

**TRANSPORTATION SCIENCES
CRASH RESEARCH SECTION**

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VERIDIAN ON-SITE SCHOOL BUS CRASH INVESTIGATION

VERIDIAN CASE NO. CA99-009

SCHOOL BUS CHASSIS -1999 FREIGHTLINER CONVENTIONAL

BODY - BLUE BIRD 65 PASSENGER CAPACITY

LOCATION - STATE OF NEW YORK

CRASH DATE - MAY, 1999

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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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<p>16. <i>Abstract</i> This on-site investigation focused on a 1999 Freightliner school bus (conventional chassis) that was involved in a right angle collision with a 1988 Ford Tempo GL 4-door sedan. The school bus was eastbound on an approach to a 4-leg intersection with thirty three (33) elementary age passengers on board. The bus driver and (approximately) fifteen (15) passengers were properly restrained by the available 2-point manual lap belt systems. The southbound Tempo was driven by an 83 year old female who was properly restrained by the available 2-point motorized automatic shoulder belt system (manual lap belt not used). The driver failed to detect the stop sign or the bus as both vehicles entered the intersection where the front of the Tempo struck the left rear axle and rear sheet metal area of the school bus. Five children were reported as injured, however, only four were transported to a local hospital for treatment and released. A lip laceration was the most severe injury sustained by the child passengers. The driver of the Ford Tempo complained of (unspecified) lower extremity pain and was also transported to a local hospital for treatment and released.</p>			
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TABLE OF CONTENTS

BACKGROUND	1
SUMMARY	
Crash Site	1
Pre-Crash	1
Crash	2
Post-Crash	2
SCHOOL BUS DATA	3
EXTERIOR VEHICLE DAMAGE	
Exterior - School Bus	4
Exterior - 1988 Ford Tempo GL	4
INTERIOR VEHICLE DAMAGE	
Interior - School Bus	4
Interior - 1988 Ford Tempo GL	5
MANUAL RESTRAINT SYSTEMS - SCHOOL BUS	5
HUMAN DEMOGRAPHICS	
School Bus Driver	6
School Bus Driver History	6
School Bus Driver Injuries	6
School Bus Driver Kinematics	6
Child Passenger Demographics/Seating Configuration	7
Row 8, Left Side Child Occupant Injuries	8
Child Passenger Kinematics	8
SCENE DIAGRAM	9

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BACKGROUND

This on-site investigation focused on a 1999 Freightliner school bus (conventional chassis) that was involved in a right angle collision with a 1988 Ford Tempo GL 4-door sedan. The school bus was eastbound on an approach to a 4-leg intersection with thirty three (33) elementary age passengers on board. The bus driver and (approximately) fifteen (15) passengers were properly restrained by the available 2-point manual lap belt systems. The southbound Tempo was driven by an 83 year old female who was properly restrained by the available 2-point motorized automatic shoulder belt system (manual lap belt not used). The driver failed to detect the stop sign or the bus as both vehicles entered the intersection where the front of the Tempo struck the left rear axle and rear sheet metal area of the school bus. Five children were reported as injured, however, only four were transported to a local hospital for treatment and released. A lip laceration was the most severe injury sustained by the child passengers. The driver of the Ford Tempo complained of (unspecified) lower extremity pain and was also transported to a local hospital for treatment and released.

The crash notification was provided to NHTSA's Office of Safety Performance Standards and was forwarded to Veridian's Special Crash Investigation Team on Wednesday May 12, 1999. Due to the police reported severity of the crash and the belted child passengers on board the bus, an on-site investigation was assigned Thursday May 13, 1999. The Veridian SCI Team departed the morning of Monday May 17, 1999 to conduct the on-site investigation.

