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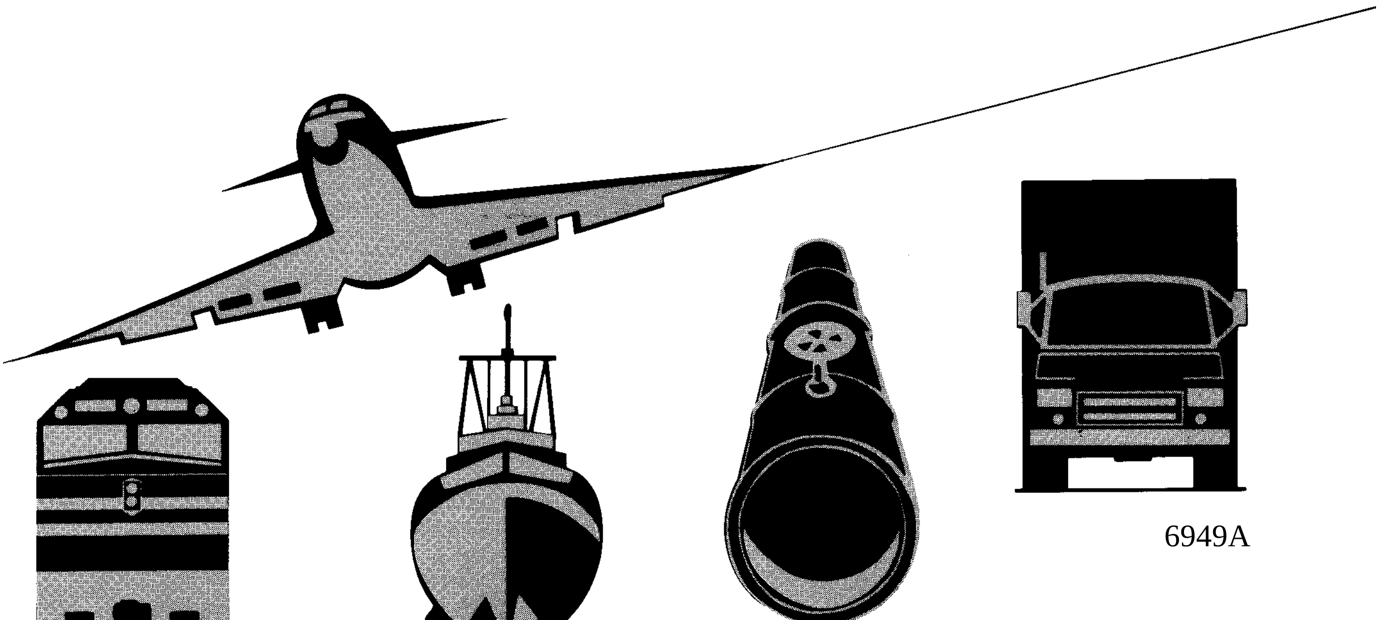
NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

HIGHWAY ACCIDENT SUMMARY REPORT

**BUS COLLISION WITH PEDESTRIANS
NORMANDY, MISSOURI
JUNE 11, 1997**



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Abstract: On June 11, 1997, a transit bus collided with seven pedestrians at a "park and ride" transit facility in Normandy, Missouri. The bus was being operated by a driver trainee who had just completed a routine stop at the station. After allowing the passengers to debark from the bus, the driver trainee began to move the bus forward to provide clearance for another bus to pass. The driver trainee, who was reportedly unable to stop the bus, allowed it to surmount the curb and continue onto the station platform. The resulting encroachment onto the platform resulted in the deaths of four pedestrians and injuries to three others.

The safety issues discussed in this report are the sufficiency of pedestrian protection provided by the saw-tooth parking bay design and the need for positive separation between the roadway and pedestrian areas of parking bay facilities.

As a result of its investigation, the National Transportation Safety Board issued recommendations to the Federal Highway Administration, the Federal Transit Administration, the American Association of State Highway and Transportation Officials, the American Public Transit Association, and the Community Transportation Association of America.

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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BUS COLLISION WITH PEDESTRIANS
NORMANDY, MISSOURI
JUNE 11, 1997

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Adopted: February 19, 1998
Notation 6949A

NATIONAL
TRANSPORTATION
SAFETY BOARD

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National Transportation Safety Board
Washington, D.C. 20594

HIGHWAY ACCIDENT SUMMARY

Accident No.:	CRH-97-F-H007
Vehicle:	1981 GMC T8H-5307A transit bus
Accident Type:	Collision with pedestrians
Location:	Normandy, Missouri
Date:	June 11, 1997
Time:	9:15 a.m.
Owner/Operator:	Bi-State Development Agency
Occupants:	Driver trainee and line instructor
Damage:	Minor damage to bus and facility structures
Injuries:	Four pedestrian fatalities; two serious and one minor pedestrian injuries

About 9:15 a.m.[1] on June 11, 1997, a 1981 General Motors Corporation (GMC) transit bus collided with seven pedestrians at a "park and ride" transit facility in Normandy, Missouri. The bus was being operated by a driver trainee who had just completed a routine stop at the station. After allowing the passengers to debark from the bus, the driver trainee began to move the bus forward to provide clearance for another bus to pass. The driver trainee, who was reportedly unable to stop the bus, allowed it to surmount the curb and continue onto the station platform. The resulting encroachment onto the platform (see figure 1) resulted in the deaths of four pedestrians and injuries to three others.

During its investigation, the National Transportation Safety Board identified two safety issues: the sufficiency of pedestrian protection provided by the saw-tooth parking bay design and the need for positive separation between the roadway and pedestrian areas of parking bay facilities. The following discussion includes a narrative description of the accident; an overview of the causal issues explored relating to the vehicle's operational characteristics, equipment design, and operator conditions and actions; a detailed examination of the safety issues; and a list of conclusions and safety recommendations developed to help prevent future accidents of this type.

[1]All times are given in central daylight time.

INVESTIGATION AND ANALYSIS

Preaccident Events

On June 11, 1997, at 4:25 a.m., a driver trainee, along with her instructor, departed from the Bi-State Development Agency (BSDA) Debaliviere facility in St. Louis, Missouri. The trainee was completing her final week of a 6-week training program and was scheduled to fill a position as a part-time busdriver at the end of the week. Initially that day, the driver trainee was on the bus as an observer while the instructor drove their route. At some time between 6:30 and 7 a.m., the driver trainee switched places with the instructor and took over as the bus's operator. The weather that morning was partly cloudy but dry, with temperatures around 70°F. At 9 a.m., the bus made a scheduled stop at the University of Missouri at St. Louis-South MetroLink facility in Normandy, Missouri. The driver trainee pulled around and parked in front of another bus that was already parked at the location. (See figures 1, 2, and 3.)

