TRANSPORTATION SCIENCES
CRASH DATA RESEARCH CENTER

Advanced Information Engineering Services
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Buffalo, NY 14225

ON-SITE SIDE IMPACT OCCUPANT PROTECTION INVESTIGATION

VEHICLE: 2000 VOLVO S80

CASE NO: CA02-042

LOCATION: PENNSYLVANIA

CRASH DATE: SEPTEMBER, 2002

Contract No. DTNH22-01-C-17002

Prepared for:

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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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16. Abstract This investigation focused on the performance of the side impact protection system of a 2000 Volvo S80. The Volvo was involved in an intersection crash with a 1996 Chevrolet Cavalier. The Volvo S80 was equipped with an Advanced Occupant Protection System (AOPS) that consisted of 3-point lap and shoulder restraints with retractor pretensioners in all five seat positions and dual stage frontal air bags. The Volvo was also equipped with a side impact protection system consisting of seat-mounted side impact air bags for the front occupants and inflatable side curtains. The Volvo's right side impact occupant protection and the frontal occupant protection systems deployed as a result of the crash. The Volvo was occupied by a 41 year old restrained male driver and an eight year old restrained male right rear passenger. Neither occupant of the Volvo sustained injuries in the crash. The Chevrolet Cavalier was equipped with frontal air bags for the driver and front right passenger. The frontal air bags deployed in the Chevrolet as a result of the crash. The Cavalier was occupied by a restrained female driver and an unrestrained female front right passenger. A 3 year old female was seated on the lap of the front right passenger at the time of the crash. The child occupant of the Chevrolet sustained fatal injuries as a result of the deploying front right passenger air bag.			
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GENERAL DYNAMICS CASE NO.: CA02-042
VEHICLE: 2000 VOLVO S80
LOCATION: PENNSYLVANIA
CRASH DATE: SEPTEMBER 2002

BACKGROUND

This investigation focused on the performance of the side impact protection system of a 2000 Volvo S80. The Volvo was involved in an intersection crash with a 1996 Chevrolet Cavalier. The Volvo S80, **Figure 1**, was equipped with an Advanced Occupant Protection System (AOPS) that consisted of 3-point lap and shoulder restraints with retractor pretensioners in all five seat positions and dual stage frontal air bags. The Volvo was also equipped with a side impact protection system consisting of seat-mounted side impact air bags for the front occupants and inflatable side curtains. The Volvo's right side impact occupant protection and the frontal occupant protection systems deployed as a result of the crash. The Volvo was occupied by a 41 year old restrained male driver and an eight year old restrained male right rear passenger. Neither occupant of the Volvo sustained injuries in the crash. The Chevrolet Cavalier was equipped with frontal air bags for the driver and front right passenger. The frontal air bags deployed in the Chevrolet as a result of the crash. The Cavalier was occupied by a restrained female driver and an unrestrained female front right passenger. A 3 year old female was seated on the lap of the front right passenger at the time of the crash. The child occupant of the Chevrolet sustained fatal injuries as a result of the deploying front right passenger air bag.

Figure 1: Front right view of the Volvo S80.

The Crash Investigations Division of the National Highway Traffic Safety Administration (NHTSA) was notified of this side impact crash by researchers at a regional trauma center on September 26, 2002. NHTSA assigned an on-site investigation of this crash to the General Dynamics Special Crash Investigations team due to the agency's interest in the performance of vehicle's equipped with side impact air bags. Coordination with the local police investigators was initiated and cooperation was established. The Chevrolet was equipped with an Event Data Recorder that was downloaded during the SCI inspection as a supplement to the investigation. The on-site inspection took place October 3, 2002.

SUMMARY

Crash Site

This two-vehicle crash occurred during the morning hours in September 2002. At the time of the crash, it was daylight and the weather was not a factor. The road surface was dry. The crash occurred at the

signalized four-leg intersection of a north/south two lane roadway and an east/west two lane roadway in a residential area. The overhead (red/amber/green) traffic signals controlling the intersection were operating properly at the time of the crash. The speed limit on the north/south road was 40 km/h (25 mph). The speed limit on the east/west road was 56 km/h (35 mph). The visibility at the intersection to the cross traffic was limited by the mature trees and bushes bordering the roads. **Figure 2** is an on-scene police photograph looking east at the final rest position of the vehicles. **Figure 3** is a westward view of the vehicles at final rest.

Figure 2: On-scene police photograph looking east.

Figure 3: On-scene police photograph looking west.

CRASH SEQUENCE

Pre-Crash

The 1996 Chevrolet Cavalier was southbound driven by a 37 year old restrained female. The front right passenger was an unrestrained 35 year old female. A 3 year old female was seated on the lap of the front right passenger (the child's mother). The occupants of the Chevrolet were unfamiliar with the area and had become lost. The 2000 Volvo S80 was westbound driven by a 41 year old restrained male. The rear right passenger was an 8 year old restrained male. The occupants of the Volvo lived in the vicinity of the crash and had recently left their home. They had traveled approximately 2 km (1 mile) prior to the crash.

The driver of the Volvo reported that the traffic light was in the green phase as he approached and entered the intersection. He indicated his speed was approximately 48 to 56 km/h (30 to 35 mph). The driver of the Chevrolet reported that she failed to see the traffic signal and entered the intersection without yielding. She did not see the Volvo until the impact. She indicated she was operating the vehicle at approximately 40 km/h (25 mph). There were no pre-crash avoidance maneuvers attributed to either vehicle.

Crash

The crash occurred with the front plane of the Chevrolet impacting the right side plane of the Volvo in a T-configuration. The principle directions of force were within the 11/2 o'clock sectors of the Chevrolet and Volvo respectively. The force of the impact deployed the frontal air bags of the Chevrolet and caused the deployment of the Volvo's right side impact protection. The frontal air bags and seat belt pretensioners (driver and rear right position) in the Volvo also deployed.

