

**TRANSPORTATION SCIENCES  
CRASH DATA RESEARCH CENTER**

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**VERIDIAN REMOTE REDESIGNED AIR BAG RELATED CHILD PASSENGER  
FATALITY INVESTIGATION  
SCI TECHNICAL SUMMARY REPORT**

**VERIDIAN CASE NO. CA00-026**

**VEHICLE - 1999 CHEVROLET METRO**

**LOCATION - STATE OF GEORGIA**

**CRASH DATE - SEPTEMBER 1999**

Contract No. DTNH22-94-D-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 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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<p>16. <i>Abstract</i></p> <p>This remote investigation focused on a 1999 Chevrolet Metro rental car that was equipped with redesigned air bags for the driver and front right positions. The front of the Chevrolet Metro struck the right rear side area of a 1993 Jeep Cherokee in an intersection collision. Visual inspection of the Metro suggested an estimated delta-V in the range of 24 - 29 km/h (15 - 18 mph), which was sufficient to deploy the redesigned frontal air bag system in the Metro. The Chevrolet Metro was occupied by a 32-year-old female driver and an 8-year-old female front right passenger. Both occupants were restrained by the 3-point lap and shoulder belts. However, the 8-year-old was wearing the shoulder belt under her right arm and may have been seated forward on the seat with her upper torso semi-reclined against the seat back. Pre-crash braking displaced the child's upper torso forward into the path of the redesigned front right passenger's air bag. At impact, the redesigned frontal air bag system deployed and both occupants initiated a forward trajectory. The driver loaded the manual restraint and contacted the deployed air bag which mitigated contact with the steering wheel assembly. The out-of-position front right child passenger submarined the lap belt and loaded the improperly worn manual restraint which resulted in seat belt-related contusions and abrasions, a right lung contusion, an extensive liver laceration, a laceration of the inferior vena cava, and a laceration of the atrial septum. She was struck under the chin by the expanding air bag which resulted in a fracture dislocation of C1-C2 with cord contusion, and abrasions and contusions on the face, neck, and chest areas. She rebounded rearward and sustained cerebellar subarachnoid and subdural hemorrhages, and contusions from lateral loading of the right front interior door surface from post-impact vehicle rotation. She was removed from the vehicle by a witness to the crash, and transported by ambulance to a local hospital where she expired two hours following the crash. The Medical Examiner stated Generalized Trauma was the cause of death.</p>			
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**VERIDIAN REMOTE AIR BAG RELATED CHILD FATALITY INVESTIGATION  
SCI TECHNICAL SUMMARY REPORT  
VERIDIAN CASE NO. CA00-026  
LOCATION: GEORGIA  
VEHICLE: 1999 CHEVROLET METRO LSi  
CRASH DATE: SEPTEMBER 1999**

***BACKGROUND***

This remote investigation focused on a 1999 Chevrolet Metro rental car (**Figure 1**) that was equipped with redesigned air bags for the driver and front right positions. The front of the Chevrolet Metro struck the right rear side area of a 1993 Jeep Cherokee in an intersection collision. Visual inspection of the Metro suggested an estimated delta-V in the range of 24 - 29 km/h (15 - 18 mph), which was sufficient to deploy the redesigned frontal air bag system in the Metro. The Chevrolet Metro was occupied by a 32-year-old female driver and an 8-year-old female front right passenger. Both occupants were restrained by the 3-point lap and shoulder belts. However, the 8-year-old was wearing the shoulder belt under her right arm and may have been seated forward on the seat with her upper torso semi-reclined against the seat back. Pre-crash braking displaced the child's upper torso forward into the path of the redesigned front right passenger's air bag. At impact, the redesigned frontal air bag system deployed and both occupants initiated a forward trajectory. The driver loaded the manual restraint and contacted the deployed air bag which mitigated contact with the steering wheel assembly. The out-of-position front right child passenger submarined the lap belt and loaded the improperly worn manual restraint which resulted in seat belt-related contusions and abrasions, a right lung contusion, an extensive liver laceration, a laceration of the inferior vena cava, and a laceration of the atrial septum. She was struck under the chin by the expanding air bag which resulted in a fracture dislocation of C1-C2 with cord contusion, and abrasions and contusions on the face, neck, and chest areas. She rebounded rearward and sustained cerebellar subarachnoid and subdural hemorrhages, and contusions from lateral loading of the right front interior door surface from post-impact vehicle rotation. She was removed from the vehicle by a witness to the crash, and transported by ambulance to a local hospital where she expired two hours following the crash. The Medical Examiner stated Generalized Trauma was the cause of death.



