

**CRASH DATA RESEARCH CENTER**

Calspan Corporation  
Buffalo, NY 14225

**CALSPAN REMOTE SCHOOL BUS CRASH INVESTIGATION**

**CASE NO: CA04-003**

**VEHICLES: 1989 BLUEBIRD TC-2000 SCHOOL BUS  
2002 BLUEBIRD TC-2000 SCHOOL BUS**

**LOCATION: GEORGIA**

**CRASH DATE: JANUARY 2004**

Contract No. DTNH22-01C-17002

Prepared for:

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National Highway Traffic Safety Administration  
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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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<b>16. Abstract</b> This remote investigation focused on the performance of the passenger compartments and integrity of the body panels on two Type D school buses that were involved in a head-on crash. The crash involved two full-size Blue Bird TC2000 school buses, a 1989 and a 2002. Both buses were configured to transport children with disabilities. A 54-year-old female driver, a 66-year-old male bus monitor, a 10-year-old male child, and a 9-year-old male child occupied the 1989 bus. The seating positions of the passengers were not known. A 63-year-old male driver and a 68-year-old female bus monitor occupied the 2002 bus. The driver of the 2002 school bus crossed the centerline of a two-lane curved roadway and struck the 1989 bus in an offset front left -to- front left configuration. Both buses sustained severe frontal damage. The driver of the 1989 bus was restrained by a lap belt and sustained diffuse axonal damage, subdural hematoma, frontal cerebral contusions, an open skull fracture, a left orbital fracture, a nasal fracture, facial avulsions, head lacerations, rib fractures, elbow fractures and dislocations, and extensive contusions on the upper and lower extremities due to jackknifing over the lap belt, engaging the steering wheel, and striking the windshield, which was reinforced by the front of the opposing bus. The driver of the 2002 bus was restrained by a 3-point lap and shoulder belt and sustained extremity injuries which included a right open tibia/fibula fracture, abrasions to both lower legs, a right wrist fracture, left carpal/metacarpal fracture dislocations, left 4 <sup>th</sup> and 5 <sup>th</sup> finger fractures, left hand abrasions, and a right lower chest contusion. The drivers of each bus were transported by helicopter to a regional trauma center and admitted for treatment. The bus monitors sustained moderate/minor injuries and were transported by ambulance to a local hospital and admitted for treatment. The child passengers sustained police-reported minor injuries and were transported by ambulance to a local hospital and treated and released.			
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**CALSPAN REMOTE SCHOOL BUS INVESTIGATION**  
**CASE NO.: CA04-003**  
**LOCATION: HENRY COUNTY, GA**  
**VEHICLES: 1989 AND 2002 BLUE BIRD TC2000 TYPE D SCHOOL BUSES**  
**CRASH DATE: JANUARY 2004**

***BACKGROUND***

This remote investigation focused on the performance of the passenger compartments and integrity of the body panels on two Type D school buses that were involved in a head-on crash (**Figure 1**). The crash involved two full-size Blue Bird TC2000 school buses; one was a 1989 and the other a 2002. Both buses were configured to transport children with disabilities. The 1989 bus was occupied by a 54-year-old female driver, a 66-year-old male bus monitor, a 10-year-old male child, and a 9-year-old male child. The seating positions of the passengers were not known. The 2002 bus was occupied by a 63-year-old male driver and a 68-year-old female bus monitor.



**Figure 1. On-scene view of the buses at final rest**

The driver of the 2002 school bus crossed the centerline of a two-lane curved roadway and struck the 1989 bus in an off-set front left-to- front left configuration. Both buses sustained severe frontal damage. The driver of the 1989 bus was restrained by a lap belt and sustained diffuse axonal damage, subdural hematoma, frontal cerebral contusions, an open skull fracture, a left orbital fracture, a nasal fracture, facial avulsions, head lacerations, rib fractures, elbow fractures and dislocations, and extensive contusions on the upper and lower extremities due to jackknifing over the lap belt, engaging the steering wheel, and striking the windshield, which was reinforced by the front of the opposing bus. The driver of the 2002 bus was restrained by a 3-point lap and shoulder belt and sustained extremity injuries which included a right open tibia/fibula fracture, abrasions to both lower legs, a right wrist fracture, left carpal/metacarpal fracture dislocations, left 4<sup>th</sup> and 5<sup>th</sup> finger fractures, left hand abrasions, and a right lower chest contusion. The drivers of each bus were transported by helicopter to a regional trauma center and admitted for treatment. The bus monitors sustained moderate/minor injuries and were transported by ambulance to a local hospital and admitted for treatment. The child passengers sustained police-reported minor injuries and were transported by ambulance to a local hospital and treated and released.

This crash was reported to NHTSA and forwarded to the Calspan SCI team for investigative follow-up on January 20, 2004. The SCI team contacted the Transportation Department of the school district and gained cooperation for this investigation. Based on the preliminary on-scene images of the involved buses, NHTSA assigned this crash as a remote investigative effort on January 22. The investigation involved the acquisition of 72 digital images of the involved buses, telephone follow-up with transportation officials, and the acquisition of official crash documentation and medical records for the occupants.

