TRANSPORTATION SCIENCES
CRASH RESEARCH SECTION

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NASS/SCI COMBINED AIR BAG DEPLOYMENT INVESTIGATION

CALSPAN CASE NO. 1997-06-140K

VEHICLE - 1997 GEO METRO

LOCATION - PENNSYLVANIA

CRASH DATE - OCTOBER, 1997

Contract No. DTNH22-94-07058

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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.

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17. *Abstract*

This remote investigation focused on the injury mechanisms of a two vehicle intersection crash that involved a 1997 Geo Metro and a 1989 Buick Electra. The Geo Metro was equipped with a Supplemental Restraint System that consisted of driver and front passenger air bags that deployed as a result of the crash. The Geo was driven by a 25 year old female, reported as 6 months pregnant and a 5 year old right front passenger. Both occupants were unrestrained.

The crash occurred when a northbound 1989 Buick Electra turned left in front of a southbound 1997 Geo Metro at an urban six-leg intersection. It was the intention of the Buick's driver to travel northwest bound on the intersecting one-way street. The Buick and the Geo impacted in a 12 o'clock/11 o'clock impact configuration. The longitudinal component of the Geo's delta V was determined to be approximately -22.3 km/h (-13.9 mph), which was of sufficient magnitude to cause the air bags to deploy. The occupants of the Geo responded to the 11 o'clock direction of the impact forces by exhibiting a forward trajectory and contacting the front interior structures and deployed air bags. The driver suffered AIS 1 level injuries to her knee and a result of contact to the knee bolster. The child occupant suffered a right frontal cerebral contusion (AIS) 3, associated loss of consciousness (AIS 2) and multiple facial and neck abrasions and lacerations (AIS 1) as a consequence of contact which the deploying front passenger air bag.

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BACKGROUND

This task involved the remote investigation into the injury mechanisms of a 25 year old pregnant female driver and the 5 year old female right front passenger of a 1997 Geo Metro. The Geo Metro was involved in a two-vehicle intersection crash with a 1989 Buick Electra. The Geo Metro was equipped with a Supplemental Restraint System that consisted of driver and front passenger air bags that deployed as a result of the crash. The National Highway Traffic Safety Administration (NHTSA) was notified of this crash by a NASS research team on Tuesday, October 28, 1997. NHTSA in-turn assigned this crash as a remote investigation effort to the Special Crash Investigation (SCI) Team at Calspan on Wednesday, October 29, 1997. The crash was subsequently selected for investigation by the NASS program.

SUMMARY

This two vehicle crash occurred at an urban six-leg intersection in the morning hours of October, 1997, in the state of Pennsylvania. The primary roadway through the intersection was a two lane asphalt road, predominately north/south in direction. Two one-way roadways intersected the primary roadway from the southwest/northeast and southeast/northwest forming the six-leg intersection. The intersection was controlled by traffic signals. At the time of the crash, it was daylight and the weather was not a factor; the roads were dry. The speed limit in the area of the crash was 40 km/h (25 mph). Figures 1 and 2 are northbound and southbound trajectory views of the intersection, respectively.

Figure 1: Northbound trajectory view.

Figure 2: Southbound trajectory view.

The 1989 Buick Electra was being driven northbound by a 24 year old male. A 4 year old male was the Buick's right front passenger. The 1997 Geo Metro was being driven southbound by the 25 year old female. She was reported as six months pregnant. The right front occupant of the Geo was a 5 year old

female. The occupants of the Geo were reported as unrestrained by the police report. The crash occurred when the Buick initiated a left turn across the path of a Geo. It was the intention of the Buick to travel northwest bound on the intersecting one-way street. The front of the Buick struck the left front corner of the Geo in a 12 o'clock/11 o'clock impact configuration. The 11 o'clock direction of the impact forces deployed the Supplement Restraint System (driver and front passenger air bags) of the Geo. The occupants of the Geo responded to the impact forces by exhibiting a forward trajectory. The vehicle inspection identified specific areas of occupant contact to the forward interior and air bags of the Geo. The post-impact vehicle dynamics and final rest positions were not known. Inspection of the crash scene did not identify any pre-impact skid marks that could be associated with this crash. Both vehicles reportedly sustained disabling damage and were towed from the scene. The occupants of the Buick denied any injuries.

The driver and right front passenger in the Geo were transported from the crash scene to the emergency room of a local University Hospital, arriving approximately 25 minutes post-crash. The police report indicated the driver suffered a vaginal bleed at the scene. Examination at the treating hospital included a pelvic X-ray, MRI and an ultrasound. These procedures did not identify any internal injuries to the driver and the pregnancy still had a normal presentation. There was not an abruption of the placenta. The ultrasound appeared normal. The driver's only codeable injuries included a laceration and abrasion (AIS 1) to her left knee and a contusion (AIS 1) to her right knee. The injuries resulted from her forward kinematic pattern and subsequent contact to the left side knee bolster.