The Accident

After the bus passengers debarked from the vehicle, the driver trainee and her instructor prepared to exit the bus for a short break. As they were doing so, the operator of the bus parked behind the accident vehicle signaled for them to pull forward to provide him with sufficient passing clearance.

The instructor, who was standing within the accident bus by the front exit door, told the driver trainee to pull the bus forward. The trainee reported that she then performed the following actions:

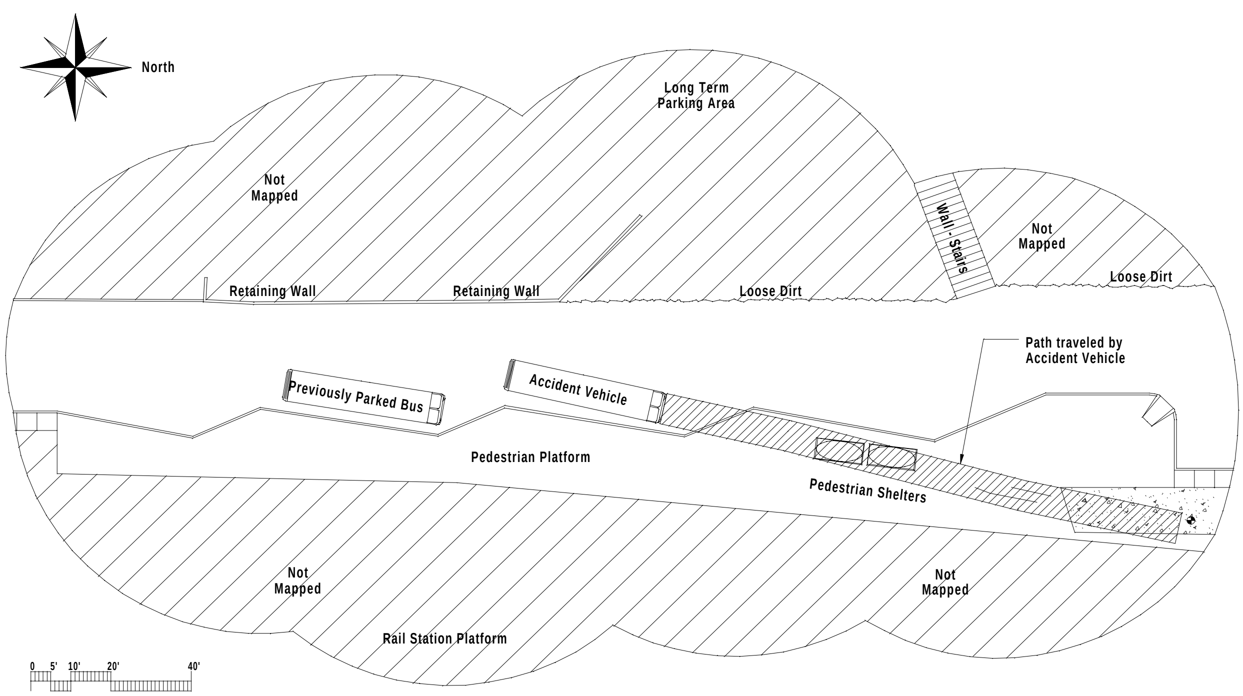

Figure 1 -- Diagram of accident scene

Figure 2 -- View from roadway toward pedestrian shelters

Figure 3 -- Bus parked in space used by the accident vehicle

- Placed her foot on the brake pedal,
- Moved the transmission gear selector into the drive position,
- Closed the doors,
- Released the emergency brake, and
- Slowly released pressure from the brake pedal.

The bus moved forward approximately 14 feet before surmounting the 5-inch-high curb dividing the roadway from the pedestrian platform. The bus continued forward onto the platform for a distance of 25 feet before making contact with the first of two pedestrian shelters. Then, after striking the second shelter and traveling an additional 93 feet, the bus came to a halt against a section of metal railing. (See figure 4.) The resulting encroachment onto the platform and collision with two pedestrian shelters resulted in the death of four pedestrians and injury to three others.

The driver's instructor later told investigators that at some point during the bus's forward progress, he activated the emergency stop switch on the bus. The switch had been designed to close down all functions on a runaway engine by depriving it of air.