## ***SUMMARY***

### **Vehicle Data – 1989 Blue Bird TC2000 School Bus**

The 1989 Blue Bird TC2000 school bus was identified by the Vehicle Identification Number (VIN): 1BAADCRH4KF (production sequence omitted). An FE designation identified the engine in the front aspect of the bus.

The driver's seating position in the 1989 school bus was configured with a single post-mounted seat with manual height and track adjustments. Based on the available photographs, the seat was adjusted two positions up from the full-down position, and the seat track appeared to be adjusted between the mid- and full-rear track positions. The seat was configured with a standard seat cushion and low seat back, which were fixed to a steel frame.

The passenger seating on the bus consisted of bench seats with high backs on steel framework, designed for compartmentalization. The bus was configured with six rows of bench seats. The right rear corner was equipped with a wheelchair lift. The left side of the bus was configured with wheelchair tie-downs in place of seats in the left third and fourth rows. A second set of wheelchair tie-downs was located behind the sixth row in the left rear corner of the bus. A non-skid ribbed floor covering was present on the center aisle between the seats. An unspecified type of child safety seat (CSS) was installed on the inboard aspect of the first row left bench seat. The CSS was installed with a tether, which was visible over the seat back in the photographs. The CSS was not occupied at the time of the crash.

The side glazing was configured with split-sash windows, and a dedicated rear entry door was present on the right rear aspect to be used in conjunction with the wheelchair lift.

### **Vehicle Data – 2002 Blue Bird TC2000 School Bus**

The 2002 Blue Bird TC2000 was identified by the VIN: 1BAADCPA12F (production sequence omitted). An FE designation identified the engine in the front aspect of the bus.

The driver's seating position in the 2002 school bus was configured with a single bucket seat with an air ride suspension system and manual seat back and track adjustments. The manual seat track appeared to be in the mid-track position in the available photographs. The bucket seat was configured with a high back that encompassed an integrated head restraint.

The passenger seating on the bus consisted of bench seats with high backs on steel framework, designed for compartmentalization. The bus was configured with seven rows of bench seats. The right rear corner was equipped with a wheelchair lift. The left side of the bus was configured with wheelchair tie-downs in place of seats in the left side second, third and fourth rows. A second set of wheelchair tie-downs was located behind the seventh row in the left rear corner of the bus. An unspecified convertible Child Safety Seat (CSS) was present on the left aspect of the floor in the area of the wheel chair tie-downs, but was not in use at the time of the crash.

The side glazing was configured with split-sash windows, and a dedicated rear entry door was present on the right rear aspect to be used in conjunction with the wheelchair lift.

## Crash Site

This two-vehicle crash occurred during the daylight hours of January 2004 in the state of Georgia. At the time of the crash, there were no adverse weather conditions and the asphalt roadway surface was dry. The curved north/south two-lane roadway was configured with one travel lane in each direction separated by a double-yellow centerline. The crash occurred at the apex of a northbound left curve. North of the crash site, two local roadways intersected the north/south roadway on the east aspect. The roadway was bordered by white fog lines and narrow dirt shoulders. A drainage ditch was present on the east side of the roadway adjacent to the shoulder. The police-reported roadway width at the crash site measured 5.8 m (19.1'). The roadside environment consisted of private driveways and wooded areas. The posted speed limit for the north/south roadway was 56 km/h (35 mph). The police scene schematic is included as **Figure 16** at the end of this report.

## Crash Sequence

### Pre-Crash

The 54-year-old female driver of the 1989 Blue Bird TC2000 school bus was operating the vehicle in a northbound direction on the two-lane roadway (**Figure 2**). The 66-year-old male driver of the 2002 Blue Bird TC2000 school bus was operating the vehicle southbound on the same roadway. The pre-crash speeds of the buses were unknown. Both buses were on approach to the curve, a left curve for the 1989 bus and a right curve for the 2002 bus. As the 2002 bus attempted to negotiate the right curve, the bus traveled across the centerline into the opposing northbound lane.



**Figure 2. Northbound approach for the 1989 school bus**

The driver of the 2002 bus applied the brakes and steered right in an attempt to avoid the collision when he detected the oncoming 1989 bus in the same lane. Police reported a tire mark from the left front wheel of the 2002 bus that measured 12.5 m (41.0') in length to the deflection at the point of impact (**Figure 3**). The driver of the 1989 bus did not attempt any avoidance maneuvers.



**Figure 3. View of the left front tire mark from the 2002 school bus**

### Crash

The school buses impacted each other in a front left-to-front left configuration on the inboard aspect of the northbound lane. The impact resulted in severe frontal damage to both buses. The 1989 bus was deflected rearward and counterclockwise (CCW) and came to rest on the east roadside, perpendicular to the roadway facing west. The bus came to rest with the rear axle positioned in the roadside ditch and both front wheels on the outboard edge of the roadway. The 2002 bus was deflected in a clockwise (CW) direction and traveled in a

tracking mode onto the west roadside. The 2002 bus came to rest at an angle straddling the west road edge. **Figure 2** illustrates the final rest positions of the buses.

