

**TRANSPORTATION SCIENCES CENTER
ACCIDENT RESEARCH GROUP**

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**CALSPAN ON-SITE FATAL SCHOOL BUS/PEDESTRIAN INVESTIGATION
CALSPAN CASE NO. CA97-01
SCHOOL BUS: INTERNATIONAL 3800 CHASSIS/
THOMAS BUILT BODY
LOCATION: GEORGIA
INCIDENT DATE: JANUARY, 1997**

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The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points are coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety systems.

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<i>16. Abstract</i> This on-site investigation focused on an 8 year old female pedestrian who attempted to exit from her school bus at her designated stop in front of her residence. Her backpack was snagged in the door of the bus as the driver accelerated from the bus stop. She was subsequently dragged 44 m (145') prior to the back pack disengaging from the door. The pedestrian was run over by the right rear tires of the bus and sustained fatal abdominal injuries.			
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TECHNICAL SUMMARY

This on-site investigation focused on a fatal school bus/pedestrian incident that occurred during daylight hours in Georgia, in January, 1997. An 8 year old female pedestrian was wearing a denim backpack over her left shoulder as she attempted to exit a conventional chassis International school bus in front of her residence. As she stepped from the bus, the driver closed the pneumatically operated bi-fold door and snagged her backpack between the door and the door frame. The driver was unaware of this event and accelerated from the bus stop. Witnesses to the incident observed the pedestrian facing the bus, pulling on the backpack in an attempt to free it from the door. As the bus began to accelerate forward, the pedestrian began running along side the bus. She was pulled and/or fell to the asphalt road surface and was dragged approximately 44 m (145') prior to the backpack disengaging from the door. The pedestrian was subsequently run over by the right rear tires of the bus. She sustained a massive disruption of the liver (AIS-5), a ruptured diaphragm (AIS-4), and multiple soft tissue injuries (AIS-1) and expired at the scene of the incident. The backpack was found clenched in her left hand. The bus driver was unaware of the incident and continued on his assigned route. None of the 12 children aboard the bus were aware of the incident.

This fatal incident was initially reported to the Special Crash Investigation (SCI) COTR by the NHTSA's Atlanta Regional Office. Calspan was subsequently notified on Friday, January 10, 1997, and initiated an on-site investigation on January 14.

The incident occurred on a rural 2-lane roadway in a mixed area of residential and institutional facilities. The asphalt road surface was level and curved to the right with respect to the travel direction of the school bus. Earth shoulders and shallow drainage ditches bordered both edges of the roadway. In the vicinity of the scene, faint solid white edge lines and double yellow center lines delineated the travel lanes. The total

road width was 6.6 m (21.6'). The posted speed limit was 56 km/h (35 mph). Weather conditions were police reported as overcast skies with rain, therefore the road surface was wet.

The involved school bus was a 1994 International 3800 series conventional chassis with a Thomas Built Buses Inc. seventy one (71) passenger body. The bus was owned and operated by the county Board of Education. The school bus was identified by vehicle identification number 1HVBBAAN4SH (production number deleted) with a body identification number of 28679-9412350-C-1100S and a chassis number of 66873. The power unit/chassis was manufactured in June, 1994, and the body was built in September, 1994. The odometer reading was 42,664.8 km (26,511.4 miles) at the time of our inspection. The overall exterior dimensions of the school bus were: length 11.1 m (36.4') and width 2.4 m (8.0'), with a wheelbase of 7 m (23').