A head CT of the 5 year old passenger revealed the child suffered a right front cerebral contusion (AIS 3) and had a unspecified loss of consciousness at the scene (AIS 2). Initial assessment indicated a Glasgow Coma Scale (GCS) of 9. The child also suffered multiple facial and neck abrasions (AIS 1). All the child's injuries were associated with contact with the deploying passenger air bag. The child's neurologic condition improved over the next hour and the child was transferred to a pediatric trauma center for further observation. She was admitted as a precautionary measure and continued to improve over the course of her four day hospitalization. She was discharged without further complications.

AIR BAG VEHICLE

The 1997 Geo Metro, 2 door hatchback, was identified by a vehicle identification number (VIN) 2C1MR2297V6 (production sequence deleted). The vehicle's odometer read 19,448 km (12,085 miles) at the time of the inspection. The vehicle was equipped with a 1.3 liter, L4 engine and an automatic transmission

Figures 3 and 4 below are front and left front views of the Geo Metro respectively. The resultant direct contact damage to the Geo began at the left corner of the front bumper and extended 61 cm (24 in) to the right. The NASS researcher measured 34 cm (13 in) of bumper deformation at the left front corner. The Collision Deformation Classification (CDC) for the Geo was 11-FYEW-2. The measured crush profile for vehicle is specified in the table below.

C1 = 34 cm (13 in)	C2 = 23 cm (9 in)	C3 = 13 cm (5in)
C4 = 8 cm (3 in)	C5 = 4 cm (1.6 in)	C6 = 0

Figure 3: Front view of the Geo Metro.

Figure 4: Left front view of the Geo.

The Geo's damage at the bumper elevation extended upward and rearward onto the left front corner of the hood. The impact foreshortened the left side wheelbase 10 cm (4 in). The deformation restricted the rotation of the left front tire and the tire was deflated. The left front fender deformed rearward in the impact, jamming the left door and fracturing the left lower corner of the windshield. There was evidence along the leading edge of the door that the door was pried open during the rescue process. The left door window glazing was also shattered in the impact.

The Buick Electra could not be located and was not inspected. The delta V of the Geo was calculated using the ROLDMISS model of the SMASH algorithm. A range of principle directions of force (PDOF's) were used in the 11 o'clock sector for the calculations. The total delta V of the Geo was determined to be approximately 25.8 km/h (16.0 mph) for a PDOF of 330 (-30) degrees. The longitudinal component of the delta V was approximately -22.3 km/h (-13.9 mph). The longitudinal component was above the threshold required for deployment. The results of the SMASH outputs are listed below:

SMASH RESULTS		
	Geo Metro	Buick Electra
PDOF:	330 (-30) degrees	10 degrees
Total delta V:	25.8 km/h (16.0 mph)	14.9 km/h (9.3 mph)
Longitudinal delta V:	-22.3 km/h (-13.9 mph)	-14.6 km/h (-9.1 mph)
Lateral delta V:	12.9 km/h (8.0 mph)	-2.6 km/h (-1.6 mph)
Energy Dissipated:	25,272 Joules	27,890 Joules
Barrier Equivalent:	20.9 km/h (13.0 mph)	20.5 km/h (12.7 mph)

INTERIOR AND INTERIOR DAMAGE

The front seats in the Geo were bucket seats with integral head restraints and folding seat backs. The left front seat in the Geo was documented in a mid to rear track position with the seat back slightly reclined. An area of blood was identified on the cushion of the left front seat. The right front seat was documented in the full forward position with the seat back upright. There were no seat performance failures. It was not known if the seat track positions had been altered from the at-crash positions prior to the NASS inspection.

Inspection of the vehicle identified two points of contact to the driver side knee bolster. These scuffs were linked to contact with the driver's knees. A crack on the interior trim panel covering the left door was also identified. The appearance of the crack indicated it was created by an external force (relative to the vehicle), rather than from an occupant contact. The cracked area was located on the forward aspect of the door in a location that would have been somewhat protected. The damaged panel probably occurred in the initial impact or during efforts to pry open the door.

MANUAL RESTRAINTS

The manual restraint system in the vehicle consisted of 3-point lap and shoulder belts with continuous loop webbing and fixed D-rings in the front outboard seat positions. Inspection of the webbing and transfer surfaces on both the left front and right front restraints did not exhibit any indication of usage in this crash. The kinematic patterns, injuries and lack of evidence on the restraints indicate that neither occupant was restrained. The police investigation indicated that the occupants of the vehicle were unrestrained, as well.