SUMMARY

Crash Site

The crash occurred during the afternoon hours of May, 1999. At the time of the crash, it was daylight with no adverse conditions as the roads were dry. The crash occurred in the eastbound lane of a 4-leg rural (asphalt) intersection (see **Figure 9 - page 9**) which was controlled by stop signs for north/southbound traffic. The east/west travel lanes were level and bordered by 2.2 meter (7.5 ft) shoulders. The southbound travel lane had a positive slope of 4 percent. The speed limit at the crash scene was 89 km/h (55 mph).

Pre-Crash

The 55 year old female driver of the 1999 Freightliner school bus was operating the vehicle eastbound (**Figure 1**) and transporting elementary aged children to their residences following a day of kindergarten. She had just begun her route as she dropped off two children less than a mile west of the crash site. The bus was first in a line of three buses proceeding straight through the rural 4-leg intersection at a driver estimated speed of 80 kph (50 mph). As the bus driver approached the

intersection (accelerating prior to impact), she noticed the southbound Tempo traveling up the hill out of the corner of her eye, but hadn't noticed if the vehicle actually stopped at the stop sign. The 1988 Ford Tempo was driven by an 83 year old female who was operating the vehicle southbound on an approach to the 4-leg intersection (**Figure 2**) located on a hillcrest for the southbound trafficway. Witnesses reported that the Tempo did stop at the stop sign and proceeded "as if no one was there". Loud children or sunlight glare was not reported as a factor in the collision.



Figure 1. Eastbound approach for the 1999 Freightliner school bus.



Figure 2. Southbound approach for the 1988 Ford Tempo.

Crash

The Ford Tempo entered the 4-leg intersection where the vehicle's front impacted the left side of the school bus. Initial contact to the bus occurred 36.2 cm (14.25 in) forward of the left rear axle as the direct contact damage continued rearward to the bumper corner. Resultant directions of force were at the 12 o'clock sector for the school bus and 3 o'clock sector for the Tempo. The momentum of the school bus rotated the Tempo 60 degrees in a counterclockwise (CCW) direction coming to rest with the front wheels positioned on the yellow centerlines of the roadway. The bus was driven to final rest approximately 91 meters (300 ft) east of the crash site as the driver was unaware of the collision. The driver felt the bus rock from side to side and realized there had been a crash when the children began crying.

Post-Crash

As the school bus came to rest, the driver unbuckled her manual restraint system and immediately checked the condition of the children. The local 911 operator was subsequently notified who dispatched the investigating State Police officer and an ambulance to the crash scene. The school bus driver retrieved the first-aid kit from the vehicle to treat a rear seated child occupant for an open facial laceration. The parents of the uninjured children were notified and subsequently arrived at the crash scene to transport them home. Four of the five injured children (along with the driver of the Tempo) were transported to a local hospital for treatment and released. The fifth (and most severely) injured child sustained a lip laceration and refused transport to the hospital. The driver of the school bus was uninjured. Both vehicles were towed from the scene.

SCHOOL BUS DATA

The involved school bus (**Figure 3**) was a 1999 Freightliner conventional chassis that was identified by the vehicle identification number (VIN): 4UZ6CFAA5XC (production number deleted). The unit was manufactured on 9/98 and was registered with a gross vehicle rating of 13,608 kg (30,000 lb). The original wheelbase was 640 cm (252 in) with a drive train that consisted of a 335 horsepower diesel engine and a 4-speed automatic overdrive transmission. The school bus body was manufactured by Blue Bird and was identified by body number B074424 with a rated capacity of 65 seated passengers and 13 standees. The vehicle's odometer reading was 17,986 km (11,176 miles) at the time of the crash. No video monitoring system (bus cam) was present at the time of the collision.



Figure 3. 1999 Freightliner school bus.

The school bus was equipped with parabolic mirrors that were mounted on a tubular stalk over the front corners of the bus. These mirrors provided the driver with a view across the frontal area of the bus. The mirrors were mounted approximately 135.9 cm (53.5 in) above ground level. Convex mirrors were mounted to tubular frames adjacent to the A-pillars of the vehicle which provided the driver with visibility along the respective sides of the bus.