The lateral momentum of the Volvo (relative to the Chevrolet) caused the Chevrolet to rotate approximately 180 degrees clockwise upon separation from the Volvo. The Chevrolet came to rest facing north within the center of the intersection approximately 7.6 m (25.0 ft) south of the impact. The Chevrolet's impact was centered approximately 25 cm (10 in) aft of the Volvo's right B-pillar. The force of the impact rearward of the Volvo's center of gravity caused the vehicle to rotate approximately 270 degrees clockwise during its slide to rest. The Volvo came to rest facing south 18.9 m (62.0 ft) west of the point of impact. A 6 m (20 ft) scuff mark attributed to the left rear tire of the Volvo defined its post-crash trajectory. In the late stages of the Volvo's post-impact trajectory the back plane of the vehicle contacted the road side hedge and then rolled forward to final rest. **Figure 22** at the end of this report is a schematic of the crash.

Post-Crash

The police and ambulance personnel responded and arrived at the scene within minutes of the crash. The occupants of the Volvo exited their vehicle and were ambulatory at the scene. They were not injured and did not seek follow-up medical attention.

The occupants of the Chevrolet exited the vehicle. The driver of the Chevrolet reported that the front right passenger exited the vehicle with the child in her arms and laid her down on the road. A physician was passing by the crash scene and also stopped to render aid. The physician indicated the child was unresponsive at that time. The child was placed in an ambulance and immediately transported to the emergency room of a local hospital and then transferred to a Level 1 trauma center at a regional children's hospital. The child was diagnosed with a high cervical spine injury with spinal cord damage and a brain injury. She was mechanically supported for nine days and expired immediately upon removal of life support. The driver and front right passenger were transported to a local hospital for police reported minor injuries and then released.

2000 VOLVO S80

The 2000 Volvo S80, 4-door sedan, **Figure 4**, was identified by the Vehicle Identification Number (VIN): YV1TS94DXY1 (production sequence deleted). The vehicle was equipped with a 2.9 liter/I-6 engine linked to a 4-speed automatic transmission. The services brakes were 4-wheel disc with ABS. The Volvo was equipped with a power package including power steering, power brakes, and 8-way adjustable driver and front passenger seats. The manual restraint system consisted of 3-point lap and shoulder belts with retractor pretensioners in the five seat positions. The Volvo was equipped with an Advanced Occupant Protection System (AOPS) consisted of dual stage driver and front right passenger air bags, seat back mounted side impact air bags for the front occupants and inflatable side

Figure 4: Right side view of the Volvo S80.

curtains. The vehicle was manufactured in September 1999. The odometer had registered 40,616 km (25,328 miles) at the time of the inspection.

Exterior Damage

Figures 5 and 6 are the right front and right rear views of the damage. The right side plane of the Volvo sustained a combined 218.7 cm (86.1 in) of direct and induced damage as a result of the impact. The induced damage began 49.3 cm (19.4 in) aft of the right front axle at the leading edge of the right front door. The width of the direct damage measured 174.2 cm (68.6 in) and began 96.3 cm (37.4 in) aft of the right front axle on the center aspect of the right front door. The end of the direct and induced damage was located 81 cm (3.2 in) forward of the right rear axle immediately aft of the right rear door. The door panels were crushed laterally and right rear glazing disintegrated in the impact. The maximum lateral deformation measured 24.4 cm (9.6 in). The residual crush profile was as follows: C1 = 0, C2 = 19.3 cm (7.6 in), C3 = 23.1 cm (9.1 in), C4 = 24.3 cm (9.6 in), C5 = 19.8 cm (7.8 in), C6 = 0. The total delta V calculated by the Damage algorithm of the WINSMASH model was 19.8 km/h (12.3 mph). The longitudinal and lateral delta V components were -12.7 km/h (-7.9 mph) and -15.2 km/h (-9.4 mph), respectively. The principle direction of the impact was within the 2 o'clock sector estimated at 50 degrees. The Collision Deformation Classification was 02-RPEW-2.

Figure 5: Right front close-up of the damage.

Figure 6: Right rear close-up of the damage.

The back plane of the Volvo exhibited minor vertically oriented abrasions to the rear bumper fascia. The direct contact measured 55 in and began at the rear right corner. The abrasions were resultant to contact with the road side hedge as the vehicle neared final rest. The CDC of this contact was 06-BDLW-1.

Interior Damage

The interior damage to the Volvo consisted of the minor intrusion of the right side doors and the deployment of the frontal and right side occupant protections systems. There were no noted occupant contacts to the interior.

The right front and right rear interior door panels intruded laterally into the occupant compartment and were in contact with outboard aspect of the front right and rear right seat. **Figure 7** is a view of the intrusion and rear right seat compression. The seat cushions were compressed laterally. The intrusion of the central aspect of the right front door measured immediately above the grab handle was 6.1 cm (2.4 in). The right B-pillar intrusion measured at the elevation of the front seat backs was 4.6 cm (1.8 in). The intrusion of the central aspect of the right rear door measured immediately above the grab handle was 5.8 cm (2.3 in).

Figure 7: View of the rear right intrusion and seat compression.

Manual Restraint System

The manual restraint systems in the 2000 Volvo S80 consisted of a 3-point lap and shoulder belt with sliding latch plate and continuous loop webbing in the five seat positions. Each inertial locking retractor was equipped with a belt pretensioner.

