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ON-SITE SIDE AIR BAG INVESTIGATION

CASE NUMBER - IN98-029
LOCATION - TEXAS
VEHICLE - 1999 INFINITI G20T
CRASH DATE - November, 1998

Submitted:

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Contract Number: DTNH22-94-D-17058

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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 be 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.

Technical Report Documentation Page

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15. *Supplementary Notes*
On-site air bag deployment investigation involving a 1999 Infiniti G20, four-door sedan, with manual safety belts and dual front and side air bags, and a 1986 GMC chassis-cab with Wayne school bus body

16. *Abstract*

This report covers an on-site investigation of an air bag deployment crash that involved a 1999 Infinity G20t (case vehicle) and a 1986 GMC school bus (other vehicle). This crash is of special interest because the case vehicle was equipped with both redesigned frontal air bags and side impact air bags (SIPS) and the case vehicle's driver (59-year-old female) sustained fatal chest injuries as a result of the impact to the side of the vehicle. In addition, the school bus was retrofitted with an alternative fuel source (i.e., liquid propane, LPG). The case vehicle was traveling east in the eastbound lane of a two-lane, undivided, city street. The school bus was traveling south in the southbound lane of a two-lane, undivided, city street. The crash occurred in the four-leg intersection of the two roadways. The left side of the case vehicle was impacted by the front of the school bus, causing the case vehicle's driver and front right passenger supplemental restraints (air bags) to deploy. Furthermore, the driver's side impact air bag also deployed. The case vehicle's driver was seated with her seat track located in its rearmost position. The tilt steering wheel's location could not be determined due to the severity of intrusion. She was restrained by her available, active, three-point, lap-and-shoulder, safety belt system. The case vehicle's front safety belts were equipped with pretensioners. She sustained, according to her autopsy, fatal thoracic injuries which included: lacerations (2) of her thoracic aorta with hemorrhage which was not confined to her mediastinum and resulting in bilateral hemothoraces–primarily to her left pleural cavity (i.e., 1.5 liters), a contusion of her posterior mediastinum, multiple left rib fractures with lacerations of her left parietal pleura, and multiple contusions of her left posterior lung. In addition, she sustained lacerations to her liver (multiple) and spleen; fractures to her left pelvis, left humerus, and right femur; and numerous abrasions, contusions, and lacerations of her skin. It should be noted that there were no fractures or dislocations involving her cranial bones or the cervical spine that could be identified. This contractor believes that the lack of head and neck trauma is a very positive and direct benefit of the availability of her side impact air bag. This occupant's chest injuries were caused by her contact with the intruding surface of her door.

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BACKGROUND

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This on-site investigation was brought to NHTSA's attention on December 2, 1998 by an employee of Nissan Corporation. This crash involved a 1999 Infinity G20t (case vehicle) and a 1986 GMC school bus (other vehicle). The crash occurred in November, 1998 at 3:55 p.m., in Texas and was investigated by the applicable county sheriff department. This crash is of special interest because the case vehicle was equipped with both redesigned frontal air bags and side impact air bags (SIPS) and the case vehicle's driver [59-year-old White (non-Hispanic) female] sustained fatal chest injuries as a result of the impact to the side of the vehicle. In addition, the school bus was retrofitted with an alternative fuel source (i.e., liquid propane, LPG). This contractor inspected the scene and vehicles on 15-16 December, 1998. This report is based on the Police Crash Report, an interview with the investigating police officer, scene and vehicle inspections, occupant kinematic principles, the driver's autopsy, and this contractor's evaluation of the evidence.

SUMMARY

The case vehicle was traveling east in the eastbound lane of a two-lane, undivided, city street and intended to continued eastward through a controlled four-leg intersection. The intersection was controlled by STOP signs for the east and westbound traffic. The school bus was traveling south in the southbound lane of a two-lane, undivided, city street and intending to continue driving southbound through the same intersection. Based upon the scene evidence, the case vehicle's driver made no avoidance maneuvers prior to the crash. The driver of the school bus braked, depositing a 15.2 meter (50 foot) skid mark from the right rear tire prior to impact. The skid marks from the school bus started approximately 20.1 meters (66 feet) north of the intersection. This distance coincides with the sight distance that the school bus's driver had when he first observed the case vehicle's eastbound travel path. The sight distance was restricted because of a 2.4 meter (8.0 foot) high brick wall that surrounded the property on the northwest corner of the intersection. The crash occurred in the four-leg intersection of the two roadways; see **CRASH DIAGRAM** below.

The left side of the case vehicle was impacted by the front of the school bus, causing the case vehicle's driver and front right passenger supplemental restraints (air bags) to deploy. Furthermore, the driver's side impact air bag also deployed. The severity of the crash was so great that the front wheel/axle assembly of the bus was torn away from the school bus, leaving the bus without any steering control.

Following the initial impact, the vehicles side slapped and the left rear half of the case vehicle (i.e., rearward of left "B"-pillar) contacted the school bus's front cowl and folding entrance/exit door, buckling the stairway. Both vehicle's remained attached together for approximately 13.1 meters (43 feet) before separating. The case vehicle subsequently traveled an additional 22.6 meters (74 feet), leaving gouges along its travel path and came to rest heading south. The school bus traveled an additional 12.8 meters (42 feet) and vaulted a 3 meter (9.8 foot) wide, but less than 1 meter deep (3.3 feet) drainage ditch prior to coming to rest straddling the ditch heading southeast. The school bus vaulted the drainage ditch without the front wheel/axle assembly.

The 1999 Infinity G20t was a front wheel drive, four-door sedan (VIN: JNKCP11A2XT------). The case vehicle was equipped with anti-lock brakes. Based on the vehicle inspection, the CDCs for the case vehicle's impacts were determined to be: **10-LYAW-5 (290)** for the initial impact and **09-LZAW-2 (270)** for the side slap event. The WinSMASH reconstruction program, barrier algorithm, was used on the case vehicle's highest severity impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 43.6 km.p.h. (27.1 m.p.h.), -14.9 km.p.h. (-9.3 m.p.h.), and +40.9 km.p.h. (+25.4 m.p.h.). Because this crash did not involve a barrier, this contractor's visually estimated Delta V is between 40 km.p.h. (25 m.p.h.) and 48 km.p.h. (30 m.p.h.). The case vehicle was towed due to damage.

