenders, elimination of diversion programs (such as education, counseling, or community service), or specialized DWI courts. Finally, New Jersey does not have legislation defining a high BAC (0.15 or greater) as an "aggravated" DWI offense requiring strong intervention similar to that ordinarily prescribed for repeat DWI offenders.[92] Because New Jersey has implemented only one of seven of the model program's primary elements, Safety Recommendation H-00-26 was classified "Open—Unacceptable Response" on September 20, 2005. The Safety Board concludes that New Jersey lacks a comprehensive approach to preventing hard core drinking driving, including legislation that defines a high BAC (0.15 or greater) as an aggravated DWI offense; therefore, the Safety Board reiterates Safety Recommendation H-00-26 to the State of New Jersey.

Operator Fatigue

The Safety Board also explored the role operator fatigue may have played in the accident. Alcohol consumption can disrupt sleep and lead to decreased total sleep time,

[91] Device attached to a vehicle's ignition system that prevents the vehicle from being started if a driver's breath alcohol concentration (as measured by blowing into the device) is above an established level.

[92] In May 2005, the New Jersey Senate proposed legislation to increase penalties for drunk drivers with BACs of 0.15 or higher (Senate Bill No. 2469, May 5, 2005), but no action has been taken on the bill.

thereby contributing to impaired performance.[93] Alcohol consumption and sleepiness can also combine to impair driving performance.[94] In the 72 hours before the accident, the Mercedes driver slept at least 17 hours; however, the driver's sleep activities the day before the accident are unknown. The Mercedes driver had been working a nontraditional schedule (8:00 p.m. to 6:00 a.m.) for approximately 1 month and, according to his family, attempted to maintain that sleep schedule on his days off. However, the driver's sleep schedule showed that on Monday, April 28, he slept from 1:00 a.m. to about 11:00 a.m. and on Tuesday, April 29, he slept from 4:00 a.m. to 11:00 a.m., times covering periods that he would normally have been awake and on duty. Furthermore, the accident occurred at 2:11 a.m., a time at which the body is predisposed for sleep.

Although information on the amount of sleep the Mercedes driver received in the 24 hours before the accident is limited, sufficient information exists to suggest the combined effects of alcohol consumption and reduced, low-quality sleep may have impaired the driver's performance. The driver's sleep schedule, the time that the accident occurred, and the consumption of alcohol all could have contributed to the driver's impaired performance. The Safety Board, therefore, concludes that although it cannot be determined conclusively whether the driver of the Mercedes was fatigued at the time of the accident or whether he fell asleep, sufficient evidence exists to suggest that impaired performance due to the combined effects of alcohol consumption and operator fatigue possibly contributed to the accident.

Survival Aspects

The drivers of both vehicles and three of the four passengers in the Ford died at the accident site. The fourth passenger died about 3.5 hours later at the hospital.

Contact damage to the Ford was along the left side of the vehicle. It began at the front grill assembly, continued across both the driver and left-rear passenger doors, and ended just before the rear left wheel. The left side of the vehicle and the roof panel were pushed into the passenger compartment. The Safety Board concludes that the intrusion into the occupant compartments of the Ford rendered the vehicle occupant space unsurvivable.

The Mercedes sustained extensive contact damage, which was concentrated in the right front and left rear of the vehicle, providing survivable space in the Mercedes. Further, the driver's air bag deployed during the accident. However, the seat belt was found in the retracted position, and the belt webbing did not show signs of stress. The driver did not sustain any injuries over the abdomen or pelvis that would have been consistent with seat belt wear at the time of the accident. Further, the driver of the

[93] (a) *Sleep, Sleepiness, and Alcohol Use* <www.niaaa.nih.gov/publications/arh25-2/101-109.htm>. (b) Alcohol Alert No. 41. (c) *Alcohol's Effects on Sleep in Alcoholics* <www.niaaa.nih.gov/publications/arh25-2/110-125.htm>.

[94] *Alcoholism: Clinical and Experimental Research*, Vol. 18, No. 1 (January/February 1994): 154-58.

Mercedes was partially ejected from the vehicle. The Safety Board concludes that had the driver of the Mercedes been restrained, the seat belt, in conjunction with the air bag and the survivable space in the Mercedes, would have reduced his risk of ejection and fatal injury.

Lap/shoulder belts reduce the risk of injury, and air bags provide supplemental protection to lap/shoulder belts.[95] Restraint use is lower for those impaired by alcohol and at night.[96] NHTSA is initiating a demonstration project of seat belt enforcement at night that will include a component of restraint use and alcohol impairment.[97] The project was awarded in September 2005 and is currently under development. The Safety Board looks forward to reviewing the results of this demonstration project.