Entrance to and egress from the bus was achieved through a bi-fold right side door. The door panels were 38.1 cm (15.0 in) in width and 191.0 cm (75.25 in) in height and were equipped with two tempered glass panels. The door was operated by an electronic switch positioned to the left of the driver's position. There was no damage to the door system.

The school bus was equipped with two hinged emergency doors; one mounted to the left side of the bus, rearward of the B-pillar area and the second mounted at the rear of the body. The left side door was 61.0 cm (24.0 in) in width and 147.3 cm (58.0 in) in height. This door was hinged on the left side and opened towards the front of the bus. Tempered glazing was mounted at the beltline level of the door. The rear mounted emergency door was hinged at the right side (as viewed from the rear exterior). The door was 95.3 cm (37.5 in) in width and 132.1 cm (52.0 in) in height. The door contained two glazing panels, one at the beltline height and the second at the level of the floor. There was no damage to the emergency doors or to the glazing.

In addition to the emergency doors, the Blue Bird body was equipped with two roof mounted emergency hatches which opened from the interior of the vehicle in a forward direction and measured 57.2 cm (22.5 in) square. These hatches were closed and not damaged. Two side windows on each side of the bus were emergency exits and were located between the second and third rows of seats and eighth and ninth rows of seats. These emergency exit windows were hinged at the top with a lever latch located at the bottom of the units frames.

EXTERIOR VEHICLE DAMAGE

Exterior-School Bus

The involved school bus sustained minor left side damage as a result of the right angle collision with the Ford Tempo (**Figure 4**). The direct contact damage began 36.2 cm (14.25 in) forward of the left rear axle and extended rearward 355.0 cm (139.75 in) to the bumper corner. The combined direct and induced contact damage (Field L) was 391.0 cm (154.0 in). Maximum crush was 9.0 cm (3.5 in) located 156.0 cm (61.4 in) forward of the left rear bumper corner.

Six crush measurements were taken at the level of the lower body panel: C1= 0 cm, C2= 5.0 cm (2.0 in), C3= 9.0 cm (3.5 in), C4= 6.4 cm (2.5 in), C5= 0 cm, C6= 0 cm. The resultant direction of force was (+)350 degrees. The riveted aluminum body of the school bus remained intact with no evidence of body panel separation. All window glazing remained intact with no cracks occurring to the laminated windshield. There was no reduction in the length of the wheelbase as a result of the collision.



Figure 4. Left side damage to the 1999 Freightliner school bus.

Exterior-1988 Ford Tempo GL

The Ford Tempo sustained moderate frontal damage as a result of the impact with the school bus (**Figure 5**). The direct contact damage began at the front right bumper corner and extended inboard 80.0 cm (31.5 in). The impact deformed the full frontal width resulting in a combined direct and induced damage length (Field L) of 90.9 cm (35.8 in).

Six crush measurements were documented at the level of the (*energy absorbing device*) pistons due to separation of the reinforcement bar: C1= 4.4 cm (1.75 in), C2= 10.2 cm (4.0 in), C3= 16.5 cm (6.5 in), C4= 19.1 cm (7.5 in), C5= 19.7 cm (7.75 in), C6= 21.0 cm (8.25 in). The Collision Deformation Classification (CDC) for this impact to the Tempo was 83-FZEW-2 (principal direction of force incremented to reflect lateral end shifting to the left) with a resultant direction of force of (+)80 degrees. The front bumper assembly separated from the energy absorbing pistons with direct damage documented to the radiator assembly. Damage was noted to both fenders which were displaced laterally to the left from structural end shifting to the vehicle. The right side was displaced approximately 14.0 cm (5.5 in) as the left side was displaced approximately 10.2 cm (4.0 in). Yellow paint and rubber transfers were noted across the hood and bumper fascia. No windshield damage was noted from exterior forces or (interior) occupant contact.