The case vehicle's initial contact with the school bus involved its left side forward of the "B"-pillar. Direct damage began at the front left bumper corner and extended rearward 182 centimeters (71.7 inches) down the left side to just forward of the "B"-pillar. Residual maximum crush was 29 centimeters (11.4 inches) below the belt line and 85 centimeters (33.5 inches) above the belt line, both at C_5. The wheelbase on the case vehicle's left side was shortened 24 centimeters (9.5 inches) while the right side was extended 5 centimeters (2.0 inches). The school bus's high profile front bumper overrode the side of the case vehicle, directly contacting the case vehicle's hood, left "A"-pillar, windshield, and roof. The damage from the case vehicle's side slap with the school bus started at the left "B"-pillar and extended to the left rear bumper corner, a distance of 224 centimeters (88.2 inches). Maximum crush for the side slap impact was measured as 24 centimeters (9.5 inches). There was a small separation or break in the side slap damage near the left rear wheel, a distance of 70 centimeters (27.6 inches). The case vehicle's left front and rear tires were physically restricted and deflated from the crash. There was integrity loss to left front door glazing and over half of the case vehicle's windshield [45 x 28 centimeters (17.7 x 11 inches)]; the windshield was separated from its bond. The case vehicle's driver door panel, left instrument panel, "A"-pillar, and steering wheel column had over 30 centimeters (11.8 inches) of intrusion into the case vehicle's driver seating position. The driver's door was taken off during the extrication process.

The case vehicle's driver side impact air bag was located in the outside seam of the driver's seat back. An inspection of the air bag module revealed that the stitching opened at the designated tear points. A silhouette of the driver's side air bag was shaped like a foot pointing upwards out of the outside of the driver's seat back. The shell was 65 centimeters (25.6 inches) in height and 26 centimeters (10.5 inches) wide at the top portion, but only 20 centimeters (7.9 inches) wide at the bottom portion. The air bag was split in half by diagonal stitching that created an upper and lower air chamber. The separate chambers and lack of vent ports kept the air bag partially inflated for a few moments post crash. The inspection also revealed an area towards the top medial half of the side air bag [i.e., the inside (facing driver) portion] had yellow paint transfers from the school bus. This most likely occurred during the side slap event, possibly from the school bus's shattered fiberglass hood. There were also three glass punctures to the inside portion towards the center of the side air bag.

The case vehicle's driver air bag was located in the steering wheel hub. An inspection of the air bag module's cover flaps and air bag revealed that the cover flaps opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover

flaps. The driver's air bag was designed with two tethers, each approximately 10 centimeters (3.9 inches) in width. The driver's air bag had two vent ports, approximately 2.5 centimeters (1.0 inch) in diameter, located at the 11 and 1 o'clock positions. The deployed driver's air bag was round with a diameter of 63 centimeters (24.8 inches). An inspection of the driver's air bag fabric revealed contact evidence readily apparent on the air bag's fabric on the upper left and right quarter sections.

The front right passenger's air bag was located in the top of the instrument panel. An inspection of the front right air bag module's cover flaps and air bag revealed that the cover flaps opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover flaps. The front right passenger's air bag was designed without any tethers. The front right air bag had two vent ports, approximately 4 centimeters (1.6 inches) in diameter, located at the 9:30 and 2:30 o'clock positions. The deployed front right air bag was rectangular with a height of approximately 42 centimeters (16.5 inches) and a width of approximately 52 centimeters (20.5 inches). An inspection of the front right passenger's air bag fabric revealed apparent blood evidence on the front surface of the air bag's fabric toward the far left side, just inside the left seam. Furthermore, there were several punctures to the top and front surfaces of the air bag from coming in contact with the intruding windshield.

Inspection of the case vehicle's interior revealed dark scuffs along the left roof side rail, deformation to the left instrument panel from contact by the driver's knee, scuffs and deformation to the interior surface of the driver's door, and skin and blood on the residue of the left windshield's glazing. In addition, the steering column compression could not be determined because of the severity of longitudinal and lateral intrusions.

The 1986 GMC was a rear wheel drive, incomplete chassis-cab, affixed with a Wayne school bus body (VIN: 1GDM6P1B8GV------). The school bus was retrofitted with a Liquid Petroleum Gas (LPG) fuel system. The school bus is neither CDC nor TDC applicable. The school bus was towed due to damage.

Immediately prior to the crash the case vehicle's driver [168 centimeters and 80 kilograms (66 inches, 176 pounds)] was seated slightly reclined (seat back was measured at 70 degrees) with her back against the seat back, her left foot on the floor, her right foot either on the accelerator pedal or possibly going for the brake, and both hands on the steering wheel. Her seat track was found in its rearmost position. The tilt steering wheel's location could not be determined due to the severity of intrusion. It is unknown if the case vehicle's driver ever saw the approaching school bus or was able to attempt any evasive action just prior to the crash.

The case vehicle's driver was restrained by her available, active, three-point, lap-and-shoulder, safety belt system. The case vehicle's front safety belts were equipped with pretensioners. Although the autopsy made no mention of belt pattern bruising and/or abrasions to the driver's body, the inspection of the driver's seat belt webbing, "D"-ring, and latch plate showed evidence of loading. Photographs taken by this contractor showed blood evidence on the webbing and a friction scrub to the webbing near the "D"-ring's placement, as well as to the backside of the "D"-ring. In comparison, the front right passenger seat belt, which was not in

use, was found taught against the right "B"-pillar while the driver's seat belt was locked in the outstretched position indicating its use during the crash. These locking actions resulted from the case vehicle's seat belt pretensioners firing during the deployment sequence, retracting the belt webbing.