Roadway Issues

Vehicle Speed and Speed Enforcement

U.S. 1 in the vicinity of the accident is considered a low-speed urban arterial roadway. It was designed for a travel speed of 45 mph and has a posted speed limit of 40 mph. The Safety Board calculated the travel speed of the Mercedes to have been between 48 and 62 mph. The driver of the Mercedes was thus speeding, which is more prevalent among alcohol-impaired drivers, and a Safety Board speed survey also showed that few other drivers were complying with the posted speed limit. According to this survey, the 85th percentile speed was 72 mph, and the median speed was 62 mph. Further, survey results showed only two vehicles were traveling at or below 40 mph, and six were traveling at 80 mph or greater. Two additional spot-speed studies conducted by the NJDOT yielded 85th percentile speeds of 58 mph and 52 mph. The widespread disregard for the speed limit suggests a low level of speed enforcement on this stretch of U.S. 1. LPD officials stated that the department was aware of the high frequency of speeding on U.S. 1 in the vicinity of the accident but had not conducted directed speed limit enforcement there because of limited resources. The Safety Board concludes that drivers are not complying with the posted speed limit of 40 mph on U.S. 1 in the vicinity of the accident and that the apparent lack of traffic law enforcement in this area may contribute to the higher travel speeds. As noted earlier, speeding contributed to 30 percent of fatal accidents in 2004,[98] resulting in nearly 13,192 lives lost. Further, speeding reduces a driver's ability to steer safely around curves or objects in the roadway, extends vehicle stopping distance, and increases the distance a vehicle travels while the driver reacts to a

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[95] *Third Report to Congress, Effectiveness of Occupant Protection Systems and Their Use* <www.nhtsa.dot.gov/cars/rules/rulings/Index_occupprotect.html >.

[96] (a) National Highway Traffic Safety Administration, *Restraint Use Among Fatally Injured Passenger Vehicle Occupants by Time of Day,* DOT HS 809 817 (Washington, DC: NHTSA, 2004). (b) National Highway Traffic Safety Administration, *Traffic Safety Facts 2002: Alcohol*, DOT HS 809 606 (Washington, DC: NHTSA, 2003).

[97] NHTSA contract number DTNHT22-05-Z-05094, "Develop and Evaluate Nighttime Belt Enforcement."

[98] DOT HS 809 915.

dangerous situation.[99] Consequently, the Safety Board believes that the city of Linden should develop and implement a speed enforcement plan for U.S. 1.

Median Barriers

The Mercedes was traveling between 48 and 62 mph in the southbound lanes of U.S. 1 just before the accident occurred. When the Mercedes lost control, it swerved to the left, mounted a 6-inch curb, crossed an 11.5-foot-wide median, and entered the northbound lanes, where it collided head on with the Ford, killing the driver of the Mercedes and the five occupants of the Ford. During the accident sequence, the Mercedes' contact with the raised median caused the vehicle to rotate about its longitudinal axis. A postaccident examination of the vehicles revealed that the right-front fender of the rotating Mercedes made contact with the Taurus' driver-side A-pillar. As a result, the crash forces were primarily directed into the passenger compartment of the Taurus, dramatically increasing the severity of the accident.

The accident segment of U.S. 1 had only a 6-inch-high raised concrete curb median to separate northbound and southbound traffic, for reasons that the NJDOT was unable to document. Consequently, no barrier was in place that could have prevented vehicles traveling in the southbound lanes from veering into the northbound lanes (or vice versa). However, median barriers were located north and south of the accident site. Physical evidence found on these median barriers, such as the black tire rubber smears and metallic scrapes, suggests vehicle contact with these taller structures.

AASHTO guidelines, which the NJDOT has adopted, suggest that raised curb medians, such as the one present at the accident site, are best used on low-speed urban arterial roadways to prevent midblock left turns and provide a place for pedestrians and signs.[100] The AASHTO guidelines also note that on high-speed roadways, striking a raised median curb can cause a driver to lose control, with the vehicle contacting the curb tripping, overturning, or becoming airborne, as was the case in this accident. Although the portion of U.S. 1 where the accident occurred had a posted 40-mph speed limit, traffic surveys showed that vehicles routinely traveled at substantially greater speeds.

