TRANSPORTATION SCIENCES
CRASH RESEARCH SECTION

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VERIDIAN ON-SITE AIR BAG FATALITY INVESTIGATION

VERIDIAN CASE NO. CA00-012

VEHICLE - 1994 GEO PRIZM

LOCATION - STATE OF MASSACHUSETTS

CRASH DATE - JANUARY, 2000

Contract No. DTNH22-94-D-07058

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.

TECHNICAL REPORT STANDARD TITLE PAGE

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16. *Abstract* This on-site investigation focused on the injury mechanisms that caused the death of a 24 year old female driver of a 1994 Geo Prizm 4-door sedan. The Geo was equipped with frontal air bags for the driver and right passenger positions which deployed as a result of a frontal collision with a W-beam guardrail. The driver of the Geo Prizm was operating the vehicle southbound when a 2000 Ford E-350 “box van” (also southbound) made an abrupt lane change to the right across the path of the Geo. As the Ford box van entered the outboard lane, the right rear side surface struck the left front side surface of the Geo resulting in minor damage to both vehicles. At this point, the Geo was re-directed towards the right (west) shoulder where the front right area impacted a W-beam guardrail resulting in moderate damage. The guardrail impact deployed the Geo’s frontal air bag system. The unrestrained 24 year old female driver of the 1994 Geo Prizm was presumed to be seated in an upright posture with the seat track adjusted to the forward position. At impact with the guardrail, she was out of position forward within the path of the expanding air bag which struck her chin and right upper chest resulting in multiple soft tissue injuries. The air bag expansion hyper-extended the head resulting in a cervical and basilar skull fracture with an underlying subarachnoid hemorrhage. The driver of the Geo was transported by ambulance to a local trauma center and pronounced dead on arrival.			
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BACKGROUND

This on-site investigation focused on the injury mechanisms that caused the death of a 24 year old female driver of a 1994 Geo Prizm 4-door sedan. The Geo was equipped with frontal air bags for the driver and right passenger positions which deployed as a result of a frontal collision with a W-beam guardrail. The driver of the Geo Prizm was operating the vehicle southbound when a 2000 Ford E-350 "box van" (also southbound) made an abrupt lane change to the right across the path of the Geo. As the Ford box van entered the outboard lane, the right rear side surface struck the left front side surface of the Geo resulting in minor damage to both vehicles. At this point, the Geo was re-directed towards the right (west) shoulder where the front right area impacted a W-beam guardrail resulting in moderate damage. The guardrail impact deployed the Geo's frontal air bag system. The unrestrained 24 year old female driver of the 1994 Geo Prizm was presumed to be seated in an upright posture with the seat track adjusted to the forward position. At impact with the guardrail, she was out of position forward within the path of the expanding air bag which struck her chin and right upper chest resulting in multiple soft tissue injuries. The air bag expansion hyper-extended the head resulting in a cervical and basilar skull fracture with an underlying subarachnoid hemorrhage. The driver of the Geo was transported by ambulance to a local trauma center and pronounced dead on arrival.

The crash notification was provided to NHTSA on Monday, May 1, 2000 and immediately assigned to the Veridian SCI team as an on-site investigative effort. The on-site investigator departed on May 3 and conducted the investigation on Thursday, May 4, 2000.

SUMMARY

Crash Site

This two vehicle crash occurred during the afternoon hours of January, 2000. At the time of the crash, it was daylight with no adverse conditions as the roads were dry. The crash occurred in the southbound lanes of a straight two lane (one-way) interstate interchange area **(see Figure 15 - page 7)**. The asphalt roadway was bordered by a narrow paved shoulder to the east and a break-down lane to the west with a tactile warning device (rumble strip) outboard of the travel lanes. A W-beam guardrail was located approximately 3.7 meters (12.0 feet) off the west fog line. I-beam strong posts approximately 1.8 meters (6.0 feet) apart supported the structure with block-outs between the post and W-beam. No traffic controls were present at the crash site which had a posted speed limit of 89 km/h (55 mph).

Figure 1. Southbound view of crash site.