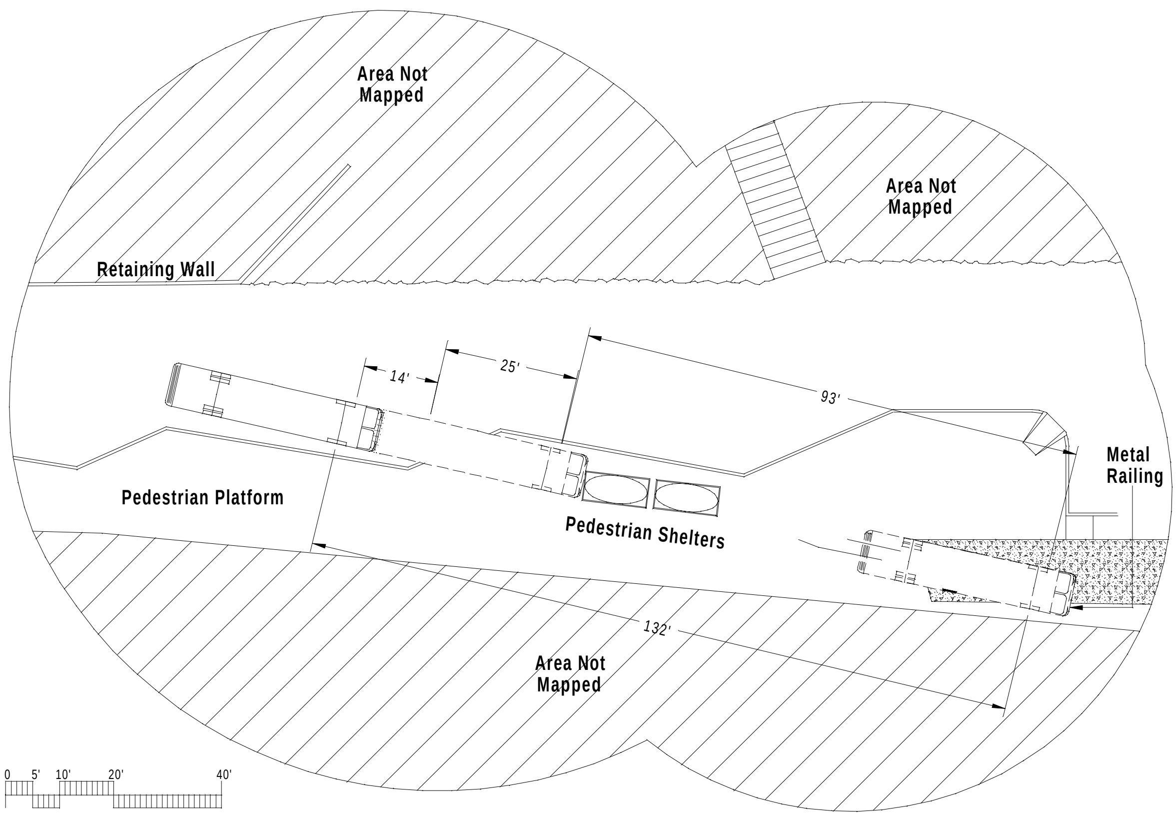

Figure 4 -- Bus collision movements

The driver trainee and the line instructor were transported to Normandy Community Hospital, where both provided blood and urine specimens for analysis. The toxicological test results were negative for alcohol and other specified drugs.[2] Subsequently, the Safety Board obtained a sample of these specimens and sent them to the Center for Human Toxicology (CHT) in Salt Lake City, Utah, for analysis. The results of the CHT tests were negative for drugs and alcohol.

The three injured pedestrians were also taken to the Normandy Community Hospital for treatment. The four deceased pedestrians were transported to the Depaul Health Center in St. Louis.

Postaccident Events

The bus was towed from the accident scene to the BSDA's principal maintenance facility, located at 3333 Spruce Street, in St. Louis, Missouri, where Safety Board investigators and officers from the Missouri State Highway Patrol Commercial Vehicle Enforcement Section inspected the vehicle. The inspections revealed that the vehicle's brakes were all adjusted within specifications. No defective items relating to the collision were observed. Investigators found the emergency stop switch in the activated position. They further found that the switch had been disconnected.

This accident resulted from the unintended forward progress into the pedestrian area of the bus driven by the trainee. In its investigation, the Safety Board attempted to determine what caused this movement by reviewing: the condition of the bus and its equipment; the design of the bus pedals; and the training, experience, and condition of the driver.

Bus Information

General -- The 40-foot transit vehicle was a 1981 GMC bus that had been purchased new by the BSDA. Maintenance on the vehicle had been performed at BSDA facilities since the purchase. The vehicle had last undergone a routine 3,000-mile safety inspection on June 10, 1997, the day before the accident.

The bus was equipped with a rear-mounted, Detroit Diesel 8V71[3] engine. The engine's fuel system components included a mechanical gear-driven supercharger and a mechanical fuel injection system. Throttle position was regulated by a foot-activated treadle valve using air pressure to control the throttle assembly. Additionally, separate throttle position controls regulated "fast idle" activation and setting. A solenoid was used for emergency engine shutdown.

Brake System -- The brake system included a service brake, an air/mechanical parking brake, and a solenoid-activated air brake system incorporated into the operation of the rear passenger loading doors. The air brake system complied with 49 *Code of Federal Regulations*, Section 571.121, Standard No. 121; Air brake systems.[4] All brakes were equipped with Haldex automatic slack adjusters.

Examination of the brake system revealed the following:

- Service brake application was controlled by a foot-activated treadle valve. Operation of the valve supplied air pressure to both front and rear axle service brake chambers.
- Parking brake activation was controlled by a floorboard-mounted hand valve located to the left of the driver's seat. Operation of the valve regulated air into the parking/emergency brake chambers on the rear axle. Air pressure to the brake chambers was restricted to between 60 and 80 psi. Activation of this valve also bled air from the roller lock plunger assembly, causing the rear brake pushrods to be

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[2]Cocaine, amphetamines, marijuana, PCP, and opiates.

[3]The "8" indicates the total number of cylinders and the "71" denotes cubic inches per cylinder, equating to a total displacement of 568 cubic inches.

[4]This standard establishes performance and equipment requirements for braking systems on vehicles equipped with air brake systems.

mechanically locked in the "applied" position.

- Release of the parking brake required two separate actions. First, the hand valve had to be pushed inward. This action bled air pressure from the parking brake chamber and allowed air pressure back into the roller lock plunger assembly. Even though air pressure was reapplied to the roller lock plunger assembly, the level of pressure was insufficient to overcome the mechanical force acting on the brake pushrod. The second required action was the application of the service brake. This allowed air pressure into the service brake chamber, which in turn moved the brake pushrod forward. This forward movement disengaged the mechanical lock of the roller lock assembly. Only after the service brake had been disengaged were the brakes completely released.

- The rear door interlock, which was controlled by a lever at the left side of the driver's control panel, activated an electronic locking mechanism on the rear passenger loading door, disabled the accelerator, and allowed air pressure into the rear axle service brakes. When the lever was rotated, an electronic solenoid retracted the door's locking lever. Once unlocked, the door could be manually opened. At the same time, the throttle was deactivated so that when the accelerator was depressed no movement was transmitted to the engine's throttle assembly. In addition, air pressure, limited to 40 psi, was supplied to the rear axle service brake chambers. The system was designed so that the rear brakes would have sufficient force to hold the vehicle while passengers exited. It was not designed to function as a separate brake system to slow or stop the bus.

Emergency Stop Switch -- The line instructor told investigators that during the accident he had activated the emergency stop switch in the bus. This switch was designed, in the event of a runaway engine, to stop all engine functions by depriving the engine of air. After the accident, investigators found this switch in the activated position. Further inspection revealed that the emergency stop switch had been disconnected, so the activation of the switch had no effect on the bus's operation.

BSDA representatives told investigators that the bus's fuel injection system had previously been modified so that the possibility of a runaway engine condition due to a stuck injector had been eliminated. Consequently, the switch had been disconnected. Investigators attempted to determine whether activation of the shutoff function could have had any effect on this accident.

The engine's mechanical fuel injection system, as originally manufactured, was equipped with "non-spring-loaded" injector control tube assemblies. The assembly was designed such that, under certain circumstances,[5] a runaway engine condition could occur. Because of the possibility of runaway, the engine's air inlet housing was equipped with an emergency air shutoff valve. The valve was controlled by an electrical switch mounted on the left side of the vehicle's dashboard. Activation of the switch caused the valve to close, preventing air from entering the engine, thus shutting down a runaway engine.

