

**TRANSPORTATION SCIENCES
CRASH RESEARCH SECTION**

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REMOTE COMBINED NASS/SCI DRIVER AIR BAG FATALITY INVESTIGATION

CALSPAN CASE NO. 1997-04-146A

VEHICLE - 1996 GEO METRO

LOCATION - NEW JERSEY

CRASH DATE - OCTOBER, 1997

Contract No. DTNH22-94-07058

Prepared for:

**U.S. Department of Transportation
National Highway Traffic Safety Administration
Washington, DC 20590**

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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 of the involved vehicle(s) or their safety systems.

TECHNICAL REPORT STANDARD TITLE PAGE

<p>1. <i>Report No.</i> 1997-04-146A</p>	<p>2. <i>Government Accession No.</i></p>	<p>3. <i>Recipient's Catalog No.</i></p>	
<p>5. <i>Title and Subtitle</i> Remote NASS/SCI Driver Air Bag Fatality Investigation Vehicle - 1996 Geo Metro Location - New Jersey</p>		<p>4. <i>Weights</i></p>	
		<p>6. <i>Report Date:</i> June, 1998</p>	
<p>8. <i>Author(s)</i> Crash Research Section</p>		<p>7. <i>Performing Organization Code</i></p>	
		<p>9. <i>Performing Organization Report No.</i></p>	
<p>10. <i>Performing Organization Name and Address</i> Transportation Sciences Crash Research Section Calspan Corporation P.O. Box 400 Buffalo, New York 14225</p>		<p>11. <i>Work Unit No.</i> 1115 (8140-8149)</p>	
		<p>12. <i>Contract or Grant No.</i> DTNH22-94-D-07058</p>	
<p>13. <i>Sponsoring Agency Name and Address</i> U.S. Department of Transportation National Highway Traffic Safety Administration Washington, DC 20590</p>		<p>14. <i>Type of Report and Period Covered</i> Technical Report Crash Date: October, 1997</p>	
		<p>15. <i>Sponsoring Agency Code</i></p>	
<p>16. <i>Supplementary Notes</i></p>			
<p>17. <i>Abstract</i></p> <p>This task involved the remote investigation of the injury mechanisms of the fatally injured driver of a 1996 Geo Metro, 2 door Hatchback. The Geo Metro was involved in an intersection collision with a 1985 Chevrolet S-10 pick-up. The Geo Metro was equipped with a Supplemental Restraint System (SRS) that consisted of driver and front passenger air bags that deployed as a result of the crash. The crash was initially selected into and investigated by the NASS system as case 04-146A. The Field Operations Branch of the National Highway Traffic Safety Administration (NHTSA) assigned this crash to the Special Crash Investigations (SCI) Team at Calspan on November 7, 1997, due to the probable association between the driver's fatality and the air bag deployment. Technical representatives for General Motors inspected the Geo Metro on January 20, 1998 and down-loaded data from the Sensing and Diagnostic Module (SDM) of the vehicle's Supplemental Restraint System.</p> <p>Post-crash, the 84 year old female driver of the Geo was transported to the trauma unit of a local medical center where she was admitted to the ICU with an open supracondylar femur fracture (AIS 3), multiple fractures of the lower extremities (AIS 2), multiple ribs fractures with pneumothorax (AIS 4) and other associated minor injuries. She had also suffered a mild concussion and was amnesic to the events of the crash. Her Glasgow Coma Score was 15 upon admission. Upon stabilization, she was taken to the operating room for fixation of the lower extremity fractures the day following the crash. The medical record indicated that during the 24 hours following surgery, the driver began to suffer acute respiratory failure and continued to deteriorate. The driver's family asked that she be listed do not resuscitate (DNR-II). The driver expired eight days post-crash. An autopsy was not performed.</p>			
<p>18. <i>Key Words</i> Remote investigation Supplemental Restraint System Air bag deployment Multiple rib fractures with pneumothorax</p>		<p>19. <i>Distribution Statement</i> General Public</p>	
<p>20. <i>Security Classif. (of this report)</i> Unclassified</p>	<p>21. <i>Security Classif. (of this page)</i> Unclassified</p>	<p>22. <i>No. of Pages</i> 7</p>	<p>23. <i>Price</i></p>

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REMOTE NASS/SCI DRIVER AIR BAG FATALITY INVESTIGATION
CALSPAN CASE NO. 1997-04-146A
VEHICLE: 1996 GEO METRO, 2 DOOR HATCHBACK
LOCATION: NEW JERSEY
CRASH DATE: OCTOBER, 1997

BACKGROUND

This task involves the remote investigation of the injury mechanisms of the fatally injured driver of a 1996 Geo Metro, 2 door Hatchback. The Geo Metro was involved in an intersection collision with a 1985 Chevrolet S-10 pick-up. The Geo Metro was equipped with a Supplemental Restraint System (SRS) that consisted of driver and front passenger air bags that deployed as a result of the crash. The crash was initially selected into and investigated by the NASS system as case 04-146A. The Field Operations Branch of the National Highway Traffic Safety Administration (NHTSA) assigned this crash to the Special Crash Investigations (SCI) Team at Calspan on November 7, 1997, due to the probable association between the driver's fatality and the air bag deployment. Technical representatives for General Motors inspected the Geo Metro on January 20, 1998 and down-loaded data from the Sensing and Diagnostic Module (SDM) of the vehicle's Supplemental Restraint System.