At the time of the inspection, the driver's restraint was extended from the retractor and laying on the seat, **Figure 8**. The retractor was locked by the fired pretensioner. The exposed webbing section measured 168 cm (66 in) from the outboard anchor to the spool of the locked retractor located in the upper B-pillar. The trim that guided and surrounded the belt path at the upper aspect of the left B-pillar separated and was laying on the seat. The trim separated due to the belt tensioning caused by the fired retractor pretensioner. Examination of the webbing revealed a 8 cm (3 in) section of stretched webbing located at the latch plate with the restraint in the buckled condition. Examination of the latch plate revealed evidence of historical use consistent with the age of the vehicle. All the evidence gathered during the inspection indicated the driver was restrained at the time of the crash.

The rear right restraint was extended from its retractor and laying on the rear bench seat, **Figure 9**. The retractor was locked by the fired pretensioner. The exposed webbing section measured 141.0 cm (55.5 in) measured from the seat bight to the upper belt guide. Examination of the webbing did not reveal any evidence of loading. However, given the relative mass of the occupant (as compared to the driver) and the principle direction of force in this crash loading evidence would not be expected. Latch plate examination revealed sign historical usage indicators. The evidence gathered during the inspection indicated the rear right occupant was restrained in this crash.

Figure 8: Driver's restraint.

Figure 9: Rear right restraint.

Advanced Occupant Protection System

The Advanced Occupant Protection System in the 2000 Volvo S80 consisted of advanced dual stage air bags for the driver and front right passenger, seat back mounted side impact air bags and inflatable side curtains. The right side impact protection (right front side impact air bag and right inflatable side) and the frontal air bags deployed as a result of the angular impact.

The driver air bag was housed in the typical manner in the center hub of the steering wheel. The H-configuration module cover flaps were symmetrical and measured 14.7 cm x 5.8 cm (5.8 in x 2.3 in), width by height. The driver air bag measured 61 cm (24 in) in its deflated state. It was tethered by four 3.3 cm (1.3 in) wide straps sewn to the face of the bag. It was vented by two 3.8 cm (1.5 in) diameter ports in the 11/1 o'clock sectors on the back side of the bag. There was no direct evidence of occupant contact to the air bag.

The front right passenger air bag was a top mount design located in the right aspect of the instrument panel. The module cover flap consisted of a single vinyl flap hinged on its forward side. The cover flap measured 31.2 cm x 19.8 cm (12.3 in by 7.8 in), width by height. The face of the passenger air bag measured 41 cm x 56 cm (16 in x 22 in) and extended 51 cm (20 in) rearward from the vertical face of the instrument panel. The bag was not tethered and was vented by two 5 cm (2 in) diameter ports on the side panels of the bag. There was no occupant contact evidence identified on the air bag.

The right side impact air bag, **Figure 10**, was housed in a vertically oriented module housed in the outboard bolster of the right front seat back. The bolster seam stitching separated vertically allowing the forward expansion of the air bag. The side impact air bag was elliptical in shape and was designed to offer thorax protection. The air bag measured 39.4 cm x 25 cm (15.5 in x 10 in), vertically by longitudinally with respect to the vehicle. The air bag was not tethered and was vented by a single 2.5 cm (1.0 in) diameter port located on the upper aspect of the bag's outboard side. The air bag inflated to an estimated thickness of approximately 5 to 8 cm (2 to 3 in). There was no contact evidence noted on the air bag.

Figure 10: View of the deployed right side impact air bag.

Figures 11 and 12 are left side views of the deployed right inflatable side curtain. The inflatable curtain deployed downward from the right roof rail. The curtain was rectangular in shape and measured 25 cm x 137 cm (10 in x 54 in) overall. The estimated thickness of the inflated curtain was approximately 5 cm (2 in). The headliner separated, along its length, from the upper interior trim allowing the curtain to deploy vertically down. The curtain provided approximately 137 cm (54 in) of coverage across the vehicle's right side glass. This coverage measured approximately 38 cm (15 in) forward of the B-pillar extending forward across approximately two thirds (2/3) of the right front glazing. The coverage extended approximately 86 cm (34 in) rearward of the B-pillar, across the left rear glazing and ending adjacent to the right rear seat back. The forward aspect of the curtain was fastened to the mid aspect of the A-pillar by a 47.0 cm (18.5 in) long tether strap. The strap was attached to the A-pillar 30 cm (12 in) above the instrument panel. The rear aspect of the curtain was fastened to the left roof rail at the C-pillar. The vertical dimension of the deflated curtain measured 25 cm (10 in). The curtain was designed with a distinct chambered pattern. There were 12 chambers with nominal dimensions that measured 8.9 cm x 21.6 cm (3.5 in x 8.5 in) This pattern provided the occupant protection when inflated, as well as providing some rigidity to the curtain and helped to maintain its shape. The curtain was not externally vented. A horizontally-mounted gas cylinder located in the upper aspect of the C-pillar provided the means for inflation.

Figure 11: Left interior view depicting the deployed right side impact protection.

Figure 12: Left interior view of the deployed inflatable curtain at the rear right position.

1996 CHEVROLET CAVALIER

The 1996 Chevrolet Cavalier 2-door coupe, **Figure 13**, was identified by the Vehicle Identification Number (VIN): 1G1JC1244TM (production sequence deleted). The vehicle's power train consisted of a 2.2 liter/I-4 engine linked to a 4-speed automatic transmission. The service brakes were a front disc/rear drum system with ABS. The manual restraint system consisted of 3-point lap and shoulder belts in the four outboard positions and a center rear lap belt. The Supplemental Restraint System consisted of driver and front right passenger air bags. The vehicle was manufactured in November 1995. The odometer had recorded 166,949 km (103,740 miles).

Figure 13: Left front view of the Chevrolet.