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[5]The control tubes were mounted along the top of each cylinder head and supported on each end by a bracket assembly that allowed the tubes to rotate. A series of rack levers, one for each cylinder, was affixed to each control tube. The opposing end of each rack lever was connected to a fuel metering rod, which fit inside a fuel injector housing. The assembly was designed so that throttle activation caused each control tube to rotate in a direction opposite from the fuel injector housing. The rack lever converted the rotational movement of the control tube into a linear motion acting on the fuel metering rod. As the control tube rotated away from the fuel injector housing, the rack lever slid the fuel metering rod out, allowing more fuel to enter the injector housing. The rack levers were mounted to the control tubes by two opposing adjustment screws with lock nuts. Because of this, if one fuel metering rod were to stay in a full fuel position, the remaining rods would also be in full fuel delivery, thereby causing a runaway engine condition.

Further investigation, however, revealed that engine shutdown upon activation of the switch was not immediate and would only occur after the oxygen supply to the engine had been sufficiently depleted. Even if the fuel injection system had remained as originally designed and the emergency stop switch had been connected to the air shutoff valve, the shutdown feature would have taken too long to have had any effect on the outcome of this accident. Therefore, the Safety Board concludes that activation of the emergency stop switch could not have averted this accident.

Pedal Configuration -- Physical examination of the throttle/brake pedal assembly revealed that the pedals were similar in design and surface texture. The accelerator pedal was approximately 11 3/8 inches long by 3 inches wide. The brake pedal was approximately 12 inches long by 3 1/8 inches wide. The spacing between the bases of the pedals was 1 3/4 inches, while the tops of the pedals were separated by 1 inch. The brake pedal was mounted so that it angled back, toward the fire wall, at 47°. The accelerator was mounted in a similar manner, except that it had a steeper 54° angle. The accelerator facing was of textured rubber with longitudinal grooves extending from top to bottom. The lower portion of the brake pedal was exposed metal; the upper portion was covered by a grooved rubber insert. (See figure 5.)

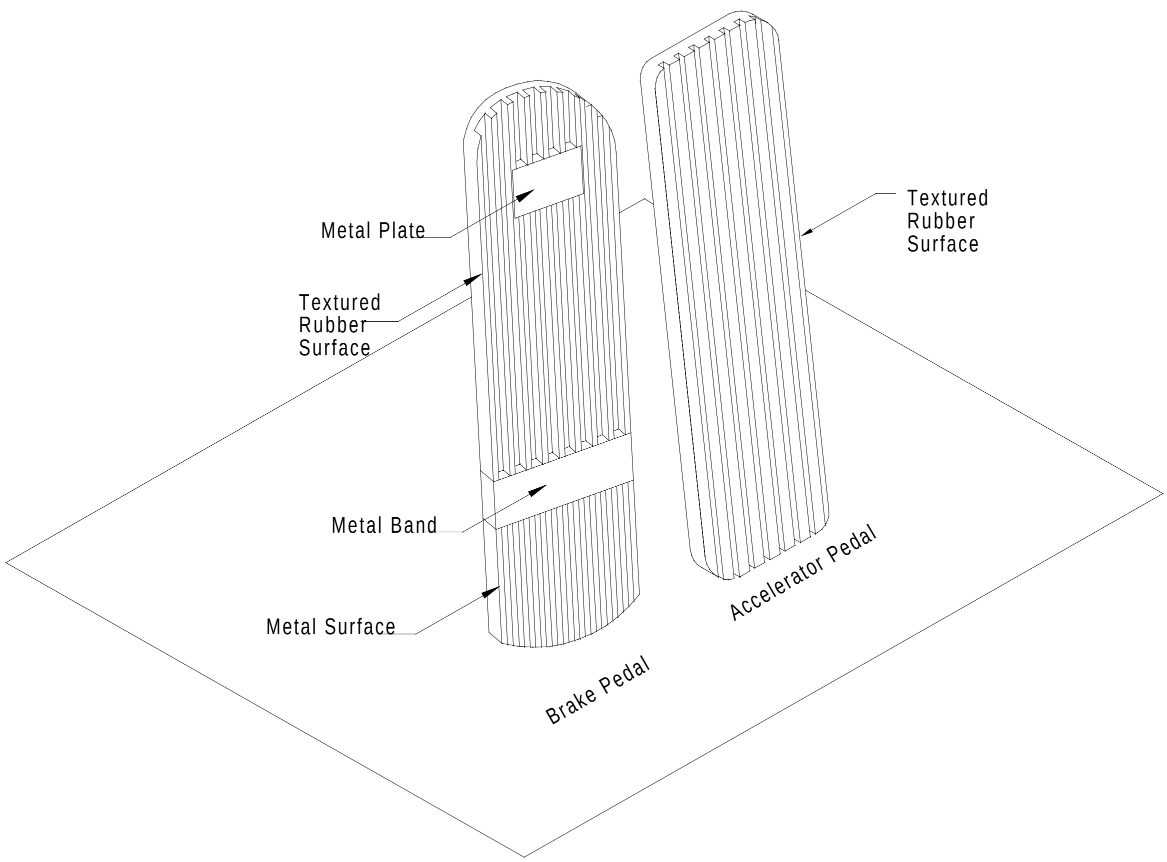

Figure 5 -- Pedal configuration

Experienced bus operators from the BSDA Debaliviere facility were interviewed regarding the vehicle's pedal design and layout. Their general belief about the pedals was that, because of their similarity and close proximity, the pedals' configuration might appear ergonomically awkward, especially to an inexperienced operator such as the driver trainee. They considered, however, that once an individual had been trained, the arrangement of the pedals represented no hindrance to proper bus operation. Their experience-based opinions are supported by past research that found no systematic link between unintended acceleration due to misapplication of pedals and pedal design.[6]

Operator Information

Driver Trainee -- The 31-year-old driver trainee had been employed by the BSDA since May 5, 1997. Although the trainee had held an operator's license since she was a teenager, she had no prior experience as a professional driver nor any history of heavy vehicle operations. An inquiry with the National Drivers Register data base and a State driver's license check disclosed only one violation pertaining to the trainee, a 1994 speeding citation. Her work/rest cycle was examined for the 96-hour period preceding the accident, and no evidence of fatigue was found. The trainee possessed a valid medical certificate and a Missouri commercial driver's license (CDL) that certified her to operate the accident vehicle. She had obtained her CDL on June 4, 1997, based on training she had received from the BSDA, and was in the final week of the BSDA's 6-week bus operator training program.

Based on the available information regarding the trainee's condition, the Safety Board concludes that the driver trainee was not fatigued, impaired, or suffering from any medical conditions that may have affected her performance.