### Post-Crash

The drivers of both buses sustained severe injuries and were removed from the vehicles by rescue personnel. Medical reports indicated that extrication for the male driver of the 2002 bus took over 30 minutes. The drivers were transported by helicopter to a regional trauma center and admitted for treatment. The bus monitors on each bus sustained moderate/minor injuries. It was not known how the bus monitors exited the buses. The bus monitors were transported by ambulance to a local hospital where they were admitted for treatment. The children on the 1989 bus sustained police-reported visible injuries and were transported by ambulance to local hospital where they were treated and released.

### Vehicle Damage

The damage to the 1989 Blue Bird TC2000 school bus was based on photographs obtained from the school district. The 1989 TC2000 bus sustained severe frontal damage as a result of the collision with the 2002 TC2000 school bus (**Figures 4 and 5**). The direct contact damage began approximately 30 cm (12”) left of the centerline and extended laterally to the front left corner. Due to the identical nature of the bus models, the direct contact involved the entire vertical height of the front of the bus. The left aspect of the steel front bumper was deflected rearward and abraded.



**Figure 4. Frontal view of the damaged 1989 school bus**

The front left corner sustained abrasions and deformation above the bumper. The lower front panel that housed the headlights was displaced and crushed on the left aspect. The windshield was fractured and out-of-place in the on-scene photographs. The maximum crush at the front left bumper corner was approximately 45 cm (18”), based on the on-scene photographs. The maximum crush along the windshield header was located approximately 30 cm (12”) to the left of the centerline and was estimated to be approximately 30 cm (12”). The combined direct and induced damage involved the entire frontal width of the bus. Vertical body panel separation occurred along the front left corner due to the longitudinal crush. The left front side access door beneath the left A- and B-pillars sustained longitudinal and outward buckling on the top aspect. The access door and side panel under the access door were displaced outward and rearward as a result of induced damage, although, there was no apparent left side body panel separation. The highest degree of lateral deflection occurred at the beltline at the left B-pillar and



**Figure 5. Left front view of the damaged 1989 school bus**

was approximately 20 cm (8"). The bottom aspect of the panel was crushed and displaced rearward approximately 30 cm (12"). The roof sustained induced buckling at the left A-, B-, C-, and D-pillars. There did not appear to be any reduction of the wheelbase, and the right side of the bus did not sustain visible damage. The school bus was out of the scope of the Collision Deformation Classification (CDC); therefore, a CDC was not assigned for this impact.

**Interior Damage – 1989 Blue Bird TC2000 School Bus**

Interior damage to the 1989 TC2000 school bus was severe and was a result of occupant contact and passenger compartment intrusion. The left instrument panel, center instrument panel, toe pan, and windshield header intruded longitudinally and vertically into the forward aspect of the passenger compartment. The longitudinal intrusion of the windshield header resulted in the buckling and separation of the interior roof sheet metal at the top left aspect of the windshield header and leading edge of the roof on the left aspect.



**Figure 6. Interior view looking forward from the second row**

The entire instrument panel was displaced and fractured from crash forces. The engine shroud located against the center floor and instrument panel was separated and the engine was exposed in the available photographs. The longitudinal intrusion and crush resulted in the upward buckling and intrusion of the floor pan under the driver's seat. The floor was also slightly buckled in the area of the D-pillars. Multiple estimated intrusions were documented in the table below:

The longitudinal intrusion and crush resulted in the upward buckling and intrusion of the floor pan under the driver's seat. The floor was also slightly buckled in the area of the D-pillars. Multiple estimated intrusions were documented in the table below:

Seating Position	Intruded Component	Estimated Magnitude	Direction
Front Left	Instrument Panel	8.0-15.0 cm (3 - 6")	Longitudinal
Front Left	Floor Pan	15.0-30.0 cm (6 - 12")	Vertical
Front Left	Toe Pan	8.0-15.0 cm (3 - 6")	Longitudinal
Front Left	Windshield Header	3.0-8.0 cm (1 - 3")	Vertical
Front Middle	Instrument Panel	3.0-8.0 cm (1 - 3")	Longitudinal

The driver's seat was deflected forward and approximately 20 degrees to the left. The steering column was deflected forward and the rear half of the horizontally oriented steering wheel rim was deflected upward (forward) approximately 90 degrees, although, rescue personnel may have further deformed the steering wheel and rim to extricate the driver. The driver's plastic sun visor was extended downward and fractured as a result of



**Figure 7. View of driver's seat position and driver contacts**

occupant contact. The visor and mounting hardware were also deformed forward on the left side from direct contact with the driver's head. A small semi-circular depression was present in the sheet metal on the left interior corner of the windshield header above the sun visor from possible contact with the driver's head. The rear view mirror located on the forward wall above the windshield was fractured from crash forces. The padded partition located behind the driver's seat was deflected rearward and slightly inboard. Body fluid (blood) was present on the left side driver's control panel and on the floor under the driver's seat. The sliding left front glazing panels were positioned forward, relative to the bus. The outboard pane was fractured and the inboard pane exhibited body fluid (blood) as a result of post-impact contact with driver.