**Figure 1. 1999 Chevrolet Metro**

The notification of this crash was provided to NHTSA and a remote investigation effort was assigned to the Veridian Special Crash Investigation team on July 25, 2000. A police report, police photographs, an autopsy report, and autopsy photographs were obtained, which provided the basis for this narrative report.

## ***SUMMARY***

### **Crash Site**

This two vehicle crash occurred at a four-leg intersection of two local arterial roadways during daylight hours. At the time of the crash, it was cloudy with no adverse weather conditions as the asphalt road surface was dry. The north south roadway consisted of one travel lane in each direction separated by a double-yellow centerline. Left turn lanes were present for the north and south legs of the intersection. The east/west roadway consisted of one travel lane in each direction with no centerline marking. Both roadway profiles were straight with a level grade. The north/south roadway was bordered by concrete curbs and sidewalks. The east/west roadway was bordered by dirt and grass shoulders. The roadside environment consisted of commercial and residential properties. Traffic control at the intersection consisted of an overhead three-phase traffic signal for each leg of the intersection. The posted speed limit for each roadway was 56 km/h (35 mph).

### **Pre-Crash**

The 32-year-old female driver of the Chevrolet Metro was operating the vehicle eastbound on a two lane roadway on approach to a four-leg intersection (**Figure 2**). The driver of the Jeep Cherokee was stopped in the north leg of the intersection waiting for the overhead traffic signal for north/south traffic to cycle to the green phase. When the traffic signal turned green for the north/south traffic, the Cherokee proceeded into the intersection to continue southbound (**Figure 3**). The driver of the Metro was inattentive and did not realize that the traffic signal for east/west traffic had cycled to red and did not notice the Cherokee traveling through the intersection. When she realized the impending harmful event, she applied the brakes in full lockup in an attempted avoidance maneuver. The investigating officer documented skid marks from the Metro from both front wheels. The left front and right front skid marks measured 15 m (50') and 20 m (65'), respectively. The driver of the Cherokee stated that when she detected the impending crash, she accelerated in an attempt to clear the intersection.



**Figure 2. Eastbound approach for the Chevrolet Metro with police documented pre-impact skid marks**



**Figure 3. Southbound approach for the Jeep Cherokee**

## Crash

The front right area of the Chevrolet Metro impacted the right rear side area of the Jeep Cherokee. The resultant directions of force were in the 11 and 2 o'clock sectors for the Metro and the Cherokee, respectively. The front right corner of the Metro struck the right rear wheel of the Cherokee and the front of the Metro underrode the right rear quarter panel area of the Cherokee. The impact induced deceleration was sufficient to deploy the redesigned frontal air bag system in the Metro. The damage algorithm of the WinSMASH program computed total velocity changes of 18.0 km/h (11.2 mph) for the Metro and 12.0 km/h (7.5 mph) for the Cherokee based on the estimated crush profiles. The longitudinal and latitudinal components for the Metro were -16.9 km/h (-10.5 mph) and 6.2 km/h (3.8 mph), respectively. The longitudinal and latitudinal components for the Cherokee were -4.1 km/h (2.6 mph) and -11.3 km/h (-7.0 mph), respectively. Although the WinSMASH results were based on the Metro's estimated crush profile, visual evaluation of the Metro and comparisons with other SCI cases suggest a delta-V in the range of 24 - 29 km/h (15 - 18 mph), based on SCI experience. As the Metro underrode the Cherokee, it began to rotate in a clockwise direction around the rear right bumper corner of the Cherokee which allowed additional direct contact against the Metro's hood. Both vehicles rotated in a CW direction after they disengaged. The Metro rotated a total of approximately 120 degrees in a clockwise (CW) direction and came to rest in the middle of the intersection (**Figure 4**). The Cherokee rotated approximately 180 degrees in a CW direction and came to rest facing north on the south leg in the left turn lane.