Motor Carrier -- The BSDA is a quasi-public,[7] not-for-profit agency that operates public transportation services within the St. Louis, Missouri, and East St. Louis, Illinois, region—an area covering 3,600 square miles and 200 municipalities. The BSDA can cross local and State boundaries, as provided through a 1949 compact between Missouri and Illinois that was ratified by the U.S. Congress. In 1963, the BSDA purchased and consolidated the area's 15 privately owned transit firms.

The BSDA operates 600 transit buses, with an average fleet age of 8 years. The BSDA transit system typically operates from 4:30 a.m. to 1 a.m. the following day. Bus service encompasses 116 scheduled routes, consisting of 18,500 bus stops and 640 bus shelters. During periods of peak service, an average of 507 buses are in operation. During FY[8] 1996, the bus fleet traveled 23 million miles, for an average of 80,140 miles per day, and was involved in a total of 529 Federal Transit Administration (FTA)-reportable collisions.[9] In FY 1997, BSDA buses were involved in 404 FTA-reportable collisions.

At the time of the Normandy accident, the BSDA employed about 1,950 people, of which 850 were full-time and 109 were part-time drivers. The BSDA initially hires drivers on a part-time basis and then promotes them to full-time status as positions become available. Drivers generally select routes and schedules periodically, based on their seniority. On their days off or during hours they are not driving, drivers can report to the station and try to pick up extra routes that may be available.

The BSDA provides 6 weeks of training to newly recruited drivers before they are allowed to operate a vehicle without supervision. The first week of the bus operator training program covers bus orientation and is conducted in a classroom environment. The second week of training includes additional classroom instruction and exposes the student to actual bus operations in a controlled environment. Later in that week, the student is allowed to operate a

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[6]Schmidt, Richard A., 1989, *Unintended Acceleration: A Review of Human Factors Contributions*. The Human Factors Society.

[7]The BSDA has no taxing power but is authorized to issue revenue bonds, collect fees, and receive funds from Federal, State, local, and private agencies.

[8]The BSDA's fiscal year runs from July 1 through June 30.

[9]The FTA requires the reporting of any collision involving death or injury or damage exceeding $1,000.

bus on a public road but is not engaged in passenger service. The remaining 4 weeks of training are devoted to actual passenger service over established routes; however, the student is still under the supervision of an on-board instructor.

Bus System Performance Tests

Test Drive -- The accident bus's brake system was visually examined and measurements of the brake system adjustment were obtained. No defects were noted, and a test drive was performed with BSDA personnel operating the vehicle. During the test drive, multiple stops were made at various speeds[10] and the dynamic brake performance was found to be satisfactory throughout the testing period. The steering system was also evaluated during the test drive. When the bus was maneuvered both left and right, no unusual feedback in the steering system was observed, and the vehicle followed a normal track.

The accident bus's "steering wheel lash" was measured at the conclusion of the test drive and found to be 5 1/2 inches. Steering wheel lash is the distance the steering wheel will turn before initiating any detectable movement by the front wheels. The Commercial Vehicle Safety Alliance out-of-service criteria dictate that a vehicle equipped with a manual steering system controlled by a 21-inch steering wheel would be in an out-of-service condition if steering wheel lash were measured at 5 1/2 inches or more.

Engine Performance and Throttle Activation -- Investigators also examined engine performance and throttle activation. Using the accelerator pedal, engine revolutions per minute (rpm) were brought to various levels. The throttle was then released and the engine returned to a normal idle speed during each test. Engine performance was also monitored during the test drive. No defects were noted.

Acceleration tests were conducted using two different procedures. All tests were performed on a level surface with the bus starting from a complete stop; the bus was then timed as it accelerated over a distance of 150 feet. The test conditions did not include provision of a 5-inch curb, such as that in place at the accident location, because investigators determined that the curb did not provide enough obstructive force to affect the acceleration of the vehicle in any significant way. The height of the curb relative to the circumference of each bus tire (21-inch rolling radius), the fact that each tire surmounted the curb independently, and the steep (55°) angle of approach taken by each tire (see figure 6) indicated that the 5-inch curb was not a meaningful barrier to the bus.

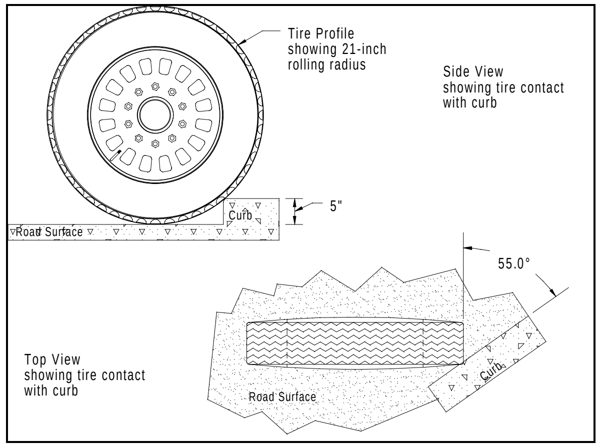

Figure 6 -- Curb and tire profiles

During the first set of tests, the service brakes were applied, the engine was at normal idle speed, the transmission was placed in drive, the service brake was released, and full throttle was applied. Wide open throttle was maintained while the bus accelerated over the test distance. (See table 1 for test results.)

The second set of tests involved bringing the engine rpm up to a range of approximately 1,200 to 1,500 rpm.[11] The transmission was in neutral, and no brakes were applied. The transmission was then shifted into drive and the accelerator was simultaneously depressed, so that full throttle was applied. Wide open throttle was maintained while the bus accelerated over the test distance. (See table 2 for test results.)

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[10]Actual speeds could not be determined, as the accident vehicle's speedometer was inoperative.

[11]Engine rpm had to be estimated based on operator experience, as the vehicle was not equipped with a tachometer.

Table 1* -- First series of acceleration tests

TEST NUMBER	DISTANCE TRAVELED IN FEET	TIME REQUIRED IN SECONDS	ACCELERATION FACTOR (g)
1	150	8.23	0.137
2	150	8.63	0.125
3	150	8.35	0.133

*Average time to travel 150 feet was found to be 8.40 seconds, with an average acceleration factor of 4.18 feet per second per second.

Table 2* -- Second series of acceleration tests

TEST NUMBER	DISTANCE TRAVELED IN FEET	TIME REQUIRED IN SECONDS	ACCELERATION FACTOR (g)
4	150	7.50	0.165
5	150	7.64	0.159
6	150	7.38	0.171

*Average time to travel 150 feet was found to be 7.50 seconds, with an average acceleration factor of 5.15 feet per second per second.

The engine is equipped with a manually activated fast idle circuit controlled by an electrical switch on the bus's left side dash panel. Fast idle operation can be initiated any time that the switch is placed in the "on" position; it operates independently of engine temperature. The fast idle system is also equipped with a drive gear interlock feature, which is designed to reduce engine idle back to normal rpm when the transmission is shifted into drive while the fast idle is engaged.