Figure 5. Frontal damage to the 1988 Ford Tempo.

INTERIOR VEHICLE DAMAGE

Interior - School Bus

The interior of the bus consisted of the stairwell, the driver's compartment and passenger area. The stairwell consisted of four stairs and three risers. A stainless steel handrail was mounted to the padded crash panel and side wall of the stairwell. The handrail was formed with a 90 degree radius at the lower attachment point and an angled end at the upper attachment point. The driver's seat was a box base bucket seat with a rigid seat back. The seat track was adjusted to the full forward position. A 2-point

manual lap belt system was mounted to the seat frame. Wear marks were documented to the latch plate of the lap belt which was an indication of frequent use. No loading marks were noted to the manual restraint. A large interior mirror was mounted to the front bulkhead of the bus which provided the driver with a view of the passenger compartment of the vehicle.

The passenger compartment area of the bus was designed to seat 65 passengers (**Figure 6**). The seating configuration consisted of 11 rows of high-back padded seats with three positions on each side. The seat frames were a 2.5 cm (1.0 in) tubular design cantilevered off the side wall. The inboard legs were bolted to the floor with two 3/8" bolts per leg. The seat cushions were 97.8 cm (38.5 in) in width and 40.6 cm (16.0 in) in depth with a height of 41.9 cm (16.5 in) off the floor. The seat backs extended 72.4 cm (28.5 in) above the seat cushions and were angled 10 degrees from vertical. Padded crash barriers were positioned forward of the first row of seats to provide crash protection against frontal impacts. The passenger seats were covered in a blue vinyl material.



Figure 6. Interior view of passenger compartment.

The fifth row seat (on the left side) was adjacent to the emergency door and was narrower in width than the other seats to allow for egress from the bus through the emergency door. The eleventh row seat (on the left side) was designed to seat two passengers and measured 66.0 cm (26.0 in) in width and 40.6 cm (16.0 in) in depth to allow for egress from the bus through the rear emergency door.

Interior - 1988 Ford Tempo GL

Interior damage to the Ford Tempo was minimal and was attributed to occupant contact (**Figure 7**). Fabric transfers were documented to the webbing of the front left 2-point motorized automatic restraint. Scuff marks were identified at the lower instrument panel on both sides of the steering column. Although wear marks were noted to the front left manual lap restraint, the webbing was found in a pristine condition and therefore presumed not used. No loading was documented on the steering wheel rim which was placed to the full up position. No windshield damage was noted from driver contact or exterior forces. No intrusions were found in the vehicle.

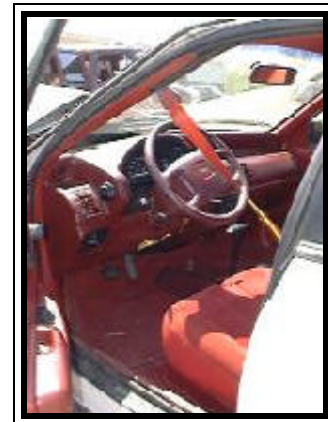


Figure 7. Interior view of the 1988 Ford Tempo.

MANUAL RESTRAINT SYSTEMS - SCHOOL BUS

New York state law requires seat belts for all designated seating positions. This bus was equipped with lap belts for each of the 65 available seats. Prior to the beginning of the school year (August),

kindergartners receive their orientation on proper belt use. A hands-on demonstration is given by the school bus driver to familiarize the children with the lap belt system. In addition, “firedrills” are conducted three times a year to review proper usage skills. The bus driver latches each belt before beginning her route to simplify the identification process. Each seat was equipped with color coded lap belts to aid in the identification of the appropriate component for each position. The three passenger seats were equipped with red belt webbings for the outboard positions, tan center belt webbings and black inboard mounted webbings. Although no loading marks were documented during the inspection, wear marks were noted to the latch plates of the manual lap belt systems which was an indication of frequent use.