**Figure 4. Eastbound view showing final rest of the Chevrolet Metro**

## Post-Crash

It was not known how the driver of the Metro exited the vehicle. The 8-year-old front right passenger was removed from the vehicle by a witness to the crash. The witness stated that she opened the right front door, unbuckled the seat belt, removed the child from the vehicle and placed the child in the rear seat of a police vehicle. Both the driver and front right child passenger were transported by ambulance to a local hospital. The 8-year-old child expired two hours after the crash. Both occupants of the Jeep Cherokee exited the vehicle under their own power and did not receive any medical treatment.

## VEHICLE DATA - 1999 Chevrolet Metro LSi

The 1999 Chevrolet Metro was identified by the Vehicle Identification Number 2C1MR5223X6 (production sequence omitted). The Metro was owned by a Rental Car agency. The police reported odometer reading was 16,028 km (9,960 miles). The vehicle was a four-door sedan and was equipped with a 1.3 liter, 4 cylinder engine, front wheel drive, power assisted front disc and rear drum brakes, and 5-speed manual transmission. It was also equipped with daytime running lights. The Metro was configured with front bucket seats with integrated head restraints and a rear bench seat with a folding back. Both front seat positions were equipped with manual 3-point lap and shoulder belts. The rear seat was equipped with manual 3-point lap and shoulder belts for the outboard positions and a lap belt for the middle position.

## VEHICLE DAMAGE

### Exterior Damage - 1999 Chevrolet Metro LSi

The 1999 Chevrolet Metro sustained moderate damage as a result of the impact with the Jeep Cherokee. The direct contact damage began approximately 35 cm (12") to the left of the centerline and extended laterally to the right bumper corner (**Figure 5**). The combined direct and induced damage involved the entire frontal plane of the vehicle. The bumper fascia was fractured and crushed rearward on the right corner from direct contact, and was separated from the vehicle on the right side. The maximum crush at the bumper level was located at the right bumper corner at C6 and was estimated to be 30 cm (12"). The right front fender was displaced rearward against the right front wheel (**Figure 6**). The right head lamp assembly was fractured and displaced rearward. The leading edge of the hood was crushed rearward and sustained abrasions from the direct contact with the Cherokee. The hood was also buckled rearward at the designated fold points. The Collision Deformation Classification (CDC) for the impact with the Cherokee was 11-FDEW-2. Six crush measurements were estimated at the level of the bumper and were as follows: C1 = 5 cm (2"), C2 = 10 cm (4"), C3 = 15 cm (6"), C4 = 20 cm (8"), C5 = 25 cm (10"), C6 = 30 cm (12").



**Figure 5. Frontal damage to the Chevrolet Metro**



**Figure 6. Right side view of the frontal damage**

### Interior Damage - 1999 Chevrolet Metro LSi

The interior damage to the Chevrolet Metro appeared to be minor based on exterior police photographs. There did not appear to be any compartment intrusion.

### Exterior Damage - 1993 Jeep Cherokee

The 1993 Jeep Cherokee sustained minor damage as a result of the impact with the Chevrolet Metro. The direct contact damage was concentrated on the bottom aspect of the right rear quarter panel (**Figure 7**). The direct damage began on the lower edge of the quarter panel, aft of the right rear wheel and extended rearward approximately 76 cm (30") to the rear right bumper corner. The combined direct and induced damage began above the rear aspect of the right rear wheel and extended approximately 80 cm (31") rearward to the rear bumper. The maximum crush was approximately 21 cm (8"), and located at C3, approximately 30 cm (12") forward of the rear bumper. The rear right bumper corner fascia was displaced downward and laterally. The CDC for this impact to the Cherokee was 02-RBEW-2. Six crush measurements were estimated from the police photographs and were as follows: C1 = 5 cm (2"), C2 = 10 cm (4"), C3 = 21 cm (8") C4 = 18 cm (7"), C5 = 8 cm (3"), C6 = 0 cm.