The driver's seat was deflected forward and approximately 20 degrees to the left. The steering column was deflected forward and the rear half of the horizontally oriented steering wheel rim was deflected upward (forward) approximately 90 degrees, although, rescue personnel may have further deformed the steering wheel and rim to extricate the driver. The driver's plastic sun visor was extended downward and fractured as a result of occupant contact. The visor and mounting hardware were also deformed forward on the left side from direct contact with the driver's head. A small semi-circular depression was present in the sheet metal on the left interior corner of the windshield header above the sun visor from possible contact with the driver's head. The rear view mirror located on the forward wall above the windshield was fractured from crash forces. The padded partition located behind the driver's seat was deflected rearward and slightly inboard. Body fluid (blood) was present on the left side driver's control panel and on the floor under the driver's seat. The sliding left front glazing panels were positioned forward, relative to the bus. The outboard pane was fractured and the inboard pane exhibited body fluid (blood) as a result of post-impact contact with driver.

The seat cushion on the left seat of the fifth row was displaced forward and slightly clockwise (CW). It could not be confirmed if the displacement was related to an occupant seated in that position. The circled area in **Figure 8** highlights the seat cushion displacement.

Based on interior photographs of the bus, there was no apparent structural bus damage aft of the E-pillars.



**Figure 8. View from the rear of the 1989 bus highlighting the displaced left 5th row seat**

### Exterior Damage - 2002 Blue Bird TC2000 School Bus

The damage to the 2002 Blue Bird TC2000 school bus was based on photographs obtained from the school district. The 2002 Blue Bird TC2000 school bus sustained severe frontal damage as a result of the collision with the 1989 TC2000 school bus. The direct contact damage began approximately 30 cm (12”) left of the centerline and extended laterally to the front left corner. Due to the identical nature of the bus models, the direct contact involved the entire vertical height of the front of the bus. The left aspect of the steel front bumper was deflected rearward. The front panel/engine hood in front of the radiator was displaced. The gasket-mounted windshield was fractured and out-of-place in the on-scene photographs. The lower front panel that housed the headlights was displaced. The front left aspect of the bus was crushed rearward and included the left aspect of the bumper, front panel, the right A-pillar, right aspect of the windshield header, and the right aspect of the roof. The front left corner sustained abrasions and deformation above the bumper. The left A-pillar was displaced slightly to the left. The combined direct and induced damage involved the entire frontal width of the bus. The entire vertical section on the left front aspect that encompassed the left A- and B-pillars was displaced downward and rearward. The lower rear aspect of the left body panel located below the left B-pillar was displaced rearward to the left C-pillar, although, there was no apparent separation of the body panels. The rearward displacement of the left front body panel resulted in the outward deflection of the left side steel rub rail at the forward aspect and the upward deflection of the roof side rail at the B-pillar. The rearward displacement and crush resulted in induced buckling of the roof at the left B- and C- pillars. There appears to be a minor reduction of the wheelbase and the right side of the bus did not sustain visible damage. The school bus was out of the scope of the CDC; therefore, a CDC was not assigned for this impact.



Figure 9. Frontal view of the damaged 2002 school bus



Figure 10. Left front view of the damaged 2002 school bus

### Interior Damage – 2002 Blue Bird TC2000 School Bus

Interior damage to the 2002 TC2000 school bus was severe and was a result of occupant contact and passenger compartment intrusion. The left instrument panel, center instrument panel, windshield header, toe pan and floor pan intruded longitudinally and vertically into the forward aspect of the passenger compartment (Figure 11). The vertical intrusion of the windshield



Figure 11. Lateral view of the driver's seat position and longitudinal intrusion

header resulted in the buckling and separation of the interior roof sheet metal at the top left aspect of the windshield header and leading edge of the roof on the left aspect. The interior roof-mounted HVAC unit was displaced and deformed due to the intrusion (**Figure 12**). Multiple estimated intrusions were documented in the table below:

Seating Position	Intruded Component	Estimated Magnitude	Direction
Front Left	Instrument Panel	8.0 – 15.0 cm (3 - 6")	Longitudinal
Front Left	Floor Pan	3.0 – 8.0 cm (1 - 3")	Vertical
Front Left	Windshield Header	3.0 – 8.0 cm (1 - 3")	Vertical
Front Left	Toe Pan	3.0 – 8.0 cm (1 - 3")	Longitudinal
Front Middle	Instrument Panel	8.0 – 15.0 cm (3 - 6")	Longitudinal

The entire instrument panel was displaced and fractured from crash forces. The driver’s lower instrument panel was deformed and fractured on each side of the steering column from contact with the driver’s knees. Pocketing was present on the inboard aspect of the left lower instrument panel consistent with a right knee contact. Body fluid (blood) was also present on the driver’s instrument panel. The rear (bottom) aspect of the steering wheel rim was cut by rescue personnel to facilitate the extrication of the driver. The steering column was also deflected forward, possibly as a result of extrication. The longitudinal intrusion caused the upward buckling of the floor under the driver’s seat. The seat was displaced upward and deflected to the left approximately 20 degrees. The floor buckling also resulted in rearward deflection of the driver’s seat into the padded partition located behind it. The engine shroud was displaced as a result of the frontal intrusion and floor buckling. The floor was also slightly buckled in the area of the D-pillars. The driver’s sun visor was fractured and deformed as a result of crash forces and intrusion. There did not appear to be any occupant contact to the visor. The rear view mirror located on the forward wall above the windshield was fractured from crash forces.