Based on the available scene evidence, the case vehicle's driver did not attempt any avoidance maneuvers prior to the crash. As a result and independent of the use of her available safety belts, the driver's pre-impact body position did not change just prior to the crash. The case vehicle's primary impact with the school bus enabled the case vehicle's driver to continue slightly forward and move primarily leftward toward the **290** degree Direction of Principal Force as the case vehicle decelerated. As a result, the driver's head and thorax loaded her deploying driver side impact air bag and the intruding interior surface of her door. As a result of the force of the collision, the driver's side impact air bag was ruptured, and the driver was compressed against her door panel throughout maximum engagement. The intruding driver's door panel, left instrument panel, and steering wheel sent the driver back into her seat back and to the right most likely contacting the center console. The case vehicle's left side, side slap impact sent the driver back to the left, with the intruding left front door panel keeping the driver's head from contacting the right side of the bus. As the two vehicles separated, the driver rebounded backwards into her seat back and then forward and to the right where her bloodied right hand came in contact with the front right passenger air bag, near its left seam. At final rest the driver was found sitting slumped forward between the intruded steering wheel and seat back.

The case vehicle's driver was transported by ambulance to the hospital. She sustained a fatal injury and was pronounced dead one hour and 38 minutes post-crash. According to her autopsy, she sustained fatal thoracic injuries which included: lacerations (2) of her thoracic aorta with hemorrhage which was not confined to her mediastinum and resulting in bilateral hemothoraces–primarily to her left pleural cavity (i.e., 1.5 liters), a contusion of her posterior mediastinum, multiple left rib fractures with lacerations of her left parietal pleura, and multiple contusions of her left posterior lung. In addition, she sustained lacerations to her liver (multiple) and spleen; fractures to her left pelvis, left humerus, and right femur; and numerous abrasions, contusions, and lacerations of her skin. It should be noted that there were no fractures or dislocations involving her cranial bones or the cervical spine that could be identified. This contractor believes that the lack of head and neck trauma is a very positive and direct benefit of the availability of her side impact air bag. This occupant's chest injuries were caused by her contact with the intruding surface of her door.

As previously mentioned the 1986 GMC school bus had a Liquid Petroleum Gas (LPG) fuel system. When the front axle and tire assembly were torn from the bus during the crash, the assembly damaged the left side body panel that protected the outside of the LPG cylinder. An inspection of the 82 gallon cylinder revealed scrapes to the underside of the front portion of the cylinder. This damage to the cylinder was also caused by the vehicle's front axle and tire assembly as a consequence of being driven over during the bus's movement to final rest.

At the time of the crash, the school bus was in the process of transporting 19 middle school students. All 19 students were listed on the Police Crash Report as sustaining "C" (Possible)

injuries, but only seven (7) were transported to the hospital. It is unknown how they were transported (i.e., there was no mention of ambulances on the Police Crash Report). Based on the Police Crash Report, all seven were treated and released with minor injuries. The school bus's driver [39-year-old, White (unknown if Hispanic) male] was not using his available, manual, two-point, lap belt. Based on the available evidence, the driver did not seek treatment. The school bus was not equipped with an on-board video camera, and no safety belt systems were available for anyone other than the driver.

CRASH CIRCUMSTANCES

Figure 1: Westward view of case vehicle's travel path into intersection (case photo #04)

Figure 2: GMC school bus's southward travel path in right-hand section of "S"-curve approaching four-leg intersection (case photo #05)

The case vehicle was traveling east in the eastbound lane of a two-lane, undivided, city street and intended to continued eastward through a controlled four-leg intersection. The intersection was controlled by STOP signs for the east and westbound traffic (**Figure 1**). The school bus was traveling south in the southbound lane of a two-lane, undivided, city street and intending to continue driving southbound through the same intersection (**Figure 2**). Based upon the scene evidence, the case vehicle's driver made no avoidance maneuvers prior to the crash. The driver of the school bus braked, depositing a 15.2 meter (50 foot) skid mark from the right rear tire prior to impact. The skid marks from the school bus started approximately 20.1 meters (66 feet) north of the intersection. This distance coincides with the sight distance that the school bus's driver had when he first observed the case vehicle's eastbound travel path. The sight distance was restricted because of a 2.4 meter (8.0 foot) high brick wall that surrounded the property on the northwest corner of the intersection (**Figure 2**). The crash occurred in the four-leg intersection of the two roadways; see **CRASH DIAGRAM** below.

Both the case vehicle and the school bus were traveling on city roadways. The case vehicle's roadway was straight and level at the area of impact. The school bus was traveling in an "S"-curve, but the roadway section near the area of impact was essentially straight and level (**Figure 2**). The pavement was bituminous for both roadways. The roadway width for the west leg of the intersection was 6.1 meters (20 feet), and the shoulders were not improved (i.e., grass). No pavement markings were present, and the estimated coefficient of friction was 0.75. A regulatory STOP sign (Manual on Uniform Traffic Control Devices, R1-1) was present, controlling traffic on both the east and west legs of the roadway. The statutory speed limit was

48 km.p.h. (30 m.p.h.). No regulatory speed limit sign was posted near the crash site. The roadway on the north leg of the intersection also had only grass/dirt shoulders, no pavement markings were present, and estimated coefficient of friction was also 0.75. The south leg of the intersection began curving leftward a short distance south of the intersection. There were no visible traffic controls for the north-south roadway. The statutory speed limit was 64 km.p.h. (40 m.p.h.). No regulatory speed limit sign was posted near the crash site. At the time of the crash the light condition was daylight, the atmospheric condition was clear, and the road pavement was dry. Traffic density on both roadways is unknown, and the site of the crash was primarily urban residential. As mention above, the properties on the northwest and northeast corners of the intersection were surrounded by a 2.4 meter (8.0 foot) high rock fence, reducing the sight lines for east, west, and southbound traffic (**Figure 3**).

Figure 3: North-northwestward view from beyond case vehicle's final rest position showing crash location and 2.4 meter (8 foot) high stone wall that limited each driver's view of the other vehicle's approaching trajectory (case photo #11)

Figure 4: On-scene view of case vehicle at final rest showing damage to left side; Note: driver's seat belt extended and side air bag (case photo #73)

The left side of the case vehicle (**Figure 4**) was impacted by the front (**Figure 5**) of the school bus, causing the case vehicle's driver and front right passenger supplemental restraints (air bags) to deploy. Furthermore, the driver's side impact air bag also deployed. The severity of the crash was so great that the front wheel/axle assembly of the bus was torn away from the school bus, leaving the bus without any steering control.