To test the drive gear interlock, the engine was allowed to warm up to normal operating temperature with the transmission in neutral and the parking brakes applied. The fast idle activation switch was then placed in the "on" position and an audible increase in engine rpm was noted. The service brake was then applied and the transmission was shifted into drive. Immediately after the transmission was shifted into drive, an audible decrease in engine rpm was observed. These test procedures were conducted two more times with the same results.

Brake Power Tests -- To determine whether engine horsepower could overcome brake application, a series of static brake tests were performed to evaluate the effectiveness of the accident vehicle's braking system. The first test involved the bus's service brakes. During this test, the bus was parked on a level surface inside the BSDA's primary maintenance facility. The engine was allowed to warm up to a normal operating temperature while the transmission was in neutral and the parking brake was applied. Once this temperature was attained, the service brakes were applied and the parking brake was released. With the service brakes still applied, the accelerator was depressed to full throttle. The engine was then held in a condition of wide open throttle for about 30 seconds with the service brakes applied. The service brakes did not allow the vehicle to move during the test.

The second test involved the parking brake. To perform this test, the parking brake was applied and the accelerator was depressed to full throttle. The engine was then held in a condition of wide open throttle for about 30 seconds with the parking brake applied. The parking brake held the bus stationary throughout this test.

The third test also involved the parking brake. During this test, the parking brake was partially released. To perform this test, the parking brake was applied and then released. However, the service brakes were not applied once the parking brake had been released. Because of the design of the parking brake system, the rear brake pushrods were still mechanically locked in an “activated” position. The bus remained stationary until the accelerator was depressed to full throttle. With the application of full throttle, the bus slowly moved forward.

The final test involved the rear door interlock system. During this test, both the parking brakes and service brakes remained unused. The rear door interlock lever was engaged and the bus’s transmission was shifted into drive. The bus remained stationary, and no vehicle movement was observed. The accelerator was depressed to full throttle, and no increase in engine rpm was detected with the engine remaining at idle speed.

In her statements to investigators, the driver trainee maintained that she had applied the brake throughout the accident sequence. The investigation did not find any corroborative evidence to verify the driver trainee’s assertion. Analysis of the results from all the foregoing tests demonstrated that the bus’s brake system was adequate to hold the vehicle stationary regardless of throttle position. Had the driver trainee placed her foot on the service brake, as she indicated to investigators, the bus would not have accelerated forward, over-ridden the curb, and traveled onto the pedestrian platform. Additionally, had the driver trainee inadvertently placed her foot on the accelerator and then either removed it from the accelerator and applied the service brake or applied the service brake while the accelerator was still depressed to wide open throttle, the bus would have stopped. The Safety Board therefore concludes that the driver trainee misapplied her foot to the accelerator pedal, thereby causing the unintended acceleration of the bus.

Time and Distance Calculations

Calculations, based on the bus’s lowest tested rate of acceleration (4.18 feet per second per second), indicate that from the moment it first started moving the bus would have required 2.5 seconds to travel to the point where the right front tire contacted the curb and would have attained a speed of 7 mph. From there, it would have taken an additional 1.8 seconds until the front of the bus collided with the first pedestrian shelter at a speed of 12 mph. Using the high value attained during the acceleration tests (5.15 feet per second per second), the results would have changed as follows: the bus would have traveled the initial distance of 14 feet in 2.3 seconds and would have rolled over the curb at a speed of 8 mph; then, continuing from the curb to the collision with the pedestrian shelter would have required an additional 1.6 seconds and the bus would have been traveling at 13 mph at the time of impact with the shelter. (See figure 7.)

The misapplication of the accelerator resulted from the associated effect of numerous conditions, including the inexperience of the driver trainee, the close proximity of the pedals, and the pedals’ similarity in shape and feel. Under the influence of these conditions, the driver trainee believed, as is common during incidents of unintended acceleration,[12] that she was applying pressure to the brake pedal. Because of this misapprehension, she maintained a continuous application of the accelerator until some point after the bus collided with the pedestrian shelters. The Safety Board therefore concludes that a combination of factors contributed to the driver trainee’s pedal misapplication. In light of the driver trainee’s failure to recognize her mistake about the pedal application, the relatively short distance traveled by the accident vehicle before striking pedestrians, and the limited time available under the acceleration scenarios tested, the Safety Board concludes that, once the bus began to accelerate, the driver trainee did not have sufficient time to avoid the encroachment onto the pedestrian platform.

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[12]Schmidt, *Unintended Acceleration: A Review of Human Factors Contributions.*