**Figure 12. Interior view from the rear of the 2002 school bus**

Based on the available photographs, there was no apparent structural damage aft of the E-pillars on the interior of the bus.

**Manual Restraint Systems – 1989 Blue Bird TC2000 School Bus**

The 1989 TC2000 school bus was configured with a manual 2-point lap belt for the driver’s position. The configuration of the lap belt was unknown, as the webbing and latch plate were not visible in any of the available photographs. The buckle stalk appeared to be mounted on



**Figure 13. Driver's buckle and stalk (highlighted) in the 1989 bus**

the floor on the inboard aspect of the seat, and was displaced rearward and clockwise (CW) against the padded partition due to the floor buckling (**Figure 13**).

The school bus passenger seats were configured with fixed-length manual lap belts with locking latch plates for each seating position. Although the police report indicated that the bus monitor, 9-year-old, and 10-year-old were restrained, the specific seating positions were unknown, and images of specific lap belts were unavailable. The lap belt webbing on the outboard aspect of the left side fifth row bench seat appeared cupped and corrugated (**Figure 14**). The deformation to the safety belt webbing combined with the displacement of the seat cushion suggested probable occupancy of the seat. However, a specific occupant could not be linked to the seat position at the time of this PCS.



**Figure 14. Close up of the lap belt in the fifth row left seat**

The TC2000 school bus was configured with four-point wheelchair tie-down systems behind the left second seat back in the left rear corner of the passenger compartment.

#### **Manual Restraint Systems – 2002 Blue Bird TC2000 School Bus**

The 2002 TC2000 school bus was configured with a manual 3-point lap and shoulder belt for the driver's position. The buckle stalk was attached to an L-shaped bracket that was mounted longitudinally on the on the inboard aspect of the seat base. There was no visible damage to the buckle or buckle stalk in the available photographs. The retractor was located along the left roof side rail approximately 20 cm (8") aft of the left B-pillar (**Figure 15**). The retractor was fixed to a metal plate, which was attached to the roof side rail, and a fixed plastic-covered D-ring was located approximately 10 cm (4") above the retractor. A second D-ring was present on the lower aspect of the roof side rail, and utilized as a guide for the shoulder belt webbing. The secondary D-ring was attached to a short section of webbing that was fixed to the aft edge of the left B-pillar at the roof side rail, and was located below the retractor. A section of the shoulder belt webbing that was visible in one of the photographs appeared to be corrugated as a result of occupant loading. The lap belt anchor and latch plate were not visible in any of the available photographs.



**Figure 15. Driver's retractor, D-ring, and shoulder belt in the 2002**

The school bus passenger seats were configured with fixed-length manual lap belts with locking latch plates for each seating position. Although the police report indicated that the bus monitor was restrained, the specific seating position was unknown, and images of specific lap belts were unavailable.

The TC2000 school bus was configured with four-point wheelchair tie-down systems behind the partition located behind the first row on the left side, and in the left rear corner of the passenger compartment.

**Occupant Demographics – 1989 Blue Bird TC2000 School Bus**

**Driver**

Age/Sex: 54-year-old female  
 Height: 165 cm (65”)  
 Weight: 107 kg (236 lb)  
 Seat Track Position: Between mid-track and full-rear  
 Manual Restraint Use: Manual 2-point lap belt  
 Usage Source: Police report  
 Eyewear: Unknown (prescription eyeglasses on floor under seat)  
 Type of Medical Treatment: Transported by ambulance to a regional trauma center and admitted for treatment

**Driver Injuries**

<b>Injury</b>	<b>Injury Severity (AIS 90/Update 98)</b>	<b>Possible Injury Mechanism</b>
Diffuse axonal damage (lesions)	Critical (140628.5,9)	Windshield, reinforced by intruding A-pillar of opposing bus
Subdural hematoma	Severe (140650.4,9)	Windshield, reinforced by intruding A-pillar of opposing bus
Frontal contusions, NFS	Serious (140602.3,9)	Windshield, reinforced by intruding A-pillar of opposing bus
Open skull fracture, NFS	Serious (150404.3,9)	Windshield, reinforced by intruding A-pillar of opposing bus
Left orbital fracture	Moderate (251200.2,2)	Windshield, reinforced by intruding A-pillar of opposing bus
Left zygoma fracture	Moderate (251800.2,2)	Windshield, reinforced by intruding A-pillar of opposing bus
Rib fractures, NFS	Moderate (450210.2,9)	Steering wheel rim
Right non-displaced radial head fracture	Moderate (752800.2,1)	Crash forces transmitted through arm from probable bracing
Left coronoid elbow fracture	Moderate (753200.2,2)	Crash forces transmitted through arm from probable bracing