Exterior Damage

Figures 14 and 15 are a left lateral and an overhead frontal view of the vehicle's exterior damage. The frontal plane of the Chevrolet sustained moderate direct contact damage that extended across its entire 142 cm (56 in) end width. The lateral momentum of the Volvo during the impact phase caused a 30 cm (12 in) right lateral deformation of the Chevrolet's bumper structure. The crash damage extended longitudinally rearward to approximately the radiator support plane. The residual frontal crush profile along the bumper reinforcement bar was as follows: C1 = 14.1 cm (5.5 in), C2 = 31.4 cm (12.4 in), C3 = 35.3 cm (13.9 in), C4 = 34.9 cm (13.8 in), C5 = 29.5 cm (11.6 in), C6 = 29.3 cm (11.6 in). The right front fender shifted rearward and restricted the operation of the right door. The right wheelbase was reduced 6.5 cm

(2.6 in) and the right front tire was restricted. The left wheelbase dimension was unchanged. The total delta V calculated by the Damage algorithm of the WINSMASH model was 25.1 km/h (15.6 mph). The longitudinal and lateral components of the delta V were -19.3 km/h (-12.0 mph) and 16.2 km/h (10.1 mph), respectively. The impact's principle direction of force (PDOF) was in the vehicle's 11 0'clock sector estimated to be 320 degrees. The Collision Deformation Classification (CDC) was 11-FDEW-2.

Figure 14: Left lateral view.

Figure 15: View of the frontal damage.

Interior Damage

The interior damage to the Chevrolet was attributed to the deployment of the Supplemental Restraint System and the occupant interior contacts. There was no intrusion into the occupant compartment as a result of the exterior crash forces.

The manual driver seat was adjusted to a forward track position. The seat's position measured 5.5.1 cm (2.0 in) aft of full forward. The total seat track travel measured 21.1 cm (8.3 in). The seat back was reclined 14 degrees. The distance from the center hub of the steering wheel to the seat back measured 47.8 cm (18.8 in). The police investigator indicated the seats had not been moved from their at-crash position.

The steering wheel/column was not adjustable. The 2-spoke steering wheel rim was rotated 90 degrees clockwise at the time of the inspection. There was no evidence of loading to the rim and there was no movement of the steering column's shear capsules.

The driver's knee bolster exhibited a possible left lower extremity contact. The contact was located 21.3 cm (8.4 in) left of the steering column center line [13 cm (5 in) right of the bolster's outboard edge] and 44.5 cm (17.5 in) above the floor. The contact consisted of a 2.5 cm x 4.0 cm (1.0 in x 1.5 in) red and blue transfer with an adjacent 10 cm (4 in) lateral swipe located outboard of the transfer. This minor surface contact did not result in any underlying bolster deformation. No other interior contacts were attributed to the driver.

The front right seat was adjusted to a mid-track position and reportedly had not been moved. The track position measured 6.6 cm (2.6 in) forward of the rear most adjustment. The total seat track travel measured 16.5 cm (6.5 in). The seat back was reclined 20 degrees. The horizontal distance from the vertical face of the instrument panel to the seat back measured 68.1 cm (26.8 in). The horizontal distance from the aft edge of the passenger air bag module to the seat back measured 80.7 cm (31.8 in).

Figure 16 is an overall view of the Chevrolet's interior. Multiple areas of contact evidence were identified on the upper surface of the instrumental panel's right aspect. These contacts were attributed to contact from the impeded expansion of the front right passenger air bag due to the forward position of the lap seated child passenger. A 25 cm x 18 cm (10 in x 7 in), width by height, area of air bag scuffing was located on the right corner of the instrument panel, **Figure 17**. This contact pattern measured 13 cm (5 in) on the vertical face of the panel and wrapped 5 cm (2 in) onto its horizontal surface. The heating vent louvers were fractured by this contact. A 10 cm x 8 cm (4 in x 3 in) air bag scuff was identified on the vertical face of the instrument panel in its right center aspect. This scuff began 36.8 cm (14.5 in) left of the panels outboard edge. An 8.0 cm (3.0 in) air bag scuff was located on the trim panel covering the right A-pillar. This scuff began 15 cm (6 in) above the instrument panel. The right door interior trim panel exhibited a 14.0 cm (5.5 in) air bag scuff on its upper aspect at the intersection with the glazing. The pattern began 24.1 cm (9.5 in) rear of the forward edge of the glazing. The trim panel was fractured within this pattern from probable occupant contact.

Figure 16: Overall forward interior view.

Figure 17: Air bag transfer pattern to the right aspect of the IP.

A head contact was identified on the center forward aspect of the headliner, **Figure 9**. The contact measured 15 cm x 10 cm (6 in x 4 in), width by length and was located 5 cm (2 in) right of the vehicle's centerline. The center mirror adjacent to this location rotated and fractured. A 13 cm x 13 cm (5 in x 5 in) body fluid spray was identified on the left aspect of the instrument panel brow located above the instrument cluster, **Figure 10**. The contact pattern began 72.4 cm (28.5 in) left of the instrument panel right outboard edge and extended left to approximately the steering column center line. Several strands of hair

were located on the brow within a probable head contact in this contact pattern (identified by the arrow in Figure 10). These contacts were both associated to the child passenger due to their relative location and orientation.

The glove box was located in the lower aspect of the right instrument panel. The glove box door was open and its operation was restricted. It would not close. The interior panel comprising the door was fractured. The fracture occurred from a probable right lower extremity contact by the adult female passenger to the exterior surface of the door. The contact area measured 5 cm x 5 cm (2 in x 2 in) and was located 15 cm (6 in) inboard (left) of the instrument panel's right outboard side.