Figure 5: GMC school bus's frontal damage; Note: front frame rails shifted 38 centimeters (15.0 inches) to the left side (case photo #50)

Following the initial impact, the vehicles side slapped and the left rear half of the case vehicle (i.e., rearward of left "B"-pillar) contacted the school bus's front cowl and folding entrance/exit door (**Figure 6** below), buckling the stairway. Both vehicle's remained attached together for approximately 13.1 meters (43 feet) before separating. The case vehicle subsequently traveled an additional 22.6 meters (74 feet), leaving gouges (**Figure 7** below) along its travel path and came to rest heading south along the east edge of the north-south road partially in the northbound lane (**Figure 8** below). The school bus was redirect approximately 20 degrees

counterclockwise and traveled an additional 12.8 meters (42 feet) before vaulting a 3 meter (9.8 foot) wide, but less than 1 meter deep (3.3 feet) drainage ditch prior to coming to rest straddling the ditch heading southeast. The school bus vaulted the drainage ditch without the front wheel/axle assembly.

Figure 6: GMC school bus's frontal damage; Note: front axle and wheels were torn away, front shift, and side slap damage to folding entrance/exit door (case photo #72)

Figure 7: On-scene view looking south at tire marks and pavement gouges from both vehicles traveling to their final rest positions (case photo #75)

Figure 8: On-scene view looking north at case vehicle's (foreground) and school bus's (background) final rest positions (case photo #74)

CASE VEHICLE

The 1999 Infinity G20t was a front wheel drive, five-passenger, four-door sedan (VIN: JNKCP11A2XT------) equipped with a 2.0L, I-4 engine and a four-speed automatic transmission. Braking was achieved by a power-assisted, front and rear disc, four-wheel, anti-lock system. The case vehicle's wheelbase was 260 centimeters (102.4 inches), and the odometer reading at inspection is unknown because the case vehicle was equipped with an electronic odometer.

Inspection of the vehicle's interior revealed adjustable front bucket seats with adjustable head restraints; a split bench back seat with folding backs and adjustable head restraints for the back outboard seating positions; continuous loop, three-point, lap-and-shoulder, safety belt systems at the front and back outboard positions; and a two-point, lap belt system at the back center position. The front seat belt systems were equipped with manually operated height adjusters for the "D"-rings along with pretensioners in the retractor. The vehicle was equipped with knee bolsters for both the driver and front right passenger. The driver's knee bolster was scuffed and deformed from both contact and intrusion. Automatic restraint was provided by a Supplemental Restraint System (SRS) that consisted of a frontal air bag for the driver and front right passenger seating positions. In addition, the vehicle was equipped with front, seat back-mounted, side impact air bags. Both frontal air bags and the driver's seat back-mounted, side air bag deployed as a result of the case vehicle's left side impact with the school bus.

The case vehicle's initial contact with the school bus involved its left side forward of the "B"-pillar. Direct damage began at the front left bumper corner and extended rearward 182 centimeters (71.7 inches) down the left side to just forward of the "B"-pillar (**Figure 9**). Residual maximum crush was 29 centimeters (11.4 inches) below the belt line and 85 centimeters (33.5 inches) above the belt line, both at C_5. The wheelbase on the case vehicle's left side was shortened 24 centimeters (9.5 inches) while the right side was extended 5 centimeters (2.0 inches). The school bus's high profile front bumper overrode the side of the case vehicle, directly contacting the case vehicle's hood, left "A"-pillar, windshield, and roof. The damage from the case vehicle's side slap with the school bus started at the left "B"-pillar and extended to the left rear bumper corner, a distance of 224 centimeters (88.2 inches). Maximum crush for the side slap impact was measured as 24 centimeters (9.5 inches). There was a small separation or break in the side slap damage near the left rear wheel, a distance of 70 centimeters (27.6 inches). The case vehicle's left front and rear tires were physically restricted and deflated from the crash. There was integrity loss to left front door's glazing and to over half of the windshield's glazing [i.e., 45 x 28 centimeters (17.7 x 11.0 inches)]; the windshield was separated from its bond. The case vehicle's driver door panel, left instrument panel, "A"-pillar, and steering wheel column had over 30 centimeters (11.8 inches) of intrusion into the case vehicle's driver seating position. The driver's door was taken off during the extrication process.

Figure 9: Case vehicle's extensive left side damage from impact with school bus; Note: yellow tape between left front bumper and "B"-pillar marks direct damage area (case photo #17)

Figure 10: Case vehicle's front seating area viewed from right front passenger door; Note: extensive intrusion into driver's seating area (case photo #29)

Inspection of the case vehicle's interior revealed dark scuffs along the left roof side rail (**Figure 10**), deformation to the left instrument panel from contact by the driver's knee, scuffs and deformation to the interior surface of the driver's door (**Figure 11**), and skin and blood on the residue of the left windshield's glazing. The rearview mirror was knocked off the windshield from the force of the impact. The instrument panel on the whole left half of the interior was damaged from intrusion (**Figure 12** below). In

Figure 11: Interior surface of case vehicle's driver door showing extensive deformity (case photo #26)

addition, the left "A"-pillar, left instrument panel, and steering column had over 30 centimeters (11.8 inches) of intrusion to the driver's seating area. The driver's seat was deformed because of the significant intrusion from the front end of the school bus to the driver's door panel, sill, and floor panel. Finally, the steering column compression could not be determined because of the severity of longitudinal and lateral intrusions.

Figure 12: Case vehicle's front right seating area showing deployed front right passenger air bag and extensive intrusion front instrument panel (case photo #34)

Based on the vehicle inspection, the CDCs for the case vehicle's impacts were determined to be: **10-LYAW-5 (290)** for the initial impact and **09-LZAW-2 (270)** for the side slap event. The WinSMASH reconstruction program, barrier algorithm, was used on the case vehicle's highest severity impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 43.6 km.p.h. (27.1 m.p.h.), -14.9 km.p.h. (-9.3 m.p.h.), and +40.9 km.p.h. (+25.4 m.p.h.). Because this crash did not involve a barrier, this contractor's visually estimated Delta V is between 40 km.p.h. (25 m.p.h.) and 48 km.p.h. (30 m.p.h.). The case vehicle was towed due to damage.