<b>Injury</b>	<b>Injury Severity (AIS 90/Update 98)</b>	<b>Possible Injury Mechanism</b>
Nasal fracture, NFS	Minor (251000.1,4)	Windshield, reinforced by intruding A-pillar of opposing bus
Head/scalp laceration, NFS	Minor (190600.1,9)	Fractured windshield laminate, sun visor
Forehead avulsion, NFS	Minor (290800.1,7)	Fractured windshield laminate, sun visor
Chin avulsion, NFS	Minor (290800.1,8)	Fractured windshield laminate, sun visor
Right elbow dislocation	Minor (750630.1,1)	Crash forces transmitted through arm from probable bracing
Left elbow dislocation	Minor (750630.1,2)	Crash forces transmitted through arm from probable bracing
Extensive contusions on upper extremities	Minor (790402.1,1) Minor (790402.1,2)	Left instrument panel, steering wheel rim
Extensive contusions on lower extremities	Minor (890402.1,1) Minor (890402.1,2)	Left lower instrument panel

Injury source: Medical records

### **Driver Kinematics**

The 54-year-old female driver of the 1989 TC2000 bus was restrained by the 2-point lap belt, per police and medical officials. Her exact pre-crash posture was unknown, and the seat track appeared to be adjusted between the mid-track and full-rear positions. At impact, she initiated a forward and slightly lateral trajectory to the left and loaded the manual restraint. The frontal crash forces combined with the vertical intrusion of the floor resulted in the forward and slightly left lateral deflection of the driver's seat, which allowed additional forward travel. Her torso loaded the steering wheel rim, evidenced by the forward deflection of the rim and column. The steering wheel rim deflection resulted in unspecified rib fractures. Her hands were probably displaced from the steering wheel onto the instrument panel. Her forward loading against her bracing hands resulted in the transmission of the crash forces through her arms that caused a right non-displaced radial head fracture, a left coronoid elbow fracture, a left elbow dislocation and a right elbow dislocation. Due to the lack of a shoulder belt, her upper torso continued in a forward and downward direction and pivoted over the deformed steering wheel rim. Her face struck the plastic sun visor, evidenced by the forward deflection and fracture of the visor. She sustained a head/scalp laceration, a forehead avulsion, and a chin avulsion from contact with the fractured visor and fractured windshield laminate. Her head probably struck the windshield, which was reinforced by the intruding A-pillar and frontal structure of the opposing bus. The head contact resulted in a diffuse axonal brain injury, a subdural hematoma, frontal contusions, an open skull fracture, a left orbital fracture, a left zygomatic fracture, and a nasal fracture. She also sustained multiple contusions on her upper and lower extremities from probable contact with the instrument panel. The driver rebounded rearward, and was redirected slightly as the bus

was deflected rearward and counterclockwise (CCW). Her head contacted the left front window pane as she came to rest inside the bus, based on a matted body fluid (blood) smear on the glazing, and significant body fluid (blood) transfers on the panels beneath the window. She was transported by helicopter to a regional trauma center and admitted for treatment.

**Bus Monitor**

Age/Sex: 66-year-old male  
 Height: Unknown  
 Weight: Unknown  
 Seat Position: Unknown  
 Manual Restraint Use: Manual 2-point lap belt  
 Usage Source: Police report  
 Eyewear: Unknown  
 Type of Medical Treatment: Transported by ambulance to a local hospital and admitted for treatment

**Bus Monitor Injuries**

Injury	Injury Severity (AIS 90/Update 98)	Possible Injury Mechanism
Hand strain, NFS	Minor (740402.1,9)	Unknown
Leg laceration, NFS	Minor (890600.1,9)	Unknown

Injury source: Medical records

**Bus Monitor Kinematics**

It was not known where the 66-year-old male bus monitor was seated at the time of the crash. Police reported that he was restrained by the manual lap belt. At impact, he initiated a forward and slightly lateral trajectory to the left. He probably struck the padded seat back of the seat in front of him and loaded the lap belt. He sustained an unspecified hand strain and leg laceration, although the specific sources could not be determined from the available photographs. The bus monitor was transported by ambulance to a local hospital where he was admitted for treatment.

**10-Year-Old Child Passenger**

Age/Sex: 10-year-old male  
 Height: Unknown  
 Weight: Unknown  
 Seat Position: Unknown  
 Manual Restraint Use: Manual 2-point lap belt  
 Usage Source: Police report  
 Eyewear: Unknown  
 Type of Medical Treatment: Transported by ambulance to a local hospital and for treatment and released

### **10-Year-Old Child Passenger Kinematics**

The 10-year-old male child was seated in the 1989 TC2000 bus, although his seating position was not identified and could not be determined from the available photographs. Police reported that the child was restrained by the lap belt. At impact, the child initiated a forward and slightly lateral trajectory to the left. He probably struck the padded seat back of the seat in front of him and loaded the lap belt. The child sustained police-reported minor injuries and it was not known how the child exited the bus. He was transported by ambulance to a local hospital where he was treated and released.