The school bus was equipped with six (6) exterior mirrors affixed to the cowl and upper A-pillars of the vehicle (refer to Photograph Nos. 20 and 21). Half-round parabolic (convex) mirrors were mounted to the outboard front corners of the bus. The mirrors measured 17.8 cm x 29.8 cm (7.0 x 11.75") height by width and were 8.9 cm (3.5") in depth. The base of the left and right parabolic mirrors were mounted 161.3 cm (63.5") and 158.8 cm (62.5") above the ground respectively. These parabolic mirrors were mounted and adjusted properly to provide the driver visibility across the front of the bus and along the forward side aspects of the vehicle (refer to Photograph No. 22). A flat plane mirror and a shallow convex mirror were mounted to the right and left pillars of the school to provide the driver with visibility along the sides of the bus. The flat plane mirror measured 26.0 cm x 18.1 cm (10.25 x 7.12") wide height by width. The bottom edge of the left mirror was 208.3 cm (82.0") above the ground and the bottom edge of the right mirror was 208.8 cm (82.5") above the ground. The convex mirror was 20.3 cm (8.0") in diameter and mounted below the plane mirror. The convex mirrors were located 189.9 cm (74.75") and 179.1 cm (70.5") above the ground, left and right respectively. These mirrors were mounted approximately 50.8 cm (20.0") forward of the windshield and were properly adjusted to provide the driver adequate visibility along the side of the school bus (refer to Photograph No. 23). It should be noted that all mirrors were original factory equipment and were adjusted to the specific requirements of the driver. The Field of View Test for Federal Motor Vehicle Safety Standard (FMVSS) 111 was performed during this on-site investigation. The results of this test area are included in the Conclusion Section of this report.

The interior of the school bus was designed for a total of 72 occupants, inclusive of the driver. The driver's compartment was configured with the forward instrument panel which housed the various gauges and the speedometer. Left of the driver's position was a second instrument panel. Mounted on this panel were switches for the interior and exterior lights, controls for wiper and washer, and rocker switches for the fan and heaters. A two-way radio system with microphone and an AM/FM radio was mounted in the lower aspect of the panel. On the forward aspect of the panel was a toggle switch that operated the pneumatic bi-fold entrance door (refer to Photograph Nos. 29 through 31). The switch was 6.0 mm (0.25") in diameter and extended outward from the console 5.7 cm (2.25"). To operate, the driver toggled the switch forward to open the door and rearward to close the door. The four-speed automatic transmission shift lever was mounted to the mid instrument panel, forward and right of the driver's position.

The driver's seat was a high-back seat with an integral head restraint mounted on a pedestal base. A three-point lap and shoulder belt system was configured into the left B-pillar. The passenger seating consisted of twelve rows of seats with a center aisle. The left side of the bus had eleven (11) rows of three (3) passenger high back seats with a two (2) passenger seat positioned in the twelfth row. The right side of the bus consisted of twelve (12) rows of three (3) passenger high backed seats. The three passenger seats were 97.1 cm (38.25") in width with seat backs that extended 66.7 cm (26.25") above the seat cushion. The overall height of the seat from floor to seat back was 101.3 cm (39.9"). The bus was not equipped with lap belts for the passenger seated positions. The two passenger seats on the left side twelfth row allowed access to the rear emergency exit door. The rear emergency door was hinged on the right side of the bus and opened in an outward direction.

The right side forward entrance/exit door was an electro-pneumatically operated bi-fold panel door. The door opened in a forward direction from the right B-pillar to A-pillar. The panels were hinged in the center and opened into the bus interior. Pneumatic power was derived from the vehicle's on board compressed air system. The operating pressure of the air system was 758 kPa (110 psi) as indicated by the pressure gauge mounted on the instrument panel. A series of tests were conducted to measure the closure time of the door. An average closure time of 2.57 seconds was measured over 10 test cycle with the engine running to maintain the required air pressure. Measurements were taken from switch actuation to full door closure. A pull test on the interior door handle was also conducted. A police officer, assisting during the inspection, could not pull the door open by the interior auxiliary handle while the door was fully closed under air pressure.

The forward door panel measured 27.9 cm (11.0") in width and the rear door panel was 42.9 cm (16.88") wide. The width of the door opening with the door swung open was approximately 71.1 cm (28.0"). Each door panel contained two glazing panels. The upper glazing of the forward door measured 72.4 cm x 19.1 cm (28.5 x 7.5") height by width. The height and width measurements of the forward door's lower glazing were 94.0 cm x 19.1 cm (37.0 x 7.5"). The upper and lower glazing measurements (height by width) of the rear door were 72.4 cm x 34.6 cm (28.5 x 13.62") and 94.0 cm x 34.6 cm (37.0 x 13.62"), respectively. The lower glazing of the rear door was covered with a light layer of road film at the time of inspection, however, visibility through the glazing was not adversely effected (refer to Photograph Nos. 33, 34 and 41).