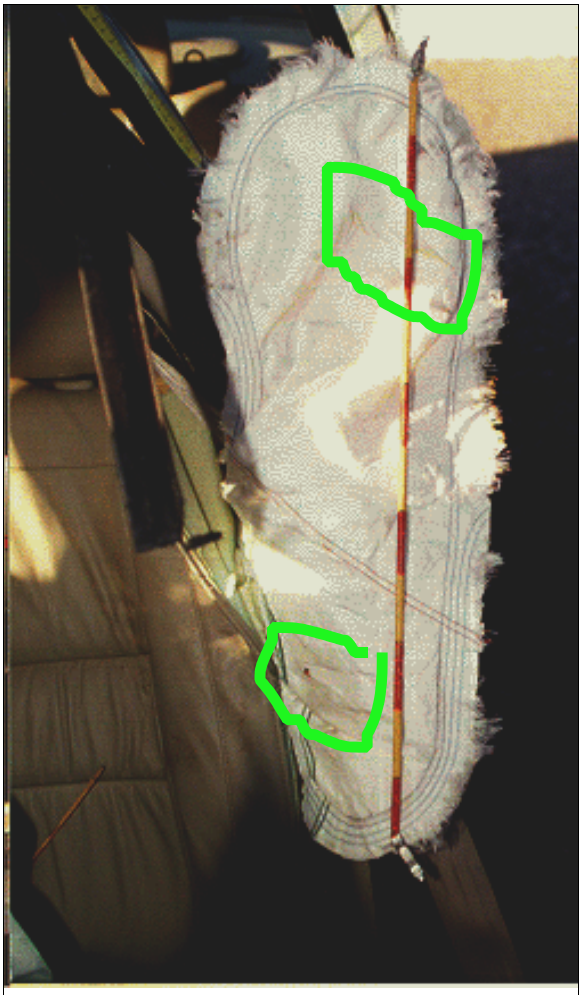


Figure 13: Vertical view of interior (medial) surface case vehicle's driver seat back-mounted side impact air bag; Note: yellow paint transfers to top half, glass punctures to middle, and blood and oil transfer to lower half (case photo #45)

AUTOMATIC RESTRAINT SYSTEM

The case vehicle was equipped with a Supplemental Restraint System (SRS) that contained frontal air bags at the driver and front right passenger positions. In addition, the vehicle was equipped with front, seat back-mounted, side impact air bags. Both frontal air bags and the driver's seat back-mounted, side air bag deployed as a result of the left front impact with the school bus. The case vehicle's driver side impact air bag was located in the outside seam of the driver's seat back. An inspection of the air bag module revealed that the stitching opened at the designated tear points. A silhouette of the driver's side air bag was shaped like a foot pointing upwards out of the outside of the driver's seat back. The shell was 65 centimeters (25.6 inches) in height and 26 centimeters (10.5 inches) wide at the top portion, but only 20 centimeters (7.9 inches) wide at the

bottom portion. The air bag was split in half by diagonal stitching that created an upper and lower air chamber. The separate chambers and lack of vent ports kept the air bag partially inflated for a few moments post crash. The inspection also revealed an area towards the top medial half of the side air bag [i.e., the inside (facing driver) portion] had yellow paint transfers from the school bus. This most likely occurred during the side slap event, possibly from the school bus's shattered fiberglass hood. There were also three glass punctures to the inside portion towards the center of the side air bag (**Figure 13** above).

The case vehicle's driver air bag was located in the steering wheel hub. The module cover consisted of asymmetrical "H"-configuration cover flaps made of thick vinyl. The top flap was rectangular with overall dimensions of 15 centimeters (5.9 inches) at the horizontal seam and 7 centimeters (2.8 inches) vertically. The lower flap was trapezoidal with overall dimensions of 15 centimeters (5.9 inches) at the upper horizontal seam and 8 centimeters (3.1 inches) vertically. An inspection of the air bag module's cover flaps and air bag revealed that the cover flaps opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover flaps. The driver's air bag was designed with two tethers, each approximately 10 centimeters (3.9 inches) in width. The driver's air bag had two vent ports, approximately 2.5 centimeters (1.0 inch) in diameter, located at the 11 and 1 o'clock positions. The deployed driver's air bag was round with a diameter of 63 centimeters (24.8 inches). An inspection of the driver's air bag fabric revealed contact evidence readily apparent on the air bag's fabric (**Figure 14**) on the upper left and right quarter sections.

Figure 14: Case vehicle's driver (front) air bag showing blood on upper left quadrant and body fluids on upper right quadrant (case photo #35)

The front right passenger's air bag was located in the top of the instrument panel. There were two symmetrical,"H"-configuration cover flaps. The cover flaps were made of a thick vinyl over a thick cardboard type frame with overall dimensions of 24 centimeters (9.4 inches) at the horizontal seam and 5 centimeters (2.0 inches) vertically for the upper and lower flaps. The profile of the case vehicle's instrument panel resulted in a 8 centimeter (3.1 inch) setback of the leading edge of the cover flap relative to the protruding right instrument panel. An inspection of the front right air bag module's cover flaps and air bag revealed that the cover flaps opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover flaps. The front right passenger's air bag was designed without any tethers. The front right air bag had two vent ports, approximately 4 centimeters (1.6 inches) in diameter, located at the

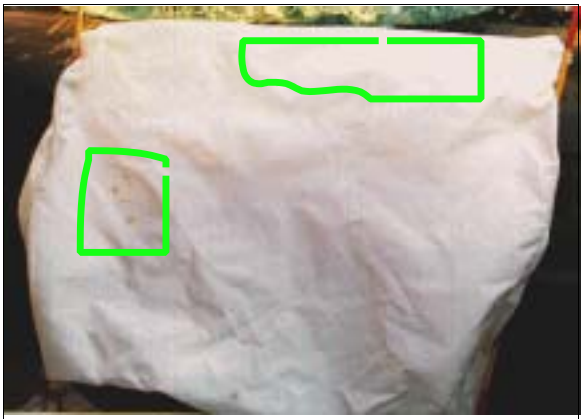


Figure 15: Front surface of case vehicle's front right passenger air bag showing blood evidence to left side and punctures along top (case photo #40)

9:30 and 2:30 o'clock positions. The deployed front right air bag was rectangular with a height of approximately 42 centimeters (16.5 inches) and a width of approximately 52 centimeters (20.5 inches). An inspection of the front right passenger's air bag fabric revealed apparent blood evidence on the front surface of the air bag's fabric toward the far left side, just inside the left seam. Furthermore, there were several punctures to the top and front surfaces of the air bag from coming in contact with the intruding windshield (**Figure 15** above).