**Figure 7. Right rear damage to the Jeep Cherokee**



### **FRONTAL AIR BAG SYSTEM - 1999 Chevrolet Metro LSi**

The 1999 Chevrolet Metro was equipped with redesigned air bags for the driver and front right passenger positions (**Figure 8**) that deployed as a result of the impact with the Jeep Cherokee. The impact sensor was centered on the frontal plane and located near the hood latch above the grille. The redesigned driver's air bag was housed in the center of the steering wheel with symmetrical H-configuration module cover flaps.



**Figure 8. Deployed redesigned frontal air bags in the Chevrolet Metro**

The redesigned front right passenger's air bag deployed from top-mounted module with a single cover flap design hinged at the forward aspect. The cover flap was rectangular in shape. There did not appear to be any damage to the air bag or module cover flap in the police photographs.

### **OCCUPANT DEMOGRAPHICS - 1999 Chevrolet Metro LSi**

#### **Driver**

Age/Sex:	32-year-old female
Height:	Not reported
Weight:	Not reported
Seat Track Position:	Appeared to be in the mid-track position in the police photographs
Manual Restraint Use:	Manual 3-point lap and shoulder belt
Usage Source:	Police report
Eyewear:	Unknown
Type of Medical Treatment:	Transported by ambulance to local hospital with police reported visible injury; her admission status was not reported

#### **Driver Kinematics**

The 32-year-old female driver was presumed to be seated in an upright posture with the seat back slightly reclined. The police report indicated that she was restrained by the manual 3-point lap and shoulder belt. At impact, the frontal air bag system deployed. She initiated a forward trajectory in response to the frontal crash force and loaded the manual restraint. She contacted the deployed redesigned driver's air bag which mitigated contact with the steering wheel assembly. She sustained police-reported visible injuries. It was not known how she exited the vehicle. She was transported by ambulance to a local hospital. A witness stated that the female driver of the Metro rode in the front right position in the ambulance. The driver's hospital admission status was not reported.

**Front Right Child Passenger**

Age/Sex: 8-year-old female  
 Height: 127 cm (50")  
 Weight: 39 kg (86 lb)  
 Seat Track Position: Appeared to be in the mid-track position in the police photographs  
 Manual Restraint Use: Manual 3-point lap and shoulder belt with the shoulder belt worn under her right arm  
 Usage Source: Injury data, police report  
 Eyewear: Unknown  
 Type of Medical Treatment: Transported by ambulance to local hospital and expired two hours following the crash

**Front Right Child Passenger Injuries**

<b>Injury</b>	<b>Injury Severity (AIS 90/Update 98)</b>	<b>Injury Mechanisms</b>
Fracture dislocation between C1 and C2 with cord contusion	Maximum (640236.6)	Expanding redesigned front right passenger's air bag
Partial-thickness laceration of the atrial septum	Critical (441300.5,4)	Lap and shoulder belt webbing
Extensive laceration of right hepatic lobe with 1200 cc. hemoperitoneum	Critical (541828.5,1)	Lap and shoulder belt webbing
Subdural hemorrhage over the occipital poles and superior convexities of the cerebellum	Severe (140438.4,6)	Impact forces - rearward acceleration of the head from air bag expansion
Partial stretch laceration of the inferior vena cava	Severe (421806.4,4)	Lap and shoulder belt webbing
Subarachnoid hemorrhage over the occipital poles and superior convexities of the cerebellum	Serious (140466.3,6)	Interior surface of the right front door
Right lung contusion with bilateral hemothorax	Serious (441406.3,1)	Shoulder belt webbing
3.5 x 3.3 cm (1.3 x 1.3") rectilinear contusion on the vertex of the scalp	Minor (190402.1,5)	Possible rebound into the seat back
2.8 x 0.2 cm (1.1 x 0.1") abrasion on the anterior left cheek	Minor (290202.1,2)	Unknown - possibly unrelated to crash