Pre-Crash

The 24 year old female driver of the 1994 Geo Prizm was en route to her residence and was operating the vehicle southbound in the outboard lane of a two lane interstate interchange area **(Figure 1)**. As she observed a 2000 Ford box van encroach into her lane of

travel, she steered right/braked in avoidance. The police *reported* no evidence present at the scene indicative of driver pre-impact braking maneuvers for this event. The 2000 Ford box van was driven by a 32 year old male who was operating the vehicle southbound on the inboard lane with the front right seating position occupied by a 36 year old male. The Ford driver reported to police he was proceeding straight as no lane change was attempted. The driver and passenger felt a "bump"from the right and quickly glanced into the right side mirror where they observed the Geo depart the roadway towards the west guardrail.

Crash

As the Ford box van entered the (southbound) outboard lane, the right rear side surface struck the left front side surface of the Geo Prizm resulting in minor damage to both vehicles. Although the impact with the van was classified as out-of-scope, the WinSMASH damage algorithm computed a (barrier equivalent) velocity change of 5.6 km/h (3.5 mph) with a lateral component of 4.8 km/h (3.0 mph). The combined initial impact force and subsequent right steering/braking maneuver re-directed the Geo towards the right (west) shoulder where the front right area impacted a W-beam guardrail **(Figure 2)** resulting in moderate damage. This trajectory was evidenced by the pre-impact brake (yaw) marks noted ***(in the police photos)*** at the scene. Although the impact occurred with a yielding object, the barrier algorithm of the WinSMASH program computed a velocity change of 17.1 km/h (10.6 mph) with a longitudinal component of -14.8 km/h (-9.2 mph). The elongated engagement produced a sufficient longitudinal deceleration to deploy the Geo's frontal air bag system late in the crash sequence. At this point, the vehicle rotated 28 degrees counterclockwise as the right side surface engaged (sideswiped) the guardrail a second time which resulted in minor damage. The 1994 Geo Prizm came to rest against the west guardrail facing south **(Figure 3)**. The 2000 Ford E-350 box van was driven to a controlled stop a short distance south of impact on the west shoulder also facing south.

Figure 2. 1994 Geo Prizm impact to W-beam guardrail.

Figure 3. Police photo (south) showing the Geo at final rest against the guardrail.

Post-Crash

Following the crash, the 24 year old female driver of the Geo Prizm was removed from the vehicle by two *(off-duty)* firefighters/EMTs in an unconscious state. After initial CPR efforts, she was transported by ambulance to a local trauma center and pronounced dead on arrival. The occupants of the Ford box van were reported by police as uninjured. The 1994 Geo Prizm was towed from the scene with disabling damage as the 2000 Ford E-350 box van was impounded by police with non-disabling damage.

VEHICLE DATA

The 1994 Geo Prizm was identified by the vehicle identification number (VIN): 1Y1SK5363RZ (production number deleted). The driver was reported by police as the owner of the vehicle. The vehicle was a 4-door sedan equipped with front wheel drive and a 1.6 liter, 4 cylinder engine. At the time of the crash, the odometer had recorded 96,547 km (59,993 miles). The seating was configured with front bucket seats and a rear bench. Although the vehicle's history was unknown prior its purchase (used) September 1999, three separate VIN tags were found on various body panels which support the vehicle was re-built from a previous crash. It was unknown if the air bag system deployed as a result of the previous crash(s). A cellular phone was present but not in use at the time of the collision, later verified by family members through phone records.

VEHICLE DAMAGE

Exterior

Figure 4. Frontal damage to the 1994 Geo Prizm.

The Geo sustained moderate frontal damage as a result of the impact with the W-beam guardrail **(Figures 4 & 5)**. The direct contact damage began at the front right bumper corner and extended 62.0 cm (24.4 in) inboard. The impact deformed the full frontal width resulting in a combined direct and induced damage length (Field L) of 119.0 cm (46.9 in). Six crush measurements were documented at the level of the reinforcement bar *(bumper fascia separation)*: C1= 0 cm, C2= 4.0 cm (1.6 in), C3= 9.0 cm (3.5 in), C4= 13.0 cm (5.1 in), C5= 17.0 cm (6.7 in), C6= 19.0 cm (7.5 in). The Collision Deformation Classification (CDC) for this frontal impact to the Geo Prizm was 01-FZEW-1 with a principal direction of force of 30 degrees. The bumper assembly shifted 15.0 cm (5.9 in) to the left *(shifting of the entire end structure required to increment the principal direction of force)*. Reduction in the right side wheelbase measured 3.0 cm (1.2 in). The hood and right fender were deformed rearward with additional contact damage documented to the right side surface attributed to the secondary guardrail impact **(Figure 6)**. This damage pattern began 46.0 cm (18.1 in) aft of the front right bumper corner and extended 295.0 cm (116.2 in) rearward. The gap in the contact damage along the right fender area necessitated assignment of another event. A maximum (lateral) crush value of 4.0 cm (1.6 in) was noted at the right rear door area. The CDC for this side impact was 12-RYES-1 with a principal direction of force of (+)10 degrees. The windshield was undamaged.