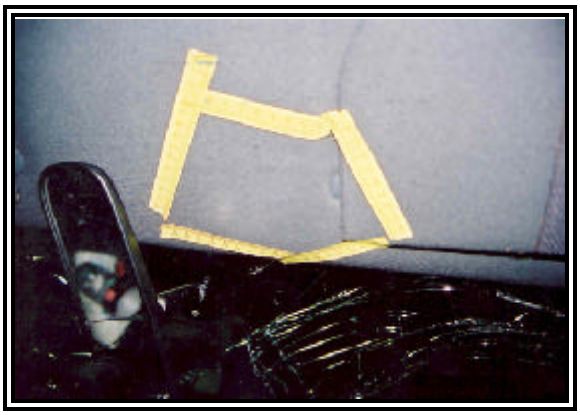


Figure 18: Contact evidence to the headliner.

Figure 19: Contact evidence to the IP brow.

Manual Restraint System

The driver's manual restraint system consisted of 3-point lap and shoulder with a cinching latch plate and a emergency locking retractor. The D-ring was fixed. The driver's restraint was stowed within its retractor upon initial inspection and was operational. Inspection of the latch plate revealed evidence of historical use. Examination of the webbing identified an abrasion located 85.3 cm (33.6 in) from the outboard anchor. This abrasion was located at the latch plate with the restraint in the simulated buckled condition and was consistent with driver restraint use during the crash. The physical evidence identified during the inspection indicated the driver was restrained at the time of the crash. It should be noted the EDR recorded as unbuckled condition for the driver. This discrepancy was attributed to a probable recording error.

The front right passenger restraint was stowed within its retractor upon inspection and was operational. Extension and examination of the webbing did not reveal any crash related evidence similar to the driver belt. Although the latch plate showed signs of historical use, the passenger in this crash was not a regular occupant in this vehicle. If the adult passenger had been restrained, the additional mass (weight) of the lap seated child would have increased the likelihood the restraint would have exhibited usage indicators. It was determined the adult passenger was unrestrained given the lack of physical evidence.

The rear seating area consisted of a fixed bench seat. The manual restraint consisted of 3-point lap and shoulder belts for the outboard occupants and a center rear lap belt. The three restraints were not visible upon initial inspection. The webbings for the outboard restraints were tucked between the outboard aspect of the rear seat back and the interior side panel on both sides of the Cavalier. The center lap belt was tucked into the seat bight. All three restraints were operational upon inspection and showed minimal evidence of historical use.

Supplemental Restraint System

The Supplemental Restraint System in the 1996 Chevrolet Cavalier consisted of driver and front right passenger air bags. The air bags deployed as a result of the crash. The SRS was monitored and controlled by a Sensing and Diagnostic Control Module (SDM) located under the front right seat. The sensing system of the SRS utilized a front satellite sensor located on the upper radiator support to help in the crash detection process. The SDM had the capabilities to record information regarding the crash event. This data was downloaded during the SCI inspection and used as a supplement to the investigation. The downloaded data is included as **Attachment A** at the end of this report. The maximum recorded longitudinal delta V was -30.01 km/h (-18.65 mph).

The driver air bag was designed in the typical manner and located in the center hub of the steering wheel. The I-configuration module cover flaps were symmetrical and measured 9.7 cm x 9.7 cm (3.8 in x 3.8 in), width by height. The deployed driver air bag measured 61 cm (24 in) in its deflated state. It was not tethered and it was vented by two 3.3 cm (1.3 in) ports located in the 3/9 o'clock sectors. There was no direct evidence of driver contact identified.

The front right passenger air bag was a top-mount design located in the right aspect of the instrument panel. The passenger air bag module cover flap was vinyl backed by sheet metal that formed a forward folding hinge. The flap was rectangular and measured 32.5 cm x 18.5 cm (12.8 in x 7.3 in). The flap contacted and fractured the right aspect of the windshield during the deployment sequence. There was no evidence of occupant contact to the flap.

The face of the front right passenger air bag measured 51 cm x 61 cm (20 in x 24 in), width by height, and extended 66 cm (26 in) from the aft edge of the air bag module. The air bag was tethered by two 5 cm (2 in) wide straps sewn to the face of the bag 13 cm (5 in) below the bag's top surface. The air bag was internally vented.

The top surface of the air bag, **Figure 20**, exhibited multiple patterns of contact evidence. A 25 cm x 15 cm (10 in x 6 in) region of vinyl transfers was located on the forward aspect of the top surface and began 15

Figure 20: Passenger air bag top surface.

cm (6 in) from the aft edge of the module. This pattern was attributed to contact with the cover flap during its impeded deployment. A 5 cm x 11.4 cm (2 in x 4.5 in) area of the air bag was yellowed from probable heating during the deployment. This pattern began 18 cm (7 in) from the module edge and was centered 18.5 cm (7.3 in) right of the inboard edge of the bag. A 14.0 cm (5.5 in) long by 3.8 cm (1.5 in) wide black vinyl transfer was located 14.0 cm (5.5 in) left of the right outboard edge of the bag. A secondary pattern linked to the former transfer measured 10 cm (4 in) long and was located on the outboard edge of the bag extending onto the outboard side panel. These transfers resulted from their contact with the right A-pillar trim. A 8 cm x 20 cm (3 in x 8 in), width by length, tissue transfer was located within the center aspect of the air bag's top surface, **Figure 21**. The transfer began 41 cm (16 in) from the module and extended rearward ending 61 cm (24 in) from the module. This transfer resulted from direct contact with the child occupant.

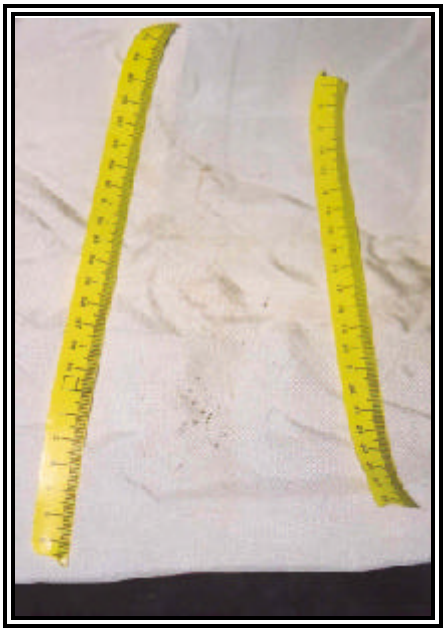


Figure 21: Close-up of the tissue transfer.