CASE VEHICLE DRIVER KINEMATICS

Immediately prior to the crash the case vehicle's driver [168 centimeters and 80 kilograms (66 inches, 176 pounds)] was seated slightly reclined (seat back was measured at 70 degrees) with her back against the seat back, her left foot on the floor, her right foot either on the accelerator pedal or possibly going for the brake, and both hands on the steering wheel. Her seat track was found in its rearmost position. The tilt steering wheel's location could not be determined due to the severity of intrusion. It is unknown if the case vehicle's driver ever saw the approaching school bus or was able to attempt any evasive action just prior to the crash.

Figure 16: Close-up of case vehicle's left side impact showing driver's deployed seat back-mounted side impact air bag protruding from seat cushion and extended safety belt with blood spots highlighted on webbing (case photo #28)

The case vehicle's driver was restrained by her available, active, three-point, lap-and-shoulder, safety belt system. The case vehicle's front safety belts were equipped with pretensioners. Although the autopsy made no mention of belt pattern bruising and/or abrasions to the driver's body, the inspection of the driver's seat belt webbing, "D"-ring, and latch plate showed evidence of loading. Photographs (**Figure 16**) taken by this contractor showed blood evidence on the webbing and a friction scrub to the webbing near the "D"-ring's placement, as well as to the backside of the "D"-ring. In comparison, the front right passenger seat belt, which was not in use, was found taught against the right "B"-pillar while the driver's seat belt was locked in the outstretched position indicating its use during the crash. These locking actions resulted from the case vehicle's seat belt pretensioners firing during the deployment sequence, retracting the belt webbing.

Based on the available scene evidence, the case vehicle's driver did not attempt any avoidance maneuvers prior to the crash. As a result and independent of the use of her available safety belts, the driver's pre-impact body position did not change just prior to the crash. The case vehicle's primary impact with the school bus enabled the case vehicle's driver to continue slightly forward and move primarily leftward toward the **290** degree Direction of Principal Force as the case vehicle decelerated. As a result, the driver's head and thorax loaded her deploying driver side impact air bag and the intruding interior surface of her door. As a result of the force of the collision, the driver's side impact air bag was ruptured (**Figure 13** above), and the driver was compressed against her door panel throughout maximum engagement. The intruding driver's door

panel (**Figure 11** above), left instrument panel, and steering wheel (**Figure 10** above) sent the driver back into her seat back and to the right most likely contacting the center console. The case vehicle's left side, side slap impact sent the driver back to the left, with the intruding left front door panel keeping the driver's head from contacting the right side of the bus. As the two vehicles separated, the driver rebounded backwards into her seat back and then forward and to the right where her bloodied right hand came in contact with the front right passenger air bag, near its left seam. At final rest the driver was found sitting slumped forward between the intruded steering wheel and seat back.

CASE VEHICLE DRIVER INJURIES

The case vehicle's driver was transported by ambulance to the hospital. She sustained a fatal injury and was pronounced dead one hour and 38 minutes post-crash. According to her autopsy, she sustained fatal thoracic injuries which included: lacerations (2) of her thoracic aorta with hemorrhage which was not confined to her mediastinum and resulting in bilateral hemothoraces–primarily to her left pleural cavity (i.e., 1.5 liters), a contusion of her posterior mediastinum, multiple left rib fractures with lacerations of her left parietal pleura, and multiple contusions of her left posterior lung. In addition, she sustained lacerations to her liver (multiple) and spleen; fractures to her left pelvis, left humerus, and right femur; and numerous abrasions, contusions, and lacerations of her skin. It should be noted that there were no fractures or dislocations involving her cranial bones or the cervical spine that could be identified. This contractor believes that the lack of head and neck trauma is a very positive and direct benefit of the availability of her side impact air bag. This occupant's chest injuries were caused by her contact with the intruding surface of her door.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Lacerations x 2, ~ 3.8 cm (~ 1.5 in), major[1], transverse, transmural[2], of the thoracic aorta–1.3 cm (0.5 in) distal to origin of left subclavian artery	420218.6 untreatable	Left side interior surface, excluding hardware and/or armrest	Certain	Autopsy

[1] The driver sustained 1,550 cc of hemothorax which amounts to a blood loss that exceeds her 20% by volume threshold, and the autopsy indicated that the aortic tears "communicate the lumina of the aorta to the left pleural space" (i.e., the hemorrhage was not confined to her mediastinum.

The following terms are defined in DORLAND'S ILLUSTRATED MEDICAL DICTIONARY as follows:

lumen (loo′men): the cavity or channel within a tube or tubular organ.

lumina (loo′mi-na): plural of *lumen*.

mediastinum (me"de-as"ti′nam): The mass of tissues and organs separating the two pleural sacs, between the sternum anteriorly and the vertebral column posteriorly *{i.e., the bodies of the 12 thoracic vertebrae}* and from the thoracic inlet superiorly to the diaphragm inferiorly. It contains the heart and its pericardium, the bases of the great vessels *{e.g., aorta, aortic arch, vena cava, pulmonary arteries and veins}*, the trachea and bronchi, esophagus, thymus, lymph nodes, thoracic duct, phrenic and vagus nerves, and other structures and tissues.