SUMMARY

This two-vehicle crash occurred at a rural four-leg intersection during the morning hours of October, 1997. The weather was not a factor; the roads were dry. The intersecting roadways were north/south and east/west in direction and were both of two lane asphalt construction. Trees and brush in the northwest quadrant of the intersection obstructed the view of the southbound driver to eastbound traffic until a point approximately 45 m (150 ft) from the intersection. At this point, there were no obstructions to impair either driver's vision. A stop sign for traffic in the north/south direction controlled the intersection. The posted speed limit for both roads was 80 km/h (50 mph). **Figure 1** is a southbound trajectory view of the crash scene.

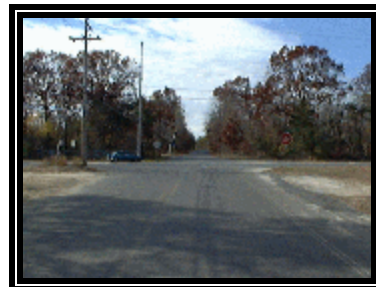


Figure 1: Southbound trajectory view of the intersection.

The crash involved a southbound 1996 Geo Metro and an eastbound 1985 Chevrolet S-10 pickup truck. The frontal plane of the Geo (**Figure 2**) struck the forward portion of the left side plane of the S-10 pickup in a 2/11 o'clock impact configuration. The Geo sustained a maximum crush value of approximately 38 cm (15 in) at C5, inboard of the right bumper corner. The direct contact damage was 94 cm (37 in) in width, began at the right front corner and extended to the left. The S-10 pickup sustained a maximum lateral crush of 46 cm (18 in) located 33 cm (13 in) forward of the left front axle (**Figure 3**). The width the of direct contact damage was 136 cm (54 in), which began at the left corner

of the front bumper and extended rearward. The field L was 164 cm (65 in). At impact, the right front structure of the Geo deformed and “locked” into the left front suspension of the S-10 pickup. This sequence displaced the front bumper structure from the Geo and foreshortened the left side wheelbase of the S-10 pickup approximately 15 cm (6 in). The Collision Deformation Classification (CDC) of the Geo was 02-FZEW-2 and the CDC of the S-10 pickup was 11-LFEW-3.



Figure 2: Left front view of the Geo Metro.



Figure 3: Left front view of the Chevrolet S-10 pick-up.

Crush profiles for the Geo Metro and Chevrolet S-10 were developed from the measurements obtained during the NASS inspection. These crush profiles are listed in the tables below.

1996 Geo Metro - adjusted crush profile		
C1 = 24.0 cm (9.5 in)	C2 = 23.0 cm (9.0 in)	C3 = 26.0 cm (10.2 in)
C4 = 37.0 cm (14.6 in)	C5 = 38.0 cm (15.0 in)	C6 = 30.0 cm (11.8 in)

1985 Chevrolet S-10 pickup - measured crush profile		
C1 = 0 cm (0 in)	C2 = 5.0 cm (2.0 in)	C3 = 11.0 cm (4.3 in)
C4 = 17.0 cm (6.7 in)	C5 = 46.0 cm (18.1 in)	C6 = 27.0 cm (10.6 in)

These crush profiles were used as an input to the SMASH damage algorithm in order to calculate the vehicle velocity changes (delta V) in the crash. The total delta V calculated for the Geo was approximately 30 km/h (19 mph), with a longitudinal component -15 km/h (-9 mph). The velocity change in the Geo was within the deployment threshold of the vehicle’s SRS. The results of the SMASH calculation are listed in the table below.

SMASH RESULTS		
	1996 Geo Metro	1985 Chevrolet S-10 pickup
Total delta V:	30.1 km/h (18.7 mph)	20.8 km/h (12.9 mph)
Longitudinal delta V:	-15.1 km/h (-9.3 mph)	-18.0 km/h (-11.2 mph)
Lateral delta V:	-26.1 km/h (-16.2 mph)	10.4 km/h (6.5 mph)
Dissipated Energy:	61,786 Joules (45,571 ft*lb)	40,194 Joules (29,645 ft*lb)
Barrier Equivalent Speed:	26.2 km/h (16.3 mph)	29.4 km/h (18.3 mph)

Due to the force of the impact, the Geo rotated counterclockwise and upon separation from the initial contact, the vehicles impacted again in a side-slap configuration. The right rear of the Geo struck the left side of the S-10 pickup box aft of the left rear axle (**Figures 4 and 5**). The CDC's of the side-slap impact were 03-RBEW-2 and 09-LBEW-3 for the Geo and S-10 pickup respectively. After the side-slap impact, the vehicles slid to their respective final rest locations in the southeast quadrant of the intersection.