Figure 5. Guardrail damage to the front right area.

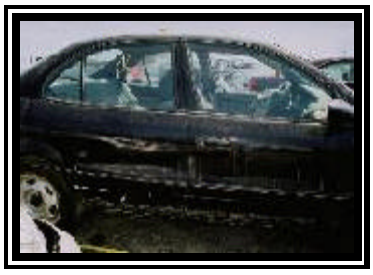

Figure 6. Guardrail damage to the right side surface.

Figure 7. Opposing vehicle damage to the left front side surface.

Direct contact damage was also identified at the left fender and wheel/rim area attributed to the initial van impact **(Figure 7)**. This damage pattern began 8.0 cm (3.1 in) aft of the front left bumper corner and extended 55.0 cm (21.7 in) rearward. The combined direct and induced damage length (Field L) also began 8.0 cm (3.1 in) aft of the front left bumper corner and extended 72.0 cm (28.3 in) rearward. Six crush measurements were documented at the level of the mid-door: C1= 0 cm, C2= 1.0 cm (0.4 in), C3= 5.0 cm (2.0 in), C4= 9.0 cm (3.5 in), C5= 7.0 cm (2.8 in), C6= 8.0 cm (3.1 in). The CDC for this side impact to the Geo was 08-LFEW-2 with a principal direction of force of (-)120 degrees.

The 2000 Ford E-350 cutaway "box van" **(Figure 9)** sustained minor right rear side surface damage as a result of the impact with the Geo Prizm. Although no deformation of the side surface was identified, scuff marks began just forward of the right rear axle and extended rearward to the bumper corner **(Figure 10)**. A break in the contact damage was noted aft of the right rear wheel well, which may indicate a separate (additional) event between the two vehicles; however, this could not be confirmed through the Geo inspection.

Figure 9. 2000 Ford E-350 cutaway "box van".

Figure 10. Right rear side surface damage.

Interior

Interior damage to the Geo identified through the vehicle inspection was minimal and was attributed to occupant contact. Scratch/scuff marks were documented on the left side of the knee bolster (rigid plastic type). Blood pooling was noted to the driver's seat cushion and aft floor area **(Figure 11)**. The right portion of the steering wheel rim (fixed column) was deformed forward 1.5 cm (0.6 in) along with 1.0 cm (0.4 in) of column compression. No intrusion of interior components were found in the vehicle.

Figure 11. Police photo of Geo interior.

MANUAL RESTRAINT SYSTEMS

The interior of the Geo Prizm consisted of a five passenger seating configuration with front bucket seats and a rear bench which accommodates three individual seating positions. There was no loading evidence on the belt systems and the systems yielded minimal routine usage indicators for the recorded mileage. This was further evidenced by the surrogate interview data which revealed minimal if no past restraint usage. The driver 3-point manual lap and shoulder belt system consisted of a continuous loop belt webbing with a sliding latchplate and dual mode retractors (inertial lock/belt sensitive). Adhesive or epoxy found on the lower webbing was also indicative of a previous crash as this substance may have been used to *(atypically)* affix the sleeve to the webbing or secure the restraint to the floor anchor. The front right 3-point manual lap and shoulder belt system

consisted of a continuous loop belt webbing with a sliding latchplate and retractors equipped with inertial and switchable lock mechanisms. The rear outboard seated positions were equipped with 3-point manual lap and shoulder belt systems which consisted of continuous loop belt webbings with sliding latchplates that retracted into dual mode locking retractors. The rear center seating position was equipped with a 2-point manual lap belt system.