[2] The following term is defined in DORLAND'S ILLUSTRATED MEDICAL DICTIONARY as follows:

transmural (trans-mu′ral): through the wall of an organ; extending through or affecting the entire thickness of the wall of an organ or cavity.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
2	Contusion {hematoma} of posterior mediastinum	441804.2 moderate	Left side interior surface, excluding hardware and/or armrest	Certain	Autopsy
3	Lacerations, multiple, to left posterior parietal pleura with bilateral hemothoraces, corresponding with rib fractures	441800.2[3] serious	Left side interior surface, excluding hardware and/or armrest	Certain	Autopsy
4	Contusions, multiple, left posterior lung	441406.3 serious	Left side interior surface, excluding hardware and/or armrest	Certain	Autopsy
5	Fractures, multiple, left ribs, anterior and posterior with bilateral hemothoraces	450230.3[3] serious	Left side interior surface, excluding hardware and/or armrest	Certain	Autopsy
6	Lacerations, multiple, transverse, anterior right lobe of liver extending deep into parenchyma with extensive tissue fraying	541826.4 severe	Console mounted transmission selector level	Probable	Autopsy
7	Laceration, 7.6 cm (3 in) lateral spleen	544224.3 serious	Left side interior hardware and/or armrest	Certain	Autopsy
8	Fracture left humerus, middle third	752602.2 moderate	Left side interior surface, excluding hardware and/or armrest	Certain	Autopsy
9	Fracture left pelvis, not further specified	852602.2 moderate	Left side interior hardware and/or armrest	Certain	Autopsy
10	Fracture right femur, middle third	851814.3 serious	Steering wheel rim	Probable	Autopsy
11	Lacerations x 2, left temporal scalp	190602.1 minor	Left front window frame	Possible	Autopsy
12	Abrasion deep, left forehead	290202.1 minor	Air bag, driver's side impact	Probable	Autopsy

[3] There were 1,550 cc of hemothorax: 1,500 cc in the left pleural cavity and 50 cc in the right pleural cavity. Because the aortic lacerations were upgraded (i.e., to an AIS = 6) for the extensive blood loss, primarily into the left pleural cavity, the AIS code for this lesion has not been upgraded for the same hemothoraces.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
13	Abrasions, numerous, deep, left cheek and face	290202.1 minor	Noncontact injury: flying glass, left front glazing	Probable	Autopsy
14	Lacerations {cuts}, numerous, small, left face	290602.1 minor	Noncontact injury: flying glass, left front glazing	Probable	Autopsy
15	Abrasions, numerous, left neck	390202.1 minor	Noncontact injury: flying glass, left front glazing	Probable	Autopsy
16	Lacerations {cut}, numerous, left neck	390602.1 minor	Noncontact injury: flying glass, left front glazing	Probable	Autopsy
17	Abrasions, numerous, deep, extending from superior and lateral left shoulder to left upper arm, left scapular area, and left forearm	790202.1 minor	Air bag, driver's side impact	Probable	Autopsy
18	Contusions, numerous, extending from superior and lateral left shoulder to left upper arm, left scapular area, and left forearm	790402.1 minor	Left side interior surface, excluding hardware and/or armrest	Probable	Autopsy
19	Lacerations x 2, left elbow	790602.1 minor	Left side interior hardware and/or armrest	Probable	Autopsy
20	Abrasion, 5 x 10 cm (2.0 x 3.9 in), deep, extending from distal right upper arm to proximal forearm	790202.1 minor	Air bag, driver's	Probable	Autopsy
21	Abrasions, numerous, superficial, dorsal left hand and fingers	790202.1 minor	Noncontact injury: flying glass, left front glazing	Probable	Autopsy
22	Lacerations {cuts}, numerous, small, dorsal left hand and fingers	790602.1 minor	Noncontact injury: flying glass, left front glazing	Probable	Autopsy
23	Contusions {bruises}, numerous, dorsal right hand	790402.1 minor	Left instrument panel and below	Probable	Autopsy
24	Lacerations {cuts}, numerous, dorsal right hand	790602.1 minor	Left instrument panel and below	Probable	Autopsy

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
25	Abrasions x 2, 2.5 cm (1.0 in) anterior lateral left knee	890202.1 minor	Left side interior surface, excluding hardware and/or armrest	Probable	Autopsy
26	Lacerations, 3.8 cm (1.25 in), deep, linear, medial right knee	890602.1 minor	Steering column	Probable	Autopsy
27	Contusions {bruises}, multiple, anterior left and right lower extremities	890402.1 minor	Left instrument panel and below	Probable	Autopsy

OTHER VEHICLE

The 1986 GMC was a rear wheel drive, incomplete chassis-cab, affixed with a two-door, forty-eight (48) passenger, Wayne school bus body (VIN: 1GDM6P1B8GV------). The school bus was equipped with a 6.0L (366 in^3) V-8 engine, a five-speed manual transmission, and was retrofitted with an 82-gallon, Liquid Petroleum Gas (LPG) fuel system tank. Braking was achieved by a power-assisted, front and rear air brake system. The bus's wheelbase was 645 centimeters (254.0 inches), and the odometer reading at inspection is unknown because the speedometer was removed from the vehicle prior to this contractor's inspection.

The vehicle was equipped with a manual, three-point, lap-and-shoulder, safety belt system for the driver seating position only. The interior was equipped with a bucket seat without head restraint for the driver and 24 rows of double bench seat for the student passengers.

Initially, the right half of the school bus's front bumper impacted the case vehicle, partially overriding the case vehicle's hood and pressing it downward under the bus's bumper as the bus was attempting to stop. The school bus knocked the case vehicle clockwise and both vehicles side slapped. Direct damage started 81 centimeters inward from the front left bumper corner and extended to the right 131 centimeters (51.6 inches). The school bus's front end was shifted approximately 38 centimeters (15.0 inches) to the driver's side (**Figures 5** above). The residual maximum crush to the front bumper was measured as 17 centimeters (6.7 inches) at C_4, and there was 50 centimeters (19.7 inches) of direct contact damage down the right side at C_6. The total field L across the front end was measured at 175 centimeters (68.9 inches). The side slap impact resulted in direct damage down the right side,

Figure 17: GMC school bus's left side body panel showing location of LPG cylinder behind panel (case photo #55)

extending back to the bus's front cowl and folding entrance/exit doors (**Figure 6** above). The frontal impact to the school bus was so severe that the front axle and tire assembly was torn from the bus during the crash. The torn axle and assembly damaged the left side body panel that protected the outside of the LPG cylinder (**Figure 17** above). An inspection of the 82 gallon cylinder revealed scrapes to the underside of the front portion of the cylinder (**Figure 18** above). This damage to the cylinder was also caused by the vehicle's front axle and tire assembly as a consequence of being driven over during the bus's movement to final rest (**Figures 19** and **20**).