HUMAN DEMOGRAPHICS

School Bus Driver

Age/Sex: 55 year old female
 Height: 157 cm (62 in)
 Weight: Unknown
 Seat Track Position: Forward position
 Manual Restraint Use: 2-point lap belt system
 Usage Source: Vehicle inspection, driver interview, police report
 Eyewear: Prescription glasses
 Type of Medical Treatment: None

School Bus Driver History

The 55 year old female school bus driver held a current Commercial Driver’s License (CDL). She had no points on her CDL or private driver’s license and has not been charged with traffic violations or involved in previous crashes. The driver was required to wear prescription glasses. Her medical physical was updated and approved in June 1998. She has completed all required training and had participated in an update training at the start of the school year. The driver was employed full time and was extremely familiar with the area of the crash as her assigned route resulted in her passing the crash scene twice daily.

Driver Injuries

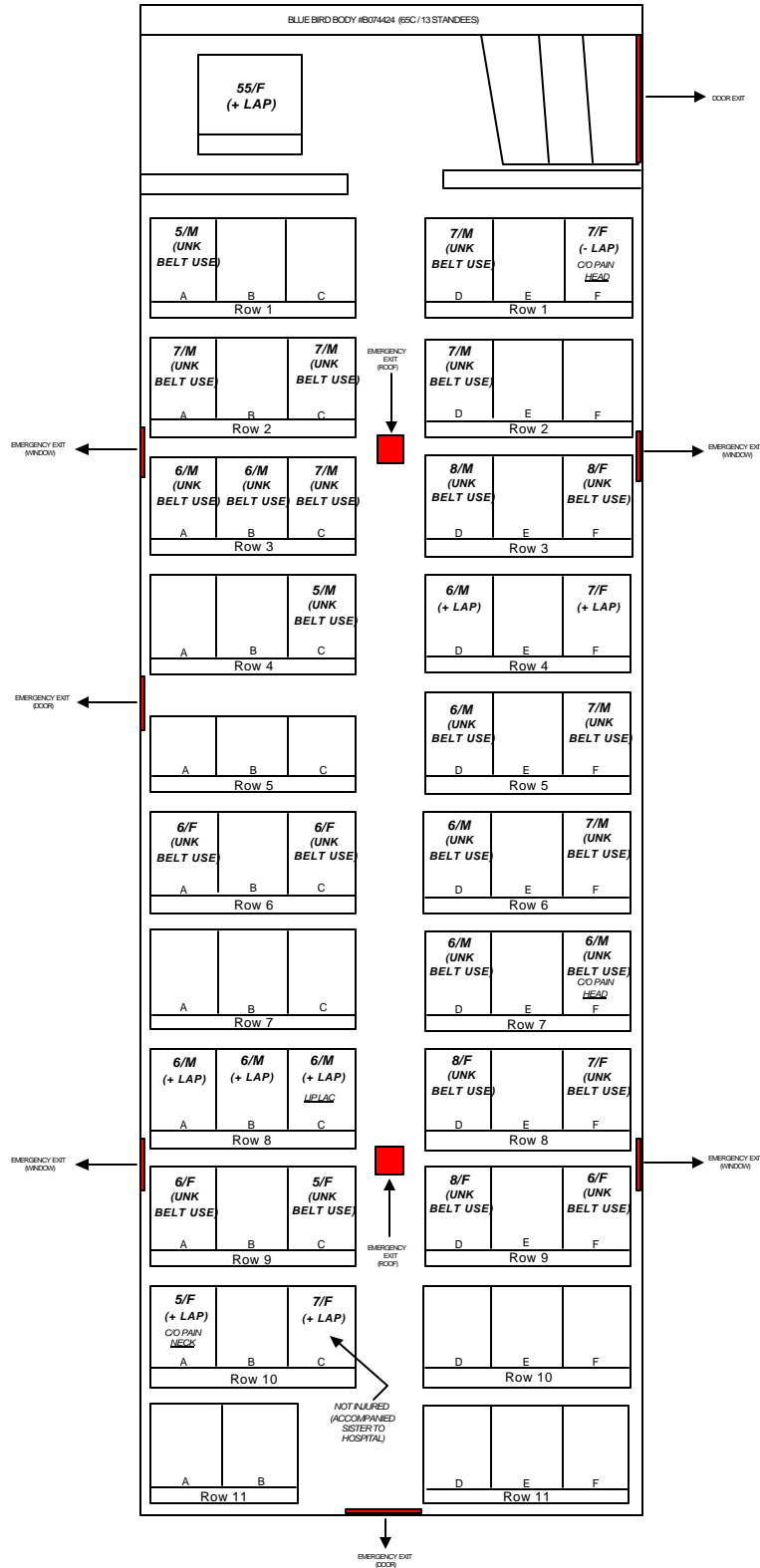
<i>Injury</i>	<i>Severity (AIS 90)</i>	<i>Injury Mechanism</i>
Not injured	N/A	N/A