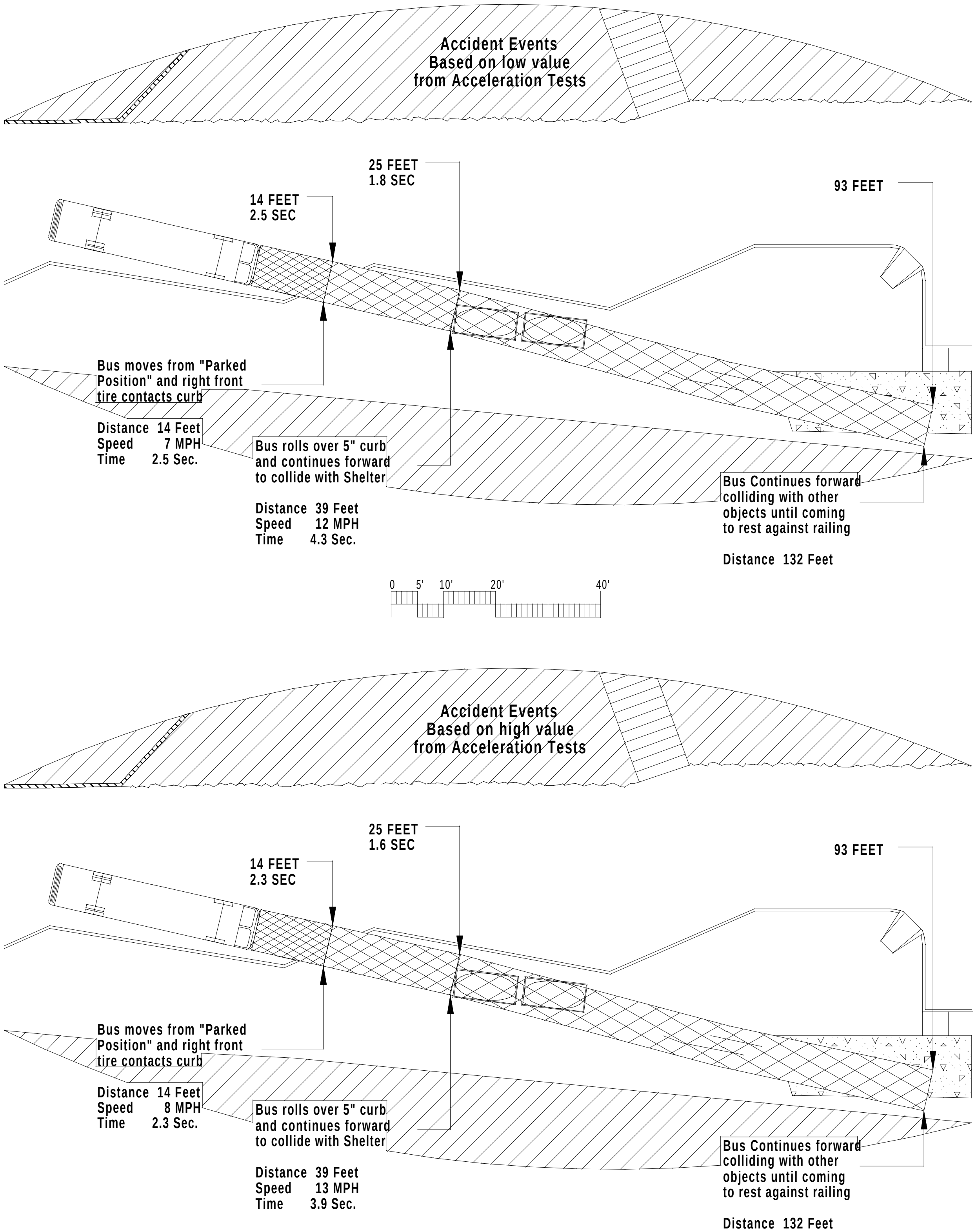

Figure 7 -- Acceleration test scenarios

Given the rapidity with which the accident developed, and the fact that the driver trainee did not immediately recognize her error, she did not have time to use steering input to avoid the pedestrians. Investigators determined that once the bus had surmounted the curb, the driver trainee did not have sufficient time to steer the bus to successfully avoid the collision with the first pedestrian shelter. Consequently, the Safety Board concludes that the excessive steering wheel lash of the accident bus did not contribute to the accident.

SAFETY ISSUES

While investigating this accident, the Safety Board found that the accident's most significant element was not its cause but its severity. In many instances, a similar momentary error on the part of a busdriver might have had far less serious consequences — such as damage to the bus and other property, slight injuries, or both. In this case, however, four people died and two suffered serious injuries. The crucial variable was the presence of unprotected pedestrians in the bus's path. Therefore, the Safety Board considered whether and how the effects of the accident could have been mitigated. The safety issues identified during the investigation were:

1. The sufficiency of pedestrian protection provided by the saw-tooth parking bay design, and

2. The need for positive separation between the roadway and pedestrian areas of parking bay facilities.

Transit Station Facility Design

The BSDA's MetroLink line has a total of 18 stations, 4 of which are designed with saw-tooth bus parking bays similar to the accident location. A review of the BSDA's facility design requirements revealed that, during design development, attention was focused on avoiding conflicts and crossovers between buses and other vehicular traffic, as well as between buses and pedestrian traffic. The BSDA design specifications provided for, among other things, "standard saw-tooth bus bay" parking spaces and walkways to be paved and raised about 6 inches above the adjacent road surface.

No provisions were made for the construction of barricades or other devices to prevent vehicular traffic from entering areas of pedestrian congregation. The only barrier planned to be between the bus parking spaces and the pedestrian platforms was a raised 6-inch-high[13] concrete curb. As a consequence of these design requirements and specifications, the facilities incorporating the saw-tooth parking bays were laid out in such a way that when buses pull into the parking spaces, their forward motion is directed toward areas where pedestrians tend to congregate.

According to the BSDA's deputy executive director and general manager of engineering and facilities management, the facility where the accident occurred was designed and built in accordance with guidelines common to the transit industry. The saw-tooth design is intended to facilitate station access by the passenger buses and minimize interference from pedestrian traffic. In 1981, the Urban Mass Transportation Administration (UMTA)[14] publicized the design specifications for saw-tooth parking bays and illustrated their efficiency in providing parking for multiple buses. Additionally, the American Association of State Highway and Transportation Officials (AASHTO) guideline for park and ride facilities[15] states:

> …where more than two buses are expected to be using a facility at one time, the saw-tooth arrangement is generally preferable, because it is easier for buses to bypass a waiting bus.

Although officials at neither the FTA nor the American Public Transit Association (APTA) could estimate the percentage of stations using the saw-tooth configuration, the Safety Board is aware that station designs similar to the accident location have been used nationwide for many years. A consulting engineer employed by the BSDA told investigators that the design has been commonly used throughout his 40-year career.

While the Safety Board recognizes the efficiency of the saw-tooth station design for

[13]The measured height of the curb overrun by the accident bus was 5 inches.

[14]In 1991, UMTA was reorganized into the FTA.

[15]AASHTO, *A Policy on Geometric Design of Highways and Streets*,1994 edition.

multiple bus parking, it is concerned that neither the design specifications followed by the BSDA nor the guidelines provided by UMTA or AASHTO include any type of positive separation that could prevent a defective or poorly driven bus from encroaching onto the pedestrian platform in normal (low-speed) operating conditions for parking lot facilities. A further selection from the AASHTO guideline for park and ride facilities states that:

> …the area delineating the passenger refuge area should be curbed in order to reduce the height between the ground and the first bus step and reduce encroachment by buses on the passenger areas.

The Normandy station was designed in accordance with this guideline, which calls for a curb as the only separating device. The Safety Board considers that design guidelines should specify a positive separation barrier between the bus parking bay and the pedestrian platform sufficient to stop a bus operating under normal parking area speed conditions from progressing into the pedestrian area. The circumstances of the Normandy accident clearly illustrate that the curb-only separation cannot contain the forward movement of a large bus. Consequently, the Safety Board concludes that the current design guidelines for saw-tooth parking bay configurations commonly followed by the transit industry fail to provide adequate pedestrian safety.

Therefore, the Safety Board believes that, in cooperation, the Federal Highway Administration, the FTA, AASHTO, APTA, and the Community Transportation Association of America, should ensure that future transit facility designs incorporating saw-tooth bus parking bays, or other types of designs that direct errant vehicular traffic toward pedestrian-occupied areas, include provisions for positive separation between the roadway and pedestrian areas sufficient to stop a bus operating under normal parking area speed conditions from progressing into the pedestrian area.