The Safety Board concludes that a raised curb median, such as the one on U.S. 1 in the vicinity of the accident, is not sufficient to prevent crossover median accidents and can cause a vehicle to become out of control or airborne at the speeds at which vehicles travel on that segment of roadway. The Safety Board further concludes that had a median barrier been present at the accident site, the Mercedes probably would not have crossed from the southbound lanes into the northbound lanes and collided with the Ford.

Following the accident, the NJDOT evaluated the accident site for the installation of a median barrier. For several reasons, including the low occurrence of median crossover accidents and the straight alignment of the roadway segment, the NJDOT determined that a median barrier was not needed for this segment of U.S. 1.

[99] DOT HS 809 915.

[100] *A Policy on Geometric Design of Highways and Streets* (2004) and *Roadside Design Guide* (2002).

Determining whether a median barrier should be installed on roadways that have relatively flat, traversable medians, such as the accident roadway, is difficult because AASHTO guidelines for median barrier installation do not provide clear guidance. AASHTO's *Roadside Design Guide* provides guidance for the installation of median barriers on high-speed, controlled-access roadways based on a combination of ADT and center median widths. Because the section of U.S. 1 where the accident occurred had an estimated ADT exceeding 66,000 vehicles and a median width of 11.5 feet, the *Roadside Design Guide* would suggest that the roadway be evaluated as to the need for a median barrier. However, these guidelines do not state how to conduct such an evaluation or suggest specific information to consider. Additional guidance in the *Roadside Design Guide* states that median barriers are sometimes used on high-volume, non-access-controlled roadways but provides no specific guidance about median barrier installation other than information pertaining to the potential hazards in terminating barrier ends and sight distance. For such roadways, AASHTO's *A Policy on Geometric Design of Highways and Streets* (as adopted by New Jersey) suggests several factors to consider in installing a median barrier on multilane expressways or other highways with partial control of access: the number of median openings, accident history, alignment, sight distance, design speed, traffic volumes, and median width. However, specific guidance is lacking concerning the conditions warranting the installation of median barriers, such as the level of traffic volume, number or rate of accidents, sight distance, or median width measurements.

The Safety Board has previously asked the FHWA and AASHTO to revise the median barrier guidelines to reflect changes in the factors affecting the probability of cross-median accidents.[101] Specifically, the Safety Board recommended that the FHWA, in conjunction with AASHTO (Safety Recommendation H-98-24):

> <u>H-98-12</u>
>
> Review, with the American Association of State Highway and Transportation Officials, the median barrier warrants and revise them as necessary to reflect changes in the factors affecting the probability of cross-median accidents, including changes in the vehicle fleet and the percentage of heavy trucks using the roadway.

AASHTO has informed the Safety Board that it is revising the guidance for median barriers. When completed, it is expected that the guidance will be released as an updated chapter in the *Roadside Design Guide*.[102] The Safety Board looks forward to the opportunity to review this additional guidance; until then, Safety Recommendations H-98-12 and -24 remain classified "Open—Acceptable Response."

[101] (a) National Transportation Safety Board, *Ford Explorer Sport Collision With Ford Windstar Minivan and Jeep Grand Cherokee on Interstate 95/495 Near Largo, Maryland, February 1, 2002*, Highway Accident Report NTSB/HAR-03/02 (Washington, DC: NTSB, 2003). (b) National Transportation Safety Board, *Multiple Vehicle Crossover Accident, Slinger, Wisconsin, February 12, 1997*, Highway Accident Report NTSB/HAR-98/01 (Washington, DC: NTSB, 1998).

[102] AASHTO plans full review of the *Roadside Design Guide*, culminating in a fully updated guide, possibly in 2008 (March 16, 2005, e-mail from the Associate Program Director, Engineering, AASHTO).

As traffic, congestion, and vehicle speeds increase on roadways similar to the accident roadway, the probability of a median crossover accident also increases. The Safety Board recognizes that the installation of median barriers on roadways entails a complex decision-making process involving a number of roadway characteristics, a process made more difficult by the fact that the current median barrier installation guidelines are inadequate for determining when to install a median barrier. The Safety Board concludes that the AASHTO guidelines for the installation of a median barrier are inadequate because they do not include specific guidance on how to evaluate highway factors, such as accident history, sight distance, and vehicle type or speed, to determine whether a median barrier is necessary. The Safety Board believes that AASHTO and the FHWA should work together to establish evaluative criteria for determining when to install median barriers on high-volume, high-speed roadways, regardless of access type.