SUPPLEMENTAL RESTRAINT SYSTEMS

The Geo Prizm was equipped with frontal air bags for the driver and right passenger positions. The air bags deployed as a result of the frontal impact with the W-beam guardrail. The driver air bag was housed in the center of the steering wheel with a horizontally oriented flap tear seam (H-configuration). The flaps were symmetrical in shape and measured 15.0 cm (5.9 in) in width and 6.5 cm (2.6 in) in height. The diameter of the driver air bag measured 63.5 cm (25.0 in) in its deflated state **(Figure 12)**. Although no contact evidence was identified on the exterior surface of the module cover flaps, green/blue fabric transfers were documented on the left section of the bag face **(Figure 13)** along with makeup transfers to the lower right quadrant. The right section of the bag face was heavily stained with blood indicative of the driver's final rest position against the air bag membrane. Black vinyl transfers were noted to the rear lower section of the air bag from expansion within the module, indicative of an impeded deployment. The bag was vented by two ports located at the 11 o'clock and 1 o'clock sectors on the rear aspect of the air bag. No internal tether straps were present.

Figure 12. 1994 Geo Prizm driver air bag.

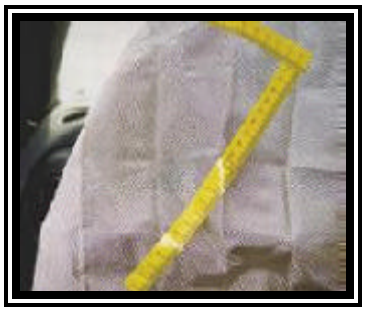

Figure 13. Green/blue fabric transfers to the driver air bag.

Figure 14. 1994 Geo Prizm passenger air bag.

The front right passenger air bag deployed from the right mid-instrument panel area with a single cover flap design hinged at the top aspect. The aluminum reinforced flap opened in an upward direction and produced a small scuff to the right lower windshield area. The cover flap was rectangular in shape and measured 34.0 cm (13.4 in) in width and 18.0 cm (7.1 in) in height. No contact evidence was found on the exterior surface of the module cover flap. The passenger air bag measured 52.0 cm (20.5 in) in width and 70.0 cm (27.6 in) in height in its deflated state **(Figure 14)**. Blood spattering was noted to the upper left quadrant of the air bag. The bag was vented by two ports located at the 9 o'clock and 3 o'clock sectors on the side aspect of the air bag. No internal tether straps were present.

DRIVER DEMOGRAPHICS

Age/Sex:	24 year old female
Height:	157 cm (62 in)
Weight:	50 kg (110 lb)
Seat Track Position:	Forward position - 4.0 cm (1.6 in) aft of the full forward position, 20.0 cm (7.9 in) forward of the full rearward position
Manual Restraint Use:	None
Usage Source:	Vehicle inspection, surrogate interview, police report
Eyeware:	Contact lenses
Type of Medical Treatment:	Transported to a local trauma center *(pronounced dead on arrival)*

Driver Injuries

Injury	***Severity (AIS 90)***	***Injury Mechanism***
*Hinge fracture at base of skull (complete)	Critical (150206.4,8)	Expanding front left air bag (indirect contact injury)
*Cervical fracture (at C2/C3 location) (with paratracheal hemorrhage)	Serious (650216.2,6)	Expanding front left air bag (indirect contact injury)
*Left cerebral subarachnoid hemorrhage (anterior pole left temporal lobe)	Severe (140684.3,2)	Expanding front left air bag (indirect contact injury)
*Subgaleal hemorrhages (2) left temporal area	Minor (190402.1,2)	Expanding front left air bag
*Multiple contusions right upper chest (4in x 8in *"blue"*)	Minor (490402.1,1)	Expanding front left air bag
*Abrasion mid-line chin (3in x 1in)	Minor (290202.1,8)	Expanding front right air bag

** Source - autopsy report*

Driver Kinematics

The 24 year old female driver of the 1994 Geo Prizm was unrestrained (3-point manual lap and shoulder belt system available) and presumed to be seated in an upright posture. The seat back support was reclined to 23 degrees from vertical with the seat track adjusted 4.0 cm (1.6 in) aft of the full forward position. This seat track position was determined by the blood pooling to the aft floor area and further verified by surrogate interview data. Lack of restraint usage was determined by the trajectory of the driver and lack of blood stains to the webbing consistent with blood pooling/spattering to the driver space. The driver was also reported to police as unrestrained by those who first rendered aid on-scene. In addition, there was no loading evidence on the belt system and the system yielded minimal routine usage indicators for the recorded mileage.