A bulb-shaped rubber type weather-strip/gasket was fixed to the leading edge of the B-pillar. The bulb gasket measured 3.5 cm (1.4") laterally across its face by 2.2 cm (0.9") in compressible depth. Affixed to the trailing edge of the door was a two piece weather-strip/gasket. The two piece gasket was attached to the trailing edge of the door by a U-channel. The interior aspect of the gasket measured 8 mm (5/16") in compressible depth while the exterior aspect of the gasket measured 3.0 cm (1 3/16"). As the pneumatic door closed, the channel section on the trailing door edge and the interior gasket contacted the face of the B-pillar bulb. With the door in the fully closed position, the bulb gasket compressed to approximately 3.2 mm (0.125"). The exterior gasket attached to the door overlapped the exterior face of the B-pillar bulb

gasket forming a weather tight seal (refer to Photograph Nos. 17 through 19). This overlapping effect of the gaskets was a causative factor in the backpack's entrapment.

The stairwell entrance to the school bus consisted of four stair treads and three risers. The fourth stair tread was the floor of the bus. The first tread was 30.5 cm (12.0") above the ground and had a depth (run) of 26.7 cm (10.5"). The stair risers were of equal height, measuring 23.3 cm (9.125"). The depth (run) of second and third stairs measured 23.5 cm (9.25"). The width of the stairwell entrance was 81.9 cm (32.25") and tapered to 57.2 cm (22.5") at the bus floor. On the trailing (right) side of the stairwell was a single rail handrail. The rail was formed from 2.5 cm (1.0") diameter stainless steel tubing and was attached to the padded crash barrier that was located in front of the first row of seats on the right side of the bus. The rail was 102.9 cm (40.5") long and extended out from the barrier 9.2 cm (3.62") and was attached to the crash barrier by cap screws. The mounting orientation of the handrail had been reversed such that the 12.7 cm (5.0") angled segment of the rail was located at the upper level. The rail terminated at the end of the second step with 9.2 cm (3.625") radius. This reversed mount defeated the "snagged drawstring scenario" seen in previous incidents (refer to Photograph No. 32).

This school bus was equipped with an on-board video camera surveillance system that was utilized by the school district to monitor the activities of the passengers and/or the driver. All buses within the fleet were equipped with the box units that house the cameras. Eight cameras were rotated within the fleet on an as-needed basis. The unit on this bus was mounted to the front bulkhead adjacent to the left A-pillar (refer to Photograph Nos. 24-26). The unit was identified as a Bus Commander that was manufactured/marketed by 3-1, Inc. of Punta Gorda, FL. The box contained a two-way mirror which concealed the installation of a camera. There was no on-board video camera installed in this bus on the day of this fatal incident.

The driver of the bus was a 62 year old male with a height of 167.6 cm (66.0") and weight of 74.8 kg (165.0 lbs). The driver's school bus experience dates back to 1971-76 when he was employed as a full-time driver. He returned to bus driving in 1985-86 as a substitute driver and had been employed as a full time driver for the school district for the past 10 years. He had received all required update training over his tenure and had received extensive training in the fall of 1996. His current commercial driver's license (CDL) was issued on May 3, 1996, and his medical certification was approved in August, 1996. This driver did not wear prescription eyeglasses and was regarded as a solid performer with an excellent driving history.

The school district maintained a fleet of 101 school buses with 81 units assigned to daily routes. The district has a 10 year replacement cycle for buses and the entire fleet of buses are less than 12 years old. This incident related school bus was initially assigned as a new vehicle to the driver's wife who was employed as a driver by the district. The bus was reassigned to this driver approximately 1 year prior to this incident. The buses are retained at the driver's residence during off-hours, unless repair orders or routine maintenance is required. Therefore, the driver was extremely familiar with the operating conditions and procedures of this vehicle.