SUPPLEMENTAL RESTRAINT SYSTEM

The Supplemental Restraint System in the Geo consisted of driver and front passenger air bags that had deployed as a result of the crash. The driver side air bag module was located in the typical configuration in the center of the steering wheel. The steering wheel was fixed and there was no steering wheel rim deformation. The air bag had deployed normally from the module (Figure 5). The H-configuration module cover flaps were symmetrical and measured 15.5 cm (6.1 in) in width. The height of the upper flap and lower flap measured 6.0 cm (2.4 in) and 8.0 cm (3.1 in) respectively. The driver side air bag measured 56 cm (22 in) in diameter in its deflated state and was tethered by 4 internal straps. The air bag was vented by two ports located on the back side of the bag in the 10 and 2 o'clock sectors. The air bag was spattered with blood in the 6 and 9 o'clock sectors. These spatters were unrelated to

Figure 5: Driver air bag.

direct contact. The passenger side air bag module was a top mount configuration located on the right side of the instrument panel (Figure 6). The hinged module cover flap measured 35.5 cm (14.0 in) by 16.0 cm (6.3 in) width by height. There was no deformation or witness marks on the cover flap. The passenger side air bag was rectangular and measured 47.0 cm (18.5 in) by 50.0 cm (19.7 in), width by height, in its deflated state. There was a large blood smear on the top surface of the air bag

SUPPLEMENT RESTRAINT SYSTEM (CONT'D)

(Figure 7). This transfer was attributed to contact with the right front passenger's head and neck. Directly forward of the cover flap on the windshield was an area of tissue/blood transfers. This area was in-line with the blood smear on the passenger air bag fabric and was transferred during the fabric's contact with the windshield (Figure8). The center mirror was also displaced from passenger air bag contact.

Figure 6: Front passenger air bag.

Figure 7: Close-up view of blood transfers to the air bag.

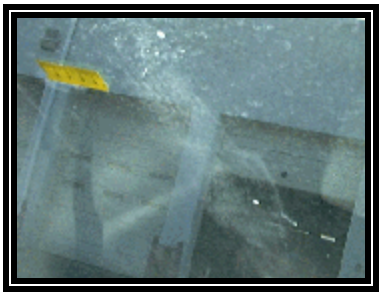

Figure 8: Close-up view of windshield transfers.

DRIVER INJURIES

Injury	Injury Severity (AIS 90)	Injury Mechanism
Left knee abrasion	Minor (890202.1,2)	Knee bolster
Left knee laceration	Minor (890402.1,2)	Knee bolster
Right knee contusion	Minor (890602,1.1)	Knee bolster

DRIVER KINEMATICS

The unrestrained driver of the Geo was seated in a presumed normal posture with her seat adjusted in a mid to rear track position. Analysis of the crash does not indicate an avoidance maneuver on the part of the Geo's driver. Upon impact, the air bag deployed and the driver responded to the 11 o'clock direction of the impact force by exhibiting a forward trajectory. The driver was displaced forward with her knees contacting the left side knee bolster causing minor injuries. The driver contacted the deployed air bag and rebounded back into the seat.

CHILD OCCUPANT INJURIES

Injury	Injury Severity (AIS 90)	Injury Mechanism
Right frontal cerebral contusion	Serious (140602.3,1)	Deploying passenger air bag
Loss of consciousness (length unknown, GCS = 9)	Moderate (160606.2,0)	Deploying passenger air bag
Occipital laceration	Minor (190602.1,6)	Deploying passenger air bag
Upper/lower lip lacerations	Minor (290602.1,8)	Deploying passenger air bag
Mouth abrasions	Minor (290202.1,8)	Deploying passenger air bag
Neck abrasions	Minor (390202,1,9)	Deploying passenger air bag
Multiple facial abrasions	Minor (290202.1,9)	Deploying passenger air bag

CHILD OCCUPANT KINEMATICS

The 5 year old child occupant was seated unrestrained in a presumed normal posture. The position of the right front seat was documented in the full forward position at inspection. There was no direct evidence of pre-impact braking which would have displaced the child forward into the deployment path of the air bag. Therefore, given the kinematics pattern and injuries sustained in the crash, the seat and child were likely to be seated in this forward position. Upon impact, the front passenger air bag deployed and the child responded to the 11 o'clock direction of the impact force by exhibiting a forward trajectory. The child's trajectory caused her head and neck to be contacted by the expanding air bag in the later stages of the deployment sequence. This contact caused the cerebral contusion. The expansion of the air bag caused the multiple minor facial abrasions and laceration to the face and neck. The air bag was then deflected upward into the windshield causing the transfers at that location. The child then rebounded back into the seat where she was found.