### **9-Year-Old-Child Passenger**

Age/Sex:	9-year-old male
Height:	Unknown
Weight:	Unknown
Seat Position:	Unknown
Manual Restraint Use:	Manual 2-point lap belt
Usage Source:	Police report
Eyewear:	Unknown
Type of Medical Treatment:	Transported by ambulance to a local hospital for treatment and released

### **9-Year-Old Child Passenger Kinematics**

The 9-year-old male child was seated in the 1989 TC2000 bus, although his seating position was also not identified and could not be determined from the available photographs. Police reported that the child was restrained by the lap belt. At impact, the child initiated a forward and slightly lateral trajectory to the left. He probably struck the padded seat back of the seat in front of him and loaded the lap belt. The child sustained police-reported minor injuries and it was not known how the child exited the bus. He was transported by ambulance to a local hospital where he was treated and released.

### **Occupant Demographics – 2002 Blue Bird TC2000 School Bus**

#### **Driver**

Age/Sex:	63-year-old male
Height:	178 cm (70")
Weight:	89 kg (197 lb)
Seat Track Position:	Mid-track
Manual Restraint Use:	Manual 3-point lap and shoulder belt
Usage Source:	Police report
Eyewear:	Prescription eyeglasses (near and far sighted, per medical records)
Type of Medical Treatment:	Transported by ambulance to a regional trauma center and admitted for treatment

### Driver Injuries

Injury	Injury Severity (AIS 90/Update 98)	Possible Injury Mechanism
Left radial styloid fracture	Moderate (752800.2,2)	Upper left instrument panel
Left carpal/metacarpal fracture dislocations	Moderate (752002.2,2)	Upper left instrument panel
4 <sup>th</sup> and 5 <sup>th</sup> digit fracture, left hand	Minor (752404.1,2)	Upper left instrument panel
Right open tibial plateau fracture	Serious (853408.3,1)	Lower left instrument panel
Right fibular fracture	Moderate (851610.2,1)	Lower left instrument panel
Right lower chest contusion	Minor (490402.1,1)	Shoulder belt
Multiple abrasions to both lower legs	Minor (890202.1,1) Minor (890202.1,2)	Lower left instrument panel
Multiple left hand abrasions	Minor (790202.1,2)	Upper left instrument panel

Injury source: Medical records

### Driver Kinematics

The 63-year-old male driver of the 2002 TC2000 was wearing prescription eyeglasses and hearing aids in each ear while operating the school bus, per the medical records. He was wearing a T-shirt, nylon pants, and a nylon jacket, and was restrained by the manual 3-point lap and shoulder belt. His pre-crash posture was not known. At impact, the driver initiated a forward and slightly lateral trajectory to the left. He loaded the 3-point lap and shoulder belt, evidenced by the corrugation of the shoulder belt webbing, and the lack of significant upper torso and head injuries. He sustained a right lower chest contusion from probable loading against the shoulder belt where it crossed the right aspect of his torso. He may have contacted the steering wheel rim; however, rescue personnel removed the lower (rear) half of the rim to extricate the driver; therefore, it could not be confirmed. His left hand was displaced from the steering wheel and into the upper instrument panel, which resulted in a right radial styloid fracture, a left carpal/metacarpal fracture dislocations, left hand 4<sup>th</sup> and 5<sup>th</sup> digit fractures, and multiple left hand abrasions. His left and right knees struck the outboard and inboard aspects of the lower left instrument panel, respectively. The right knee contact resulted in pocketing to the inboard aspect of the instrument panel and an open right tibial plateau fracture and an open right fibular fracture. The driver rebounded rearward into the seat back and came to rest in the driver's seat. Police reported that the extrication of the driver took over 30 minutes. He was transported by helicopter to a regional trauma center where he was admitted for treatment.

### Bus Monitor

Age/Sex: 68-year-old female  
Height: Unknown  
Weight: Unknown

Seat Position: Unknown  
 Manual Restraint Use: Manual 2-point lap belt  
 Usage Source: Police report  
 Eyewear: Unknown  
 Type of Medical Treatment: Transported by ambulance to a local hospital and released.