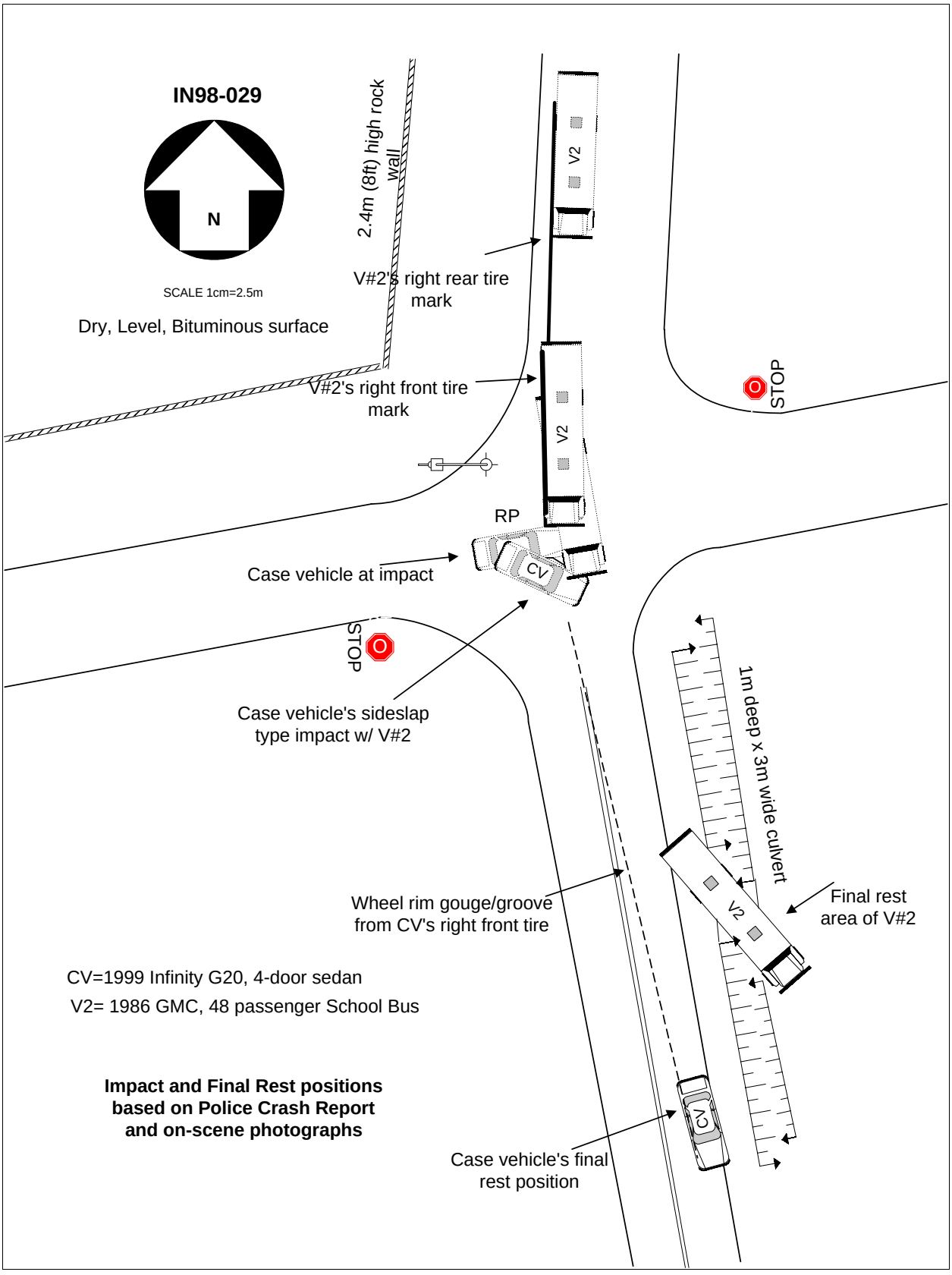
Figure 18: Close-up of GMC school bus's LPG gas cylinder under left body panel showing scrapes and yellow paint transfers (highlighted) to underneath side (case photo #59)

Figure 19: On-scene view of GMC school bus at final rest; Note: case vehicle's bumper under left rear dual wheels and bus's broken away front axle and tires laying under LPG cylinder towards front (case photo #77)

Figure 20: On-scene close-up view of GMC school bus's front axle and tire, laying on its side, under vehicle at final rest (case photo #78)

The school bus is neither CDC nor TDC applicable. This contractor's visually estimated Delta V is between 40 km.p.h. (25 m.p.h.) and 48 km.p.h. (30 m.p.h.). The school bus was towed due to damage.

At the time of the crash, the school bus was in the process of transporting 19 middle school students. All 19 students were listed on the Police Crash Report as sustaining "C" (Possible) injuries, but only seven (7) were transported to the hospital. It is unknown how they were transported (i.e., there was no mention of ambulances on the Police Crash Report). Based on the Police Crash Report, all seven were treated and released with minor injuries. The school bus's driver [39-year-old, White (unknown if Hispanic) male] was not using his available, manual, two-point, lap belt. Based on the available evidence, the driver did not seek treatment. The school bus was not equipped with an on-board video camera, and no safety belt systems were available for anyone other than the driver.


IN98-029
N
SCALE 1cm=2.5m
Dry, Level, Bituminous surface
2.4m (8ft) high rock wall
V2
V#2's right rear tire mark
V#2's right front tire mark
V2
STOP
RP
CV
Case vehicle at impact
STOP
Case vehicle's sideslap type impact w/ V#2
1m deep x 3m wide culvert
Wheel rim gouge/groove from CV's right front tire
V2
Final rest area of V#2
CV=1999 Infinity G20, 4-door sedan
V2= 1986 GMC, 48 passenger School Bus
Impact and Final Rest positions based on Police Crash Report and on-scene photographs
CV
Case vehicle's final rest position