OCCUPANT DEMOGRAPHICS

2000 Volvo S80

	Driver	**Rear Right Child Passenger**
Age/Sex:	41 year old/Male	8 year old/Male
Height:	185 cm (73 in)	124 cm (49 in)
Weight:	107 kg (235 lb)	33 kg (72 lb)
Manual Restraint Use:	3-pt. lap and shoulder	3-pt. Lap and shoulder
Usage Source:	SCI inspection	SCI inspection
Medical Status:	Not injured	Not injured

1996 Chevrolet Cavalier

	Driver	**Front Right Adult Passenger**	**Lap Seated Child Passenger**
Age/Sex:	37 year old/Female	35 year old/Female	3 year old/Female
Height:	unknown	unknown	unknown
Weight:	unknown	unknown	15 kg (33 lb) approx.
Manual Restraint Use:	3-pt. lap and shoulder	None	None
Usage Source:	SCI inspection	SCI inspection	SCI inspection
Medical Status:	Treated and released	Treated and released	Fatally injured

OCCUPANT INJURIES

2000 Volvo S80

None of the occupants in the Volvo sustained injury and they did not seek follow-up medical attention.

1996 Chevrolet Cavalier

The 3 year child seated on the lap of the adult front right passenger sustained fatal cervical spinal cord and brain injuries as a result of direct contact with the expanding front right passenger air bag.

OCCUPANT KINEMATICS

2000 Volvo S80 Driver

The 41 year old driver of the Volvo was seated in an upright posture with his seat adjusted to a rear track position. The driver was restrained at the time of the crash by the 3-point lap and shoulder belt. At impact, the driver's safety belt pretensioner and frontal air bag deployed. The driver responded to the 2 o'clock direction of the impact by initiating a forward and right trajectory. The driver contacted and loaded the safety belt system and rode down the force of the crash. The driver probably contacted the deployed driver air bag during the ride down. The driver then rebounded into his seat and exited the vehicle under his own power. He was not injured in the event.

2000 Volvo S80 Rear Right Passenger

The 8 year old rear right passenger was seated in an upright posture and was restrained by the 3-point lap and shoulder belt. At impact, the safety belt pretensioner fired and the right side curtain deployed. The child occupant responded to the 2 o'clock direction of the impact by initiating a forward and right trajectory. The child loaded the safety belt system and began to ride down the force of the crash. Coincident to this kinematic pattern, the right side structure of the vehicle was intruding. The child probably contacted the door panel with his right flank and the deployed side curtain with his head. There was no evidence of these contacts identified by inspection and were probably minor in nature. The child then rebounded back into his seat. After the came to rest, he unfastened his safey belt and exited the vehicle through the left rear door and was not injured.