The pedestrian was an 8 year old female with a reported height of 132.0 cm (52.0") and weight of 31.8 kg (70.0 lb). She was wearing a multi-colored jacket, blue denim jeans, a pink sweat shirt and white tennis shoes. In addition, she was carrying a backpack that was constructed of blue denim material and measured 27.9 cm by 38.1 cm (11.0 X 15.0"), width by length. Crayons and papers were found inside the backpack at the time of the incident and the pack weighed approximately 0.5 kg (1.0 lb). Two 3.8 cm (1.5") wide straps, 54.6 cm (21.5") in length, were attached to the back of the pack. The two straps were sewn approximately 8.9 cm (3.5") apart to the top of the pack, at the shoulder. Each strap then fed through a brass eyelet at the bottom pack and returned through a brass adjustment clip located 29.2 cm (11.5") above the bottom of the pack (refer to Photograph Nos. 44 through 46). The eyelets on the bottom edge of the pack were 21.3 cm (8.0") apart.

The pedestrian had initially boarded the school bus at her school following the conclusion of the school day. The driver departed the school at approximately the scheduled time. He had completed several stops and discharged the elementary aged children at their respective stops. However, due to the inclement weather, the driver fell behind on his schedule and was approximately 15 minutes late for the discharge of this involved pedestrian. On the approach to this stop, the driver was traveling in an easterly direction and negotiating the right curve.. A non-contact passenger vehicle was following the school bus on the approach to the bus stop adjacent to the pedestrian's driveway. Due to the curvature of the roadway, this driver was afforded a clear line of sight along the right side of the bus and therefore, witnessed the event. A second witness was traveling westbound and stopped for the bus, east of the designated stop point. A third witness was the pedestrian's father who was standing in the doorway of his residence. He became concerned about his daughter due to the 15 minute delay in her return from school.

As the driver stopped adjacent to the pedestrian's driveway, the pedestrian walked toward the door of the bus and descended the stairwell, exiting the vehicle through the right front bi-fold door. As she exited the bus, her denim backpack was positioned over her left shoulder with her left arm extended through the right shoulder strap. She did not wear the backpack with both straps positioned over her shoulders. As she stepped from the bus, the driver closed the pneumatic doors by activating the left side mounted toggle switch. The witness who was positioned in the westbound vehicle noted that the driver was looking to his left away from the pedestrian as he closed the door and began to accelerate from the bus stop. The driver stated to the investigating officer that he observed the pedestrian step from the bus and walk 3-4 steps from the vehicle prior to his departure from the stop.

As the driver closed the pneumatic doors, the pedestrian's denim backpack became caught in the door between the door's weatherstripping and the B-pillar bulb-type gasket. The witness positioned in the vehicle behind the bus indicated that the pedestrian began to pull on her backpack in an attempt to free the item from the bus. She further noted that the pedestrian began to run along side the bus as the driver accelerated from the stop. The witness traveling opposite the bus, saw the pedestrian exit the bus and turn toward the bus and pull on something. As the bus began to move, the witness lost sight of the pedestrian and began to accelerate her vehicle in a westerly direction. The pedestrian's father saw the bus approach

the bus stop and walked to the door to greet his daughter. As he opened the door, he initially did not see the pedestrian. He heard her scream and then observed her being pulled along by the bus.

The pedestrian was dragged by the bus for a police reported distance of 44 m (145'). The backpack subsequently disengaged from the door and the pedestrian fell onto the asphalt road surface in a face-down attitude. The right rear dual tires of the school bus subsequently ran over the buttock and lower back area of the pedestrian. Tire marks were visible on the posterior aspect of the pedestrian's jeans (refer to Photograph No. A-13). Road film was prevalent on the anterior aspect of the jeans as documented in Photograph No. 14.