The impact with the Ford box van did not significantly displace the unrestrained driver. The subsequent impact with the W-beam guardrail probably resulted in late deployment of the frontal air bag system due to the yielding design of the guardrail and elongated crash sequence. This would have allowed the unrestrained driver to move forward prior to deployment. During engagement with the guardrail, she

was forward within the path of the expanding air bag which struck the chin and right upper chest area resulting in multiple soft tissue injuries. The expansion of the air bag hyper-extended the head which resulted in a cervical fracture and basilar skull ("hinge") fracture with an underlying cerebral subarachnoid hemorrhage. The driver's knees impacted the knee bolster which scuffed the plastic panel, however, no injury resulted from that contact sequence.

The driver was displaced both up and rearward by the expanding air bag. She rebounded forward in combination with the subsequent guardrail impact and came to rest slumped over the deflated front left air bag. Following the collision, she was removed from the vehicle by off-duty firefighters/EMTs in an unconscious state. After initial CPR efforts, the driver was transported by ambulance to a local trauma center and pronounced dead on arrival.

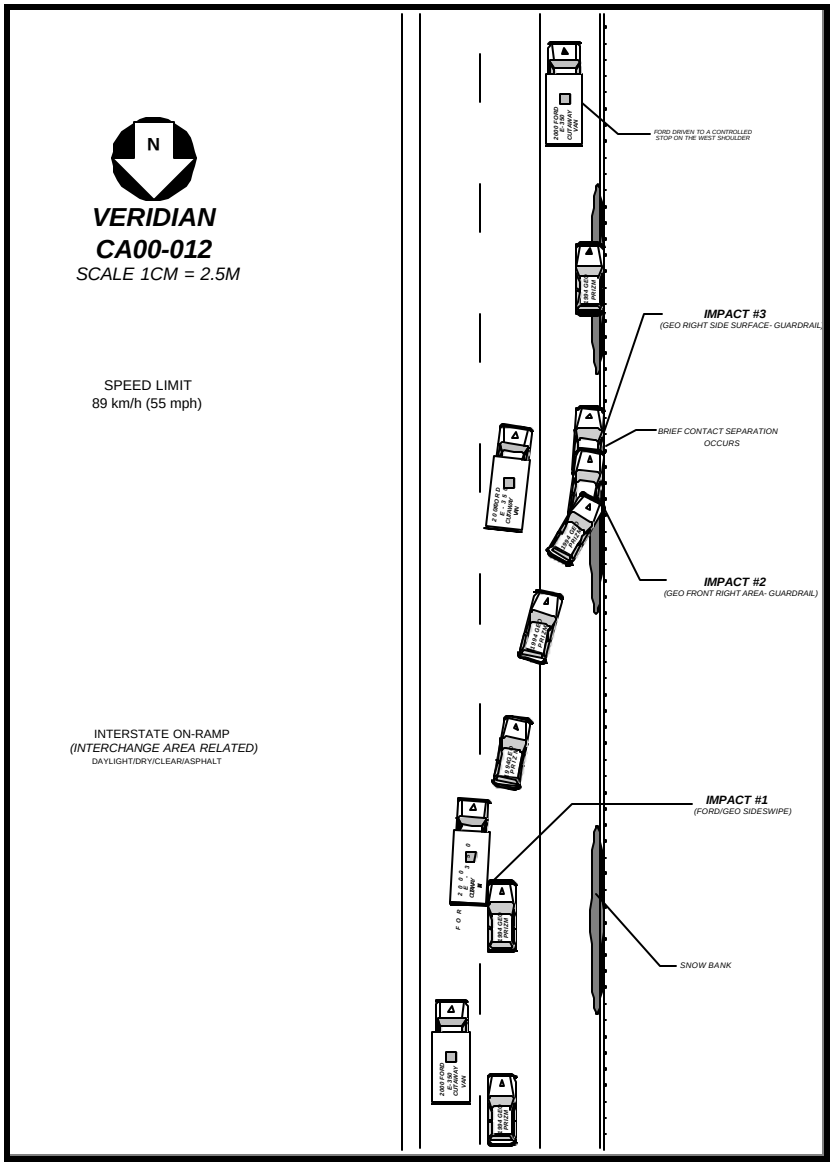

Figure 15. Scene Diagram