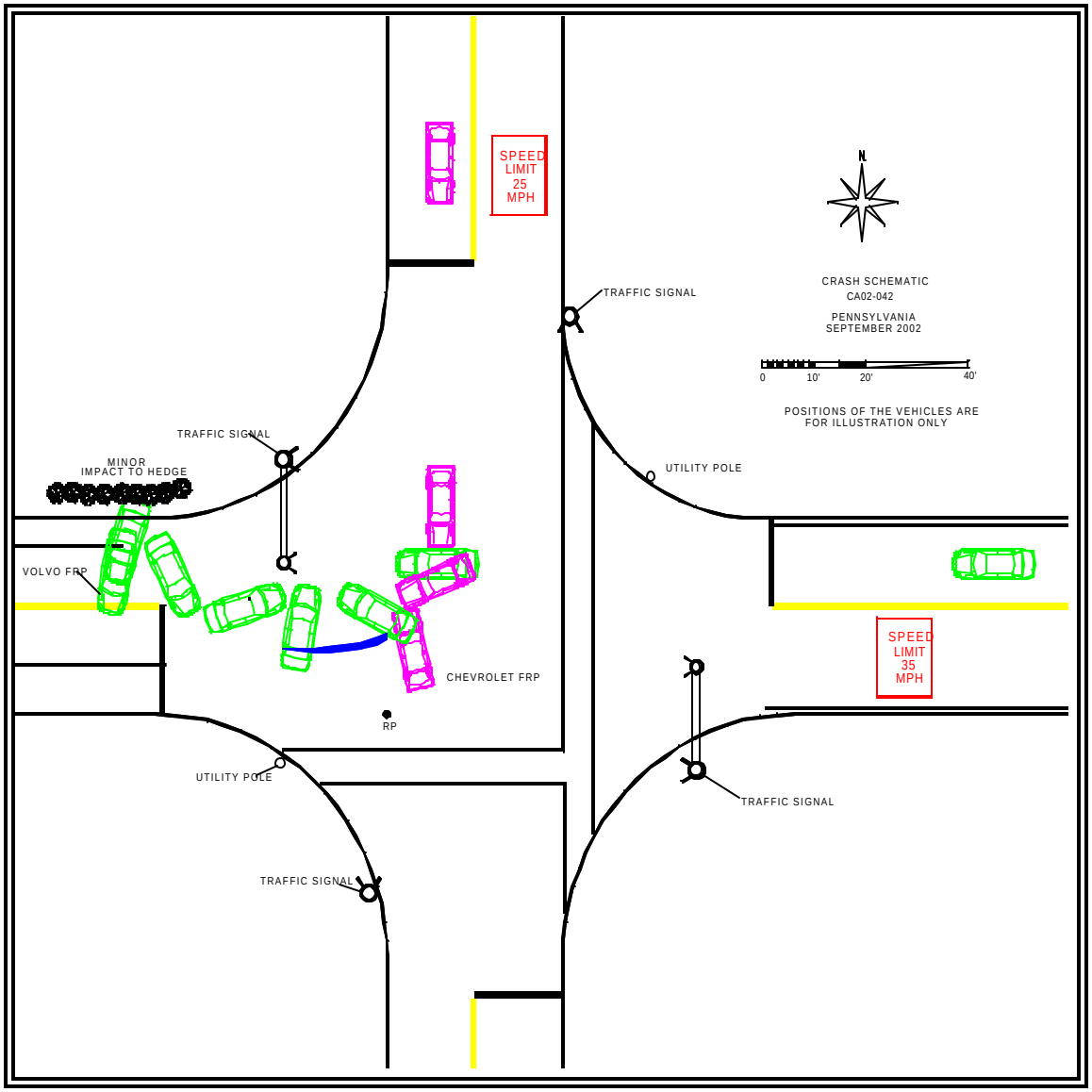


Figure 22: Crash schematic.

ATTACHMENT A

Vetronix CDR Report
1996 Chevrolet Cavalier

Vehicle Identification Number	1G1JC1244TMxxxxxx
Investigator	
Case Number	
Investigation Date	
Crash Date	
Filename	
Saved on	10/21/2002 1:34:59 PM
Data check information	B6870680
Collected with CDR version	Crash Data Retrieval Tool 1.602
Collecting program verification number	AD206938
Reported with CDR version	Crash Data Retrieval Tool 1.602
Reporting program verification number	AD206938
Event(s) recovered	Deployment

SDM DATA LIMITATIONS

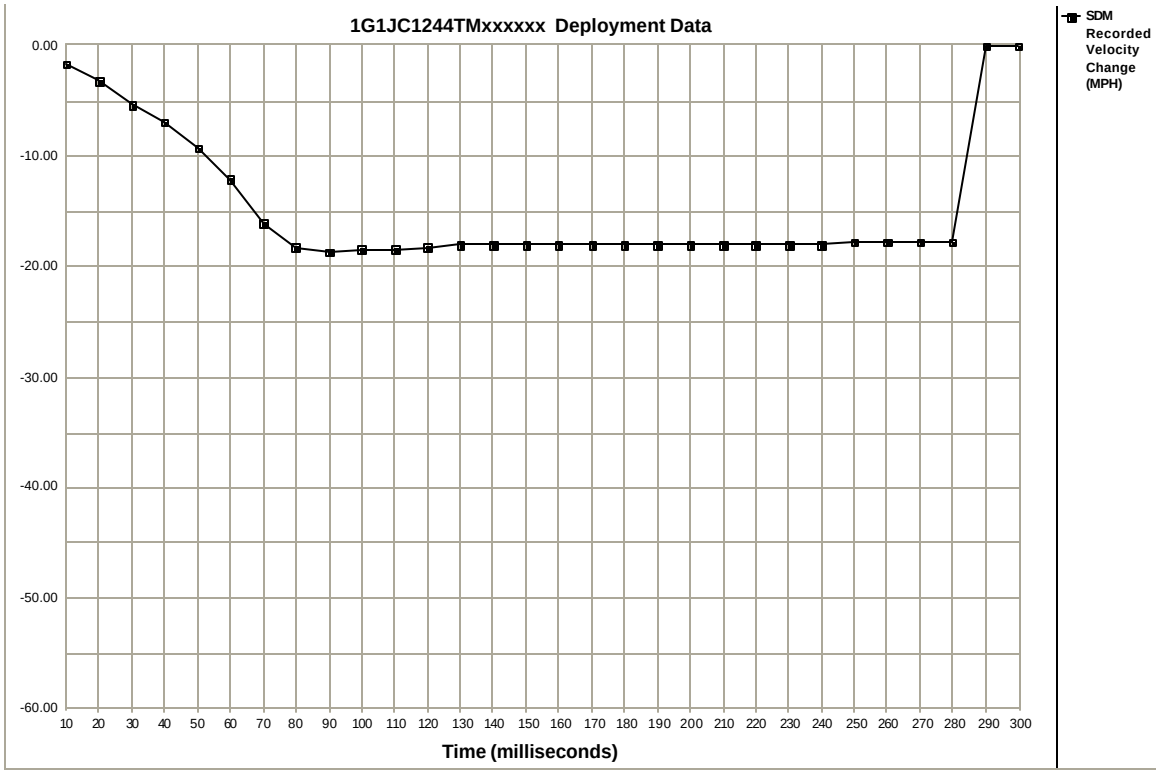
SDM Recorded Crash Events:
There are two types of SDM recorded crash events. The first is the Near Deployment Event. A Near Deployment Event is an event severe enough to "wake up" the sensing algorithm but not severe enough to deploy the air bag(s). The SDM can store up to one Near Deployment Event. This event can be overwritten by an event that has a greater SDM recorded forward velocity change. This event will be cleared by the SDM after the ignition has been cycled 250 times.
The second type of SDM recorded crash event is the Deployment Event. The SDM can store up to two different Deployment Events, if they occur within five seconds of one another. The first deployment event will be stored in the Deployment file (this would have been the event that deployed the air bag) and the second Deployment Event will be stored in the Near Deployment file. Deployment events can not be overwritten or cleared from the SDM. Once the SDM has deployed the air bag, the SDM must be replaced.
The data in the near deployment file will be locked after a deployment, if the near deployment occurred within 5 seconds before the deployment or a deployment level event occurs within 5 seconds after the deployment.