Conclusions

Findings

1. The following elements neither caused nor contributed to the accident: the weather, the mechanical condition of the vehicles, the roadway markings, the roadway lighting, and the driver's use of prescription drugs.

2. The emergency response was timely and adequate.

3. The Mercedes' contact with the puddle in the southbound lanes of U.S. Route 1 was of insufficient extent and duration to have caused the vehicle to hydroplane and did not contribute to the accident.

4. The Mercedes driver's ability to function (that is, to talk with friends and drive his vehicle for 3.35 miles) after consuming amounts of alcohol that would have incapacitated a nontolerant individual indicates that he had probably developed a tolerance to alcohol.

5. Despite the Mercedes driver's apparent alcohol tolerance, he exhibited alcohol-impaired performance in allowing his vehicle to drift over and strike the curb, steering abruptly after hitting the curb, and crossing the three lanes of traffic and the median.

6. Although the Mercedes driver had no record of impaired driving penalties or violations, it is very likely that a driver with such a high blood alcohol concentration had previously driven impaired.

7. The driver of the Mercedes associated with and worked with other police officers who should have been able to recognize signs of excessive alcohol use and impairment.

8. New Jersey lacks a comprehensive approach to preventing hard core drinking driving, including legislation that defines a high blood alcohol concentration (0.15 or greater) as an aggravated DWI offense.

9. Although it cannot be determined conclusively whether the driver of the Mercedes was fatigued at the time of the accident or whether he fell asleep, sufficient evidence exists to suggest that impaired performance due to the combined effects of alcohol consumption and operator fatigue possibly contributed to the accident.

10. The intrusion into the occupant compartments of the Ford rendered the vehicle occupant space unsurvivable.

11. Had the driver of the Mercedes been restrained, the seat belt, in conjunction with the air bag and the survivable space in the Mercedes, would have reduced his risk of ejection and fatal injury.

12. Drivers are not complying with the posted speed limit of 40 mph on U.S. Route 1 in the vicinity of the accident, and the apparent lack of traffic law enforcement in this area may contribute to the higher travel speeds.

13. A raised curb median, such as the one on U.S. Route 1 in the vicinity of the accident, is not sufficient to prevent crossover median accidents and can cause a vehicle to become out of control or airborne at the speeds at which vehicles travel on that segment of roadway.

14. Had a median barrier been present at the accident site, the Mercedes probably would not have crossed from the southbound lanes into the northbound lanes and collided with the Ford.

15. American Association of State Highway and Transportation Officials guidelines for the installation of a median barrier are inadequate because they do not include specific guidance on how to evaluate highway factors, such as accident history, sight distance, and vehicle type or speed, to determine whether a median barrier is necessary.

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the Mercedes driver's loss of control of the vehicle due to alcohol impairment. Contributing to the severity of the accident were the lack of barriers separating traffic in the northbound and southbound traffic lanes and the failure of the Mercedes driver to wear his seat belt.

Recommendations

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

New Recommendations

To the Federal Highway Administration:

Work with the American Association of State Highway and Transportation Officials to establish evaluative criteria for determining when to install median barriers on high-volume, high-speed roadways, regardless of access type. (H-06-12)

To the American Association of State Highway and Transportation Officials:

Work with the Federal Highway Administration to establish evaluative criteria for determining when to install median barriers on high-volume, high-speed roadways, regardless of access type. (H-06-13)

To the city of Linden:

Develop and implement a speed enforcement plan for U.S. Route 1. (H-06-14)

Reiterated Recommendation

The National Transportation Safety Board reiterates the following previously issued recommendation:

To the State of New Jersey:

Establish a comprehensive program that is designed to reduce the incidence of alcohol-related crashes, injuries, and fatalities caused by hard core drinking drivers and that includes elements such as those suggested in the National Transportation Safety Board's Model Program. (H-00-26)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

MARK V. ROSENKER
Acting Chairman

DEBORAH A. P. HERSMAN
Member

ELLEN ENGLEMAN CONNERS
Member

KATHRYN O'LEARY HIGGINS
Member

Adopted: February 7, 2006

Appendix A

Investigation and Public Hearing

The National Transportation Safety Board was notified of the Linden, New Jersey, accident on May 1, 2003. Investigative team members were dispatched from the Washington, D.C., and Atlanta, Georgia, offices. Groups were established to investigate human performance, highway, and vehicle factors.

Participating in the investigation were representatives of the Federal Highway Administration, the New Jersey Department of Transportation, and the Linden, New Jersey, Police Department.

No public hearing was held; no depositions were taken.