As a result of the dual rear tires of the bus riding over the pelvic and lumbar regions of the pedestrian, she sustained a 10.2 cm (4.0") wide contusion across the lower back (AIS-1), a contusion across the lower buttocks and thigh areas (AIS-1), and extensive liver laceration with retroperitoneal blood (AIS-5), a ruptured diaphragm (AIS-3), and a right lung laceration with bilateral hemothorax (AIS-3). In addition, the pedestrian sustained multiple soft tissue injuries from compression and contact with the asphalt road surface. These soft tissue injuries (AIS-1) included a left palmar thumb contusion which measured 4.4 x 2.5 cm, a left upper abdominal contusion (3.8 x 3.8 cm), a left medial knee abrasion with contusion, a 1.3 cm abrasion of the right lateral knee, a right lateral ankle abrasion (3.8 cm), a right lateral ankle contusion (6.4 x 3.8 cm), and a left lateral knee abrasions.

The pedestrian's father stated that he heard the child scream and observed her as she was dragged by the school bus. He immediately ran toward the bus and observed the pedestrian as she disengaged from the bus and was subsequently run over by the rear dual tires of the vehicle. As he reached the pedestrian, she was conscious momentarily and communicated that she had difficulty breathing. The father noted that her backpack remained in her left hand. He grabbed the backpack and threw it off road approximately 9 m (30') from the final rest position of the pedestrian. The pedestrian expired at the scene following the arrival of police personnel.

The driver of the school bus was unaware of the sequence of events that involved the pedestrian. He stated to the investigating officer that he observed the pedestrian walk 3-4 steps from the bus prior to closing the pneumatic door and proceeding in an easterly direction from the bus stop. He noted that there was no sounds associated with the incident or bump from running over the pedestrian. The driver continued on his route to discharge the remaining 12 students who were on-board the bus when the incident occurred. The students on-board the bus were reportedly unaware of the pedestrian's involvement with the bus and subsequent overrun. The driver returned to the school for his second scheduled bus run and completed this run prior to returning to his residence where he was informed of the fatal incident.

The involved school bus was impounded by the investigating police agency and was retained for our inspection. In addition, the pedestrian's backpack was retained by the police and was available for our inspection. The following evidence supported the scenario that the backpack was snagged between the pneumatically operated bi-fold door and the B-pillar:

Evidence on the denim backpack consisted of an abrasion/scuff on the lower aspect of the right strap adjacent to the bottom eyelet. The abrasion/scuff extended 14.0 cm (5.5 in) from the eyelet on the main strap material and extended 6.4 cm (2.5 in) on the adjustment strap (refer to Photograph Nos. 47 through 50). Two probable fabric transfers were found on the inside edge of the school bus door weatherstripping. These transfers were located 94.0 to 100.0 cm (37.0 to 39.5 in) and 109.9 to 112.4 cm (43.25 to 44.25 in) above the ground respectively. Based on this evidence, the backpack was repositioned between the bus door and the B-pillar. Photograph Nos. 39 through 43 depict the manner in which the backpack was caught in the door. With the backpack caught in this manner the adjustment clip was trapped on the interior of bus (refer to Photograph No. 43). A series of pull tests was conducted to determine if the backpack could be freed from this type of entrapment. These tests indicate that the strap material would slide through and between the weatherstripping, however, the adjustment clip would disengage only if pulled vertically through the weatherstrip. The backpack would not disengage from the door by pulling the straps and clip horizontally.