Driver Kinematics

The driver of the school bus was seated in an upright posture with the seat track adjusted to the forward position. She was properly restrained by the 2-point manual lap belt system with her hands at the 3 o’clock and 9 o’clock sectors on the steering wheel rim. No interior contacts were documented for the driver who was not displaced by the minor severity of the crash. The police report noted that she was belted, further evidenced by the lack of interior contacts and injury. Immediately following the

crash, the driver unbuckled her manual restraint system and checked on the status of the children on board the bus; assisting with their care and removal from the vehicle.

Child Passenger Demographics/Seating Configuration



Row 8, Left Side Child Occupant Injuries

<i>Injury</i>	<i>Injury Severity</i>	<i>Injury Mechanism</i>
Lip laceration	Minor (790602.1,8)	Unknown

Child Passenger Kinematics

The thirty three (33) children were properly seated in the school bus with approximately fifteen (15) restrained by the manual lap belt systems. Although wear marks were noted to the latch plates of the manual restraints, there was no evidence of loading on the belt systems for the identified seating positions.

The 6 year old male child seated in the eighth row, left inboard position (**Figure 8**) was properly restrained by the 2-point manual lap belt system. At impact, he initiated a forward trajectory in response to the 12 o'clock impact force and probably contacted the front seat back or (unknown) hand held item (lunch box, etc.) resulting in the minor lip laceration. There was no evidence of contact within the seated area to support a specific injury mechanism. After the collision the bus driver attended to this occupant and found him to be "covered in blood". She discovered a minor cut on the lower lip and cleaned him up before the ambulance arrived, however, he subsequently refused transport to a local hospital for treatment.

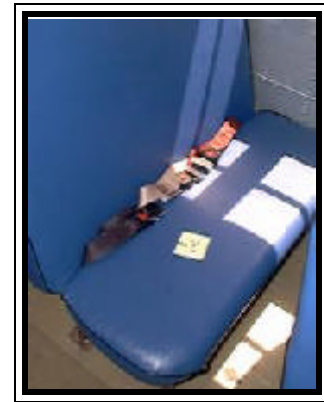


Figure 8. Seating location of injured child with lip laceration (seat 8/C).

Four children were reported to have been transported to the hospital with complaints of pain and were subsequently treated and released. No specific trauma was sustained but rescue personnel felt they should be checked out at the hospital. A 7 year old female seated in the first row, right outboard position complained of (unspecified) head pain. A 6 year old male seated in the seventh row, right outboard position also complained of (unspecified) head pain. A 5 year old female seated in the tenth row, left outboard position complained of (unspecified) neck pain. A fourth child was transported but only to accompany her sister to the hospital (uninjured). The remaining children on the bus were picked up by the parents at the crash scene to be transported home.