Further, to ensure that the significance of this issue is appreciated within the public transport industry, the Safety Board believes that APTA and the Community Transportation Association of America should notify their memberships of the circumstances of the Normandy, Missouri, accident of June 11, 1997, and encourage them to retrofit any existing facilities that incorporate saw-tooth bus parking bays or other types of designs that direct errant vehicular traffic toward pedestrian-occupied areas to include provisions for positive separation between the roadway and pedestrian areas sufficient to stop a bus operating under normal parking area speed conditions from progressing into the pedestrian area.

Postaccident Actions

After the accident, the BSDA took immediate action to address the safety problem posed by inadequate protection between bus parking and pedestrian areas. The BSDA installed barriers at all its facilities with saw-tooth parking bay layouts. Bollards[16] designed to prevent low-speed overruns were placed at the forward ends of all saw-tooth bus parking spaces at each of the four stations with saw-tooth bus bays. Such bollards will be included in the designs of future BSDA stations. Safety Board investigators examined the bollard installations and found them adequate to have stopped the bus involved in this accident from reaching the pedestrian area. Therefore, the Safety Board concludes that, had the positive separation barriers now installed at the Normandy station been in place at the time of the accident, the collision with the pedestrians would not have occurred.

The Safety Board is aware that other transit jurisdictions have used means other than bollards for providing positive separation between buses and pedestrian areas. The Safety Board appreciates that site- or system-specific approaches to positive separation that provide for adequate pedestrian safety can be successfully developed and employed by transit authorities. The Safety Board does not intend to prescribe any particular means of positive separation, so long as the means selected are effective in ensuring pedestrian safety.

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[16] A single bollard is designed to stop a 36,000-pound vehicle traveling at 4 mph. Three bollards of concrete-filled, 8-inch-diameter, heavy-wall steel pipe are used at each parking space. The pipe is set vertically in a 6-foot, auger-drilled hole, and retained by reinforced concrete.

CONCLUSIONS

Findings

1. Neither weather nor vehicle conditions were factors in this accident.

2. Activation of the emergency stop switch could not have averted this accident.

3. The driver trainee was not fatigued, impaired, or suffering from any medical conditions that may have affected her performance.

4. The driver trainee misapplied her foot to the accelerator pedal, thereby causing the unintended acceleration of the bus.

5. A combination of factors contributed to the driver trainee's pedal misapplication.

6. Once the bus began to accelerate, the driver trainee did not have sufficient time to avoid the encroachment onto the pedestrian platform.

7. The excessive steering wheel lash of the accident bus did not contribute to the accident.

8. The current design guidelines for saw-tooth parking bay configurations commonly followed by the transit industry fail to provide adequate pedestrian safety.

9. Had the positive separation barriers now installed at the Normandy station been in place at the time of the accident, the collision with the pedestrians would not have occurred.

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the driver trainee's misapplication of the accelerator, resulting in the bus's over-ride of the curb and travel onto the occupied pedestrian platform. Contributing to the deaths and injuries was the absence of effective positive separation between the transit facility roadway and the station's pedestrian platform.

RECOMMENDATIONS

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

— to the Federal Highway Administration:

Ensure, in cooperation with the Federal Transit Administration, the American Association of State Highway and Transportation Officials, the American Public Transit Association, and the Community Transportation Association of America, that future transit facility designs incorporating “saw-tooth” bus parking bays, or other types of designs that direct errant vehicular traffic toward pedestrian-occupied areas, include provisions for positive separation between the roadway and pedestrian areas sufficient to stop a bus operating under normal parking area speed conditions from progressing into the pedestrian area. (H-98-1)

— to the Federal Transit Administration:

Ensure, in cooperation with the Federal Highway Administration, the American Association of State Highway and Transportation Officials, the American Public Transit Association, and the Community Transportation Association of America, that future transit facility designs incorporating “saw-tooth” bus parking bays, or other types of designs that direct errant vehicular traffic toward pedestrian-occupied areas, include provisions for positive separation between the roadway and pedestrian areas sufficient to stop a bus operating under normal parking area speed conditions from progressing into the pedestrian area. (H-98-2)

— to the American Association of State Highway and Transportation Officials:

Ensure, in cooperation with the Federal Highway Administration, the Federal Transit Administration, the American Public Transit Association, and the Community Transportation Association of America, that future transit facility designs incorporating “saw-tooth” bus parking bays, or other types of designs that direct errant vehicular traffic toward pedestrian-occupied areas, include provisions for positive separation between the roadway and pedestrian areas sufficient to stop a bus operating under normal parking area speed conditions from progressing into the pedestrian area. (H-98-3)

— to the American Public Transit Association:

Ensure, in cooperation with the Federal Highway Administration, the Federal Transit Administration, the American Association of State Highway and Transportation Officials, and the Community Transportation Association of America, that future transit facility designs incorporating “saw-tooth” bus parking bays, or other types of designs that direct errant vehicular traffic toward pedestrian-occupied areas, include provisions for positive separation between the roadway and pedestrian areas sufficient to stop a bus operating under normal parking area speed conditions from progressing into the pedestrian area. (H-98-4)

Notify your members of the circumstances of the Normandy, Missouri, accident of June 11, 1997, and encourage them to retrofit any existing facilities that incorporate saw-tooth bus parking bays or other types of designs that direct errant vehicular traffic toward pedestrian-occupied areas to include provisions for positive separation between the roadway and pedestrian areas sufficient to stop a bus operating under normal parking area speed conditions from progressing into the pedestrian area. (H-98-5)

— to the Community Transportation Association of America:

Ensure, in cooperation with the Federal Highway Administration, the Federal Transit Administration, the American Association of State Highway and Transportation Officials, and the American Public Transit Association, that future transit facility designs incorporating "saw-tooth" bus parking bays, or other types of designs that direct errant vehicular traffic toward pedestrian-occupied areas, include provisions for positive separation between the roadway and pedestrian areas sufficient to stop a bus operating under normal parking area speed conditions from progressing into the pedestrian area. (H-98-6)

Notify your members of the circumstances of the Normandy, Missouri, accident of June 11, 1997, and encourage them to retrofit any existing facilities that incorporate saw-tooth bus parking bays or other types of designs that direct errant vehicular traffic toward pedestrian-occupied areas to include provisions for positive separation between the roadway and pedestrian areas sufficient to stop a bus operating under normal parking area speed conditions from progressing into the pedestrian area. (H-98-7)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

JAMES E. HALL
Chairman

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Vice Chairman

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Member

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February 19, 1998