Figure 4: Right side damage of the Geo Metro.



Figure 5: Left side damage of the Chevrolet S-10 pick-up.

The police and local volunteer EMS responded to the crash scene. The 84 year old female driver of the Geo was transported to the trauma unit of a local medical center where she was admitted to the ICU with an open supracondylar femur fracture (AIS 3), multiple fractures of the lower extremities (AIS 2), multiple ribs fractures with pneumothorax (AIS 4) and other associated minor injuries. She had also suffered a mild concussion and was amnesic to the events of the crash. Her Glasgow Coma Score was 15 upon admission. Upon stabilization, she was taken to the operating room for fixation of the lower extremity fractures the day following the crash. The medical record indicated that during the 24 hours following surgery, the driver began to suffer acute respiratory failure and continued to deteriorate. The driver's

family asked that she be listed do not resuscitate (DNR-II). The driver expired eight days post-crash. The county medical examiner listed the immediate cause of death as respiratory failure as a consequence of severe chest trauma as a consequence of multiple fractures due to a motor vehicle collision. An autopsy was not performed.

There were a total of two occupants in the Chevrolet S-10 pickup. The driver was a 49 year old female and the right front occupant was a 82 year old female. Both occupants were reported by the police as restrained by the vehicle's manual lap and shoulder belt system. The driver reportedly suffered only an unspecified ankle sprain (AIS 1) and was not hospitalized. The right front occupant sustained a concussion (AIS 2), fractures of the left zygoma and maxilla (AIS 2), a ruptured renal cyst with kidney laceration (AIS 2), an open facial wound and other minor contusions. She was hospitalized for 3 days and had full recovery.

AIR BAG VEHICLE

The 1996 Geo Metro, 2 door hatchback ,was identified by the manufacturer's vehicle identification number (VIN) of 1GCBS14B8F2 (production sequence deleted). The odometer read 19,302 km (11,994 miles) at the time of the inspection. The vehicle was equipped with a 1.3 liter, L4 engine linked to an automatic transmission.

The front seating system in the Geo Metro consisted of bucket seats with reclining backs . The head restraints were integral. Inspection of the left front seat (**Figure 6**) found the seat to be in a mid to rear track position at the time of inspection. The seat back was slightly reclined and there was no seat performance failure. The horizontal distance between the center of the steering wheel hub and the left front seat back measured 61 cm (24 in). It was unknown if the seat track position had been altered from its at-crash position prior to the NASS inspection.



Figure 6: View of the left front seat.



Figure 7: View of the left front interior.

Figure 7 is a view of the left front interior. **Figures 8 - 10** are the occupant contacts identified during the inspection. The driver's knee bolster exhibited a scuff mark attributed to contact with the driver's right knee. The scuff was located directly below and to the right of the steering column centerline. A scuff mark was also identified on the center left aspect of the driver's sun visor. This scuff was attributed to probable contact with the driver's left hand. A rebound contact from the driver's head was noted on the leading aspect of the left B-pillar above the D-ring elevation. There was no deformation to the 4 spoke steering wheel rim, and there was no compression of the steering column's shear capsules.



Figure 8: View of the driver's knee bolster contact.



Figure 9: View of the contact to the driver's sunvisor.



Figure 10: View of contact to the left B-pillar.

MANUAL RESTRAINTS

The manual restraint system in the Geo Metro consisted of 3-point lap and shoulder belts, with continuous loop webbings, in the four outboard seating positions. The D-rings were fixed. The police report indicated the driver was restrained by the 3-point lap and shoulder belt. General Motors' interpretation of the data stored on-board the vehicle's SDM indicated the latch plate was buckled at the time of the crash. However, inspection of the belt webbing and hardware surfaces found no conclusive witness marks that indicated seat belt usage in the crash. All factors (the high impact energy in the crash, the lack of evidence on the manual restraint, the kinematic pattern, and the driver's sustained injuries) indicate the driver was not properly restrained in this crash. It was probable the driver was wearing the lap belt and had the shoulder belt webbing positioned behind her back or under her arm.