PEDESTRIAN INJURIES

Injury	Severity (AIS-90)	Injury Mechanism
Left palmar thumb contusion, 4.4 x 2.5 cm	Minor (790402.12)	Asphalt road surface
Left upper abdomen contusion, 3.8 x 3.8 cm	Minor (590402.12)	Asphalt road surface
10 cm lower back contusion	Minor (690402.18)	Dual rear tires of bus
Contusion across lower buttock and thigh	Minor (890402.13)	Dual rear tires of bus
Left medial knee contusion	Minor (890402.12)	Asphalt road surface
Left medial and lateral knee abrasions	Minor (890202.12)	Asphalt road surface
Right lateral knee abrasion, 1.3 cm	Minor (890202.11)	Asphalt road surface
Right lateral ankle abrasion, 3.8 cm	Minor (890202.11)	Asphalt road surface
Left lateral ankle contusion, 6.4 x 3.8 cm	Minor (890402.11)	Asphalt road surface
Right lung laceration with bilateral hemothorax	Serious (441430.31)	Dual rear tires of bus
Ruptured diaphragm	Serious (440604.38)	Dual rear tires of bus
Extensive liver laceration	Critical (541828.51)	Dual rear tires of bus

FIELD OF VIEW TEST RESULTS

The Field of View Test was performed utilizing a 30 cm (12") tall cylinder that was 30 cm in diameter. The test cylinder was painted orange as a contrasting color to the bus and the asphalt surface. A grid system was established around the perimeter of the bus and the cylinder was placed at the standard 13 positions (Grid Points A-P). In addition, the cylinder was placed adjacent to the right B-pillar. The schematic of the grid points is included as Attachment D of this report. The results of the test are as follows:

FIELD OF VIEW TEST RESULTS

Grid Point	Mirror/Location	Observation
A	Front cowl mounted parabolic mirrors, left and right side	Test cylinder was not visible in either mirror
B	Front cowl mounted parabolic mirrors, left and right side	Test cylinder was not visible in either mirror
C	Front cowl mounted parabolic mirrors, left and right side	Test cylinder was not visible in either mirror
D	Front cowl mounted parabolic mirrors, left and right side	Test cylinder was visible in the inboard aspect of the right parabolic mirror, however, not visible in the left side mirror
E	Front cowl mounted parabolic mirrors, left and right side	Test cylinder was not visible in either mirror
F	Front cowl mounted parabolic mirrors, left and right side	Test cylinder was visible in the inboard aspect of the left parabolic mirror, however, not visible in the right mirror
G	Front cowl mounted parabolic mirrors, left and right side	Test cylinder was visible in the right parabolic mirror, however, not visible in the left mirror
H	Front cowl mounted parabolic mirrors, left and right side	Test cylinder was visible in both front mounted parabolic mirrors
I	Front cowl mounted parabolic mirrors, left and right side	Test cylinder was visible in the left convex parabolic mirror, however, not visible in the right mirror
K	Right side cowl mounted parabolic mirror	Test cylinder was fully visible in the right parabolic mirror

N	Right A-pillar mounted convex mirror	Test cylinder was faintly visible in the right convex mirror, not visible in the right plane mirror
O	Right side cowl mounted parabolic mirror and the right A-pillar mounted convex mirror	Test cylinder was centered in both the right front parabolic mirror and the right convex mirror
P	Not tested at this location	N/A
Adjacent to the right B-pillar area	Right side cowl mounted parabolic mirror and the right A-pillar mounted convex mirror	Test cylinder was centered in the right parabolic mirror and visible in the lower center area of the right convex mirror

CONCLUSIONS/CAUSAL FACTORS

1. The primary causal factor for the fatal pedestrian incident was the driver's failure to visually track the pedestrian to a safe distance from the bus prior to his departure from the bus stop. In addition, the driver failed to check his rear views for persons, vehicles, or objects, adjacent to the right side of the bus. The right B-pillar area of the bus was visible to the driver in the center area of the right front corner mounted parabolic mirror and in the lower center area of the right A-pillar mounted convex mirror. The transportation supervisor stated that the driver was approximately 15 minutes behind schedule, therefore he was probably attempting to makeup time by initiating rapid departures of the students on-board the bus.
2. The location of the pneumatic door toggle (activation) switch on the left side console panel, required the driver to divert his attention away from the pedestrian's egress from the school bus.
3. The construction and fitment of the pneumatically operated bi-fold door against the the right B-pillar prevented object similar to the backpack from pulling through with minimal resistance such as that offered by a small child.