SDM Data Limitations:
-SDM Recorded Vehicle Forward Velocity Change is one of the measures used to make air bag deployment decisions. SDM Recorded Vehicle Forward Velocity Change reflects the change in forward velocity that the sensing system experienced during the recorded portion of the event. This data should be examined in conjunction with other available physical evidence from the vehicle and scene when assessing occupant or vehicle forward velocity change. The SDM records the first 300 milliseconds of Vehicle Forward Velocity Change after Algorithm Enable. The maximum value that can be recorded for Vehicle Forward Velocity Change is 56 MPH.
-Driver's Belt Switch Circuit Status indicates the status of the driver's seat belt switch circuit.
-The Time between Near Deployment and Deployment Events is displayed in seconds. If the time between the two events is greater than five seconds, "N/A" is displayed in place of the time.
-If power to the SDM is lost during a crash event, all or part of the crash record may not be recorded. An indication of a loss of power would be if the ignition cycles at Deployment or Near Deployment is recorded as zero. Data recorded after that may not be reliable, such as Time Between Near Deployment and Deployment Events and Driver Belt Switch Circuit Status.

SDM Data Source:
All SDM recorded data is measured, calculated, and stored internally, except for the following:
-The Driver's Belt Switch Circuit is wired directly to the SDM.

System Status At Deployment

SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	UNBUCKLED
Ignition Cycles At Deployment	0
Ignition Cycles At Investigation	22897
Time From Algorithm Enable To Deployment Command (msec)	12.5
Time Between Near Deployment And Deployment Events (sec)	N/A



Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Recorded Velocity Change (MPH)	-1.54	-3.07	-5.27	-6.80	-9.21	-12.07	-16.02	-18.21	-18.65	-18.43	-18.43	-18.21	-17.99	-17.99	-17.99
Time (milliseconds)	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
Recorded Velocity Change (MPH)	-17.99	-17.99	-17.99	-17.99	-17.99	-17.99	-17.99	-17.99	-17.99	-17.77	-17.77	-17.77	-17.77	0.00	0.00

Hexadecimal Data

This page displays all the data retrieved from the air bag module.
It contains data that is not converted by this program.

```
B600:  20 42 00 00 00 00 AA 00
B608:  00 AA 00 00 00 00 AA 00
B610:  00 AA 00 00 00 5B F9 F9
B618:  F9 93 F9 F9 F9 F9 FF AA
B620:  AA AA 00 00 AA 00 00 7D
B628:  00 02 00 0A 07 0E 18 1F
B630:  2A 37 49 53 55 54 54 53
B638:  52 52 52 52 52 52 52 52
B640:  52 52 52 52 51 51 51 51
B648:  00 00 00 00 00 00 00 00
B650:  00 00 00 00 00 00 00 00
B658:  00 00 00 00 00 00 00 00
B660:  00 00 00 00 00 00 00 00
B668:  00 00 00 00 00 00 00 00
B670:  00 00 00 00 00 00 00 00
B678:  00 00 00 00 00 00 00 00
B680:  00 00 00 00 00 00 00 00
B688:  00 00 00 11 84 00 00 00
B690:  00 00 00 00 7D FA 00 00
B698:  7D FA 00 00 00 00 00 00
B6A0:  81 00 00 02 82 00 00 0C
B6A8:  83 00 00 00 00 00 00 00
B6B0:  BB CC B4 A8 CE BE AC 8C
B6B8:  96 B4 EA CF E0 92 6E C6
B6C0:  34 4E 1A 01 00 64 02 00
B6C8:  00 AA 00 01 01 00 00 00
B6D0:  00 00 00 00 00 00 00 00
B6D8:  00 00 00 00 00 00 00 00
B6E0:  00 00 45 4C 00 00 02 4A
B6E8:  02 AA 00 00 00 00 00 00
B6F0:  28 08 F0 05 50 04 0C 29
B6F8:  64 FF FF FF 2B 36 44 4D
B700:  50 5A 5C 68 6D 6F 70 70
B708:  71 7C 7E 83 85 85 85 87
B710:  8D 91 94 96 96 96 96 9C
B718:  A7 B2 BB C7 D1 DB E2 ED
B720:  F5 40 43 45 48 4A 4C 4E
B728:  50 52 54 55 57 59 5A 5C
B730:  5D 5F 60 61 63 64 65 66
B738:  67 67 68 69 69 69 69 6A
B740:  6B 6C 6C 6C 6C 6D 6D 6E
B748:  6E 6F 6F 6F 6F 6F 70 70
B750:  70 70 70 71 71 71 71 71
B758:  71 71 71 71 71 00 6C 00
B760:  E0 0A 24 3C 22 12 15 06
B768:  0A AA 00 4C 4D FF FF FF
B770:  29 34 3F 47 49 55 57 63
B778:  67 6A 6B 6B 6B 74 77 79
B780:  7A 7A 7A 7D 83 86 88 89
B788:  89 89 89 89 89 89 89 89
B790:  89 89 89 89 89 89 89 89
B798:  89 89 89 89 8B 8C 8C 8C
```

```
B7A0:  8C 8C 8C 8C 8C 8C 8C 8C
B7A8:  8C 8C 8C 8C 8C 8C 8C 8C
B7B0:  8C 8C 8C 8C 8C 90 92 94
B7B8:  97 FF FF FF FF 00 00 B6
B7C0:  39 00 00 00 00 00 00 00
B7C8:  00 00 00 00 00 00 00 00
B7D0:  00 00 00 00 00 00 00 00
B7D8:  00 00 00 00 00 00 00 00
B7E0:  00 00 00 00 00 00 00 00
B7E8:  00 00 00 00 00 00 00 00
B7F0:  00 00 00 00 00 00 00 00
B7F8:  00 00 A5 A5 A5 A5 75 FD
```