**Bus Monitor Injuries**

<b>Injury</b>	<b>Injury Severity (AIS 90/Update 98)</b>	<b>Possible Injury Mechanism</b>
Closed head injury, brief loss of consciousness, concussion	Moderate (160202.2,9)	Forward seat back
Bilateral periorbital hematoma	Minor (297402.1,1) Minor (297402.1,2)	Forward seat back
Bilateral subconjunctival hemorrhage	Minor (240416.1,1) Minor (240416.1,2)	Forward seat back
Left elbow contusion	Minor (790402.1,2)	Forward seat back
Left thumb contusion	Minor (790402.1,2)	Forward seat back

Injury source: Medical records

**Bus Monitor Kinematics**

The 68-year-old female bus monitor on the 2002 TC2000 school bus was reported by police to have been lap belted. Her posture and seating position was unknown. At impact, she initiated a forward and slightly lateral trajectory to the left. Based on the reported restraint use, she loaded the 2-point lap belt, and loaded the rear aspect of the seat back forward of her seating position. She sustained bilateral periorbital hematoma, bilateral subconjunctival hemorrhage, a left elbow contusion, a left thumb contusion, a closed head injury with a brief loss of consciousness, and a concussion from possible contact with the seat back in front of her position. The female bus monitor was transported by ambulance to a local hospital and admitted for treatment.

**Note:** The subject vehicle in this case is the 1989 Bus due to children being passengers. As written in this report, the 1989 Bus is listed first followed by the 2002 Bus. The police schematic below has the opposite represented. In the EDS system, the 1989 Bus is considered Vehicle 1 and the 2002 Bus as Vehicle 2.

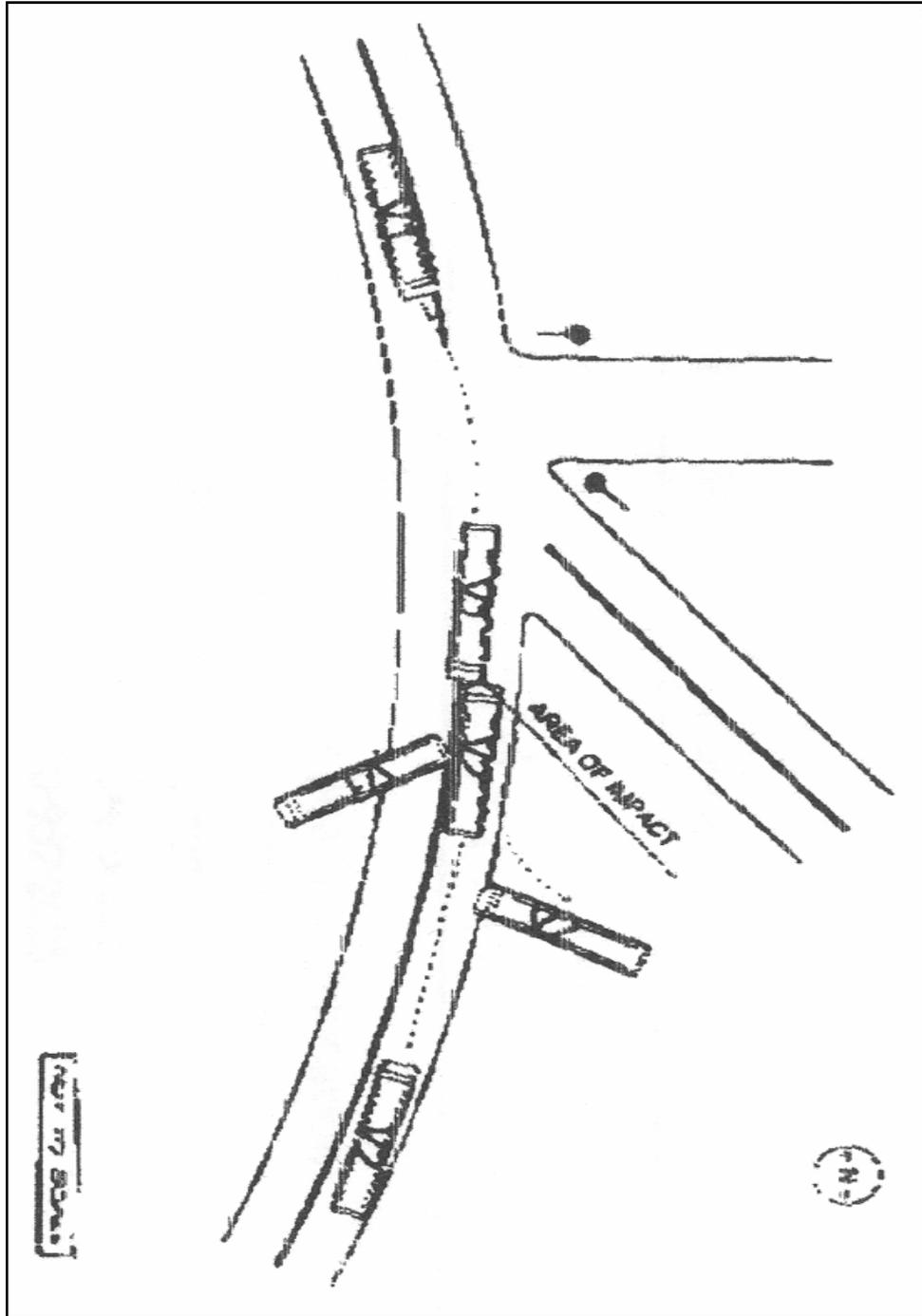


Figure 16. Police scene schematic.