SUPPLEMENTAL RESTRAINT SYSTEM

The Geo Metro was equipped with a Supplemental Restraint System (SRS) that consisted of frontal air bags for the driver and front passenger position. The air bags had deployed due to the force of the impact. The driver air bag module was located in the typical configuration in the center hub of the steering wheel rim. The front passenger air bag was configured as a mid mount design on the right side of the instrument panel. The SRS utilized a Sensing and Diagnostic Module (SDM) located within the occupant compartment. The SDM controlled the air bag deployment and recorded the history of the crash event.

The driver air bag had deployed as designed from the H-configuration air bag module cover flaps. The width of the cover flaps measured 15 cm (6 in). The height of the upper and lower flaps measured 6.0 cm (2.4 in) and 8.0 cm (3.1 in) respectively. There was no contact evidence on the exterior surfaces of the flaps. The interior surfaces of the module cover flaps were noted to be scuffed in several areas.

The air bag membrane measured 70.0 cm (27.5 in) in its deflated state (**Figure 11**). The air bag was tethered and had two vent ports in the 10/2 o'clock sector on the back side of the bag. The face of the air bag exhibited scattered blood spatters. The air bag fabric



Figure 11: Driver air bag.

SUPPLEMENTAL RESTRAINT SYSTEM (CONT'D)

also exhibited black transfers in the six o'clock sector on the back side of the bag and in the 12 o'clock sector and right lower quadrant on the front side of the bag. The black transfers on the air bag and scuffs on the interior surfaces of the module cover flaps were indicators of an altered air bag deployment path due to the forward position of the driver at the time of deployment.

Technical representatives for General Motors inspected the Geo Metro on January 20, 1998. These individuals were specifically asked to download the SRS deployment history stored in the module's SDM. A record of the deployment history was requested from General Motors. This record indicated that the driver's seat belt was latched, referred to earlier in this report. The record further indicated that the air bag warning lamp, located in the instrument panel, was not on prior to the crash and that normal criteria were met that caused the SDM to deploy the air bags. The maximum velocity change recorded in the crash event was 41.4 km/h (25.7 mph).

DRIVER INJURIES

Injury	Severity (AIS 90)	Injury Mechanism
Multiple right rib fractures (x8) w/ pneumothorax	Severe (450232.4,1)	Deploying driver air bag
Open supracondylar fracture - right femur	Serious (851822.3,1)	Driver knee bolster
Right medial malleous tibia fracture	Moderate (853412.2,1)	Foot controls/Toe pan
Right fibula fracture (distal)	Moderate (851606.2,1)	Foot controls/Toe pan
Left tibia shaft fracture (distal)	Moderate (853420.2,2)	Foot controls/Toe pan
Left fibula fracture (proximal)	Moderate (851606.2,2)	Foot controls/Toe pan
Right iliac wing fracture	Moderate (852602.2,1)	Restraint loading (lap belt)
6 cm (2.2 in) laceration - right hand	Minor (790602.1,1)	Unidentified
Anterior chest contusion	Minor (490402.1,0)	Deploying driver air bag
Right iliac crest contusions	Minor (890402.1,1)	Restraint loading (lap belt)
Mild concussion	Minor (160402.1,0)	Left B-pillar rebound contact

DRIVER KINEMATICS

The sole occupant of the Geo Metro was the 84 year old female driver with an unknown height and weight. She was seated in a presumably normal posture with the seat adjusted to a probable mid-track position. She was not properly restrained by the manual 3-point restraint. It was probable that the shoulder portion of the restraint webbing was positioned behind her back or under her arm. Upon impact, the driver initiated a forward trajectory and pitched forward (jack-knifed) about the waist in response to the 2 o'clock direction of the impact force. The forward trajectory displaced the driver's right knee into the knee bolster causing the right femur fracture. The multiple lower leg fractures probably occurred at this time due to contact with the foot controls or toe pan. Her forward motion loaded the lap portion of the restraint causing the contusion to the right hip and fracture of the right iliac crest. The angular impact of the Chevrolet S-10 into the relatively "soft" structure of the Geo's right front fender may have delayed the deployment sequence of the vehicle's air bag system. This delayed deployment, coupled with the driver's forward kinematic pattern placed her torso in close proximity to the driver side air bag module at the time of deployment. Upon deployment, her forward position altered the air bag's egress from the module evidenced by the scuffs on the interior surfaces of the cover flaps and black transfers on the air bag. The deploying air bag expanded against the driver's torso causing anterior chest contusions, multiple rib fractures and pneumothorax. The air bag's continued expansion caused the driver to rebound rearward. Her left hand may have been displaced up into the sunvisor. As the driver rebounded rearward, the Geo Metro began to rotate counterclockwise. Relative to the vehicle, this displaced the driver rearward and to the left. The driver's head contacted the left B-pillar evidenced by the scuffs noted at those locations. This contact probably caused the mild concussion. The driver then rebounded back into seat where she was found.