<b>Injury</b>	<b>Injury Severity (AIS 90/Update 98)</b>	<b>Injury Mechanisms</b>
2.5 x 0.1 (1.0 x 0.1") interrupted vertical laceration on the anterior inferior left cheek	Minor (290202.1,2)	Possible fling injury from driver's right hand
3.3 x 0.9 cm (1.3 x 0.4") patterned abrasion on the right nasal bridge	Minor (290202.1,4)	Unknown - possibly unrelated to crash
1.0 x 1.0 cm (0.4 x 0.4") circular contusion on the left mid-forehead and left and right forehead contusions measuring 0.8 cm and 1.5 cm	Minor (290402.1,7)	Unknown - possibly unrelated to crash
0.2 cm (0.1") triangular abrasion on the left periorbital area	Minor (297202.1,2)	Unknown - possibly unrelated to crash
20.0 x 14.5 cm (7.9 x 5.7") patterned abrasion distributed on the anterior chin, anterior neck, anterior upper chest and anterior left shoulder with a 4.5 x 2.0 cm (1.8 x 0.8") triangular shaped deep abrasion on the anterior right neck	Minor (290202.1,8) (390202.1,5) (490202.1,3) (790202.1,2)	Expanding redesigned front right passenger's air bag membrane
23.0 x 18.0 cm (9.1 x 7.1") area of patterned abrasion stemming from the anterior right deltoid onto the right axilla and anterior lateral right chest wall	Minor (490202.1,1)	Shoulder belt webbing
2 overlapping rectilinear contusions that covered a 5.7 x 3.8 cm (2.4 x 1.5") area on the anterior inferior left chest	Minor (490402.1,2)	Buckle assembly for the 3-point manual lap and shoulder belt

<b>Injury</b>	<b>Injury Severity (AIS 90/Update 98)</b>	<b>Injury Mechanisms</b>
23.0 x 18.0 cm (9.1 x 7.1") area of contusion stemming from the anterior right deltoid onto the right axilla and anterior lateral right chest wall and a 10.8 x 0.1 cm (4.3 x 0.1") linear contusion on the upper right arm and anterior right axillary line	Minor (490402.1,1)	Shoulder belt webbing
Oblique patterned abrasions and contusions on the superior abdomen	Minor (590202.1,7) (590402.1,7)	Lap and shoulder belt webbing
0.4 cm (0.2") oval abrasion on the sacrum	Minor (690202.1,8)	Possible rebound into the seat back
4.3 x 2.1 cm (1.7 x 0.8") contusion on the medial right upper arm	Minor (790402.1,1)	Interior surface of the right front door

\*Injury source: Autopsy report

### **Front Right Child Passenger Kinematics**

The 8-year-old female front right child passenger may have been seated forward in the seat with her upper torso semi-reclined against the seat back. She was improperly restrained by the manual 3-point lap and shoulder belt and had the shoulder belt positioned under her right arm and the lap belt placed high over her pelvic region. The position of the manual restraint was supported by the soft-tissue and internal injury patterns to the torso. Pre-crash braking caused her to submarine the lap belt and be displaced forward into the path of the redesigned front right passenger's air bag. At impact, she initiated a forward trajectory and loaded the improperly worn lap and shoulder belt. She loaded the lap belt with her upper abdominal region and the shoulder belt with the anterior lateral right chest area which resulted in a 23.0 x 18.0 cm (9.1 x 7.1") area of patterned abrasion and contusion stemming from the anterior right deltoid onto the right axilla and anterior lateral right chest wall, oblique patterned abrasions and contusions on the superior abdomen, a right lung contusion with bilateral hemothorax, a stretch laceration of the inferior vena cava, a laceration of the atrial septum, and an extensive laceration of the right hepatic lobe. The shoulder belt extended into the soft tissue around the child's armpit. The webbing compressed the soft tissue which caused the shoulder belt to ride higher than armpit level on the anterior aspect and resulted in a linear right clavicle contusion and a 10.8 x 0.1 cm (4.3 x 0.1") linear contusion on the upper right arm and anterior right axillary line. The shoulder belt under her right arm allowed her upper torso to rotate slightly clockwise (CW) as she moved forward. She sustained two overlapping rectilinear contusions that covered a 5.7 x 3.8 cm (2.4 x 1.5") area on the anterior inferior left chest which were indicative of loading against the seat belt buckle assembly as she submarined the seat belt system.

At the time of the frontal air bag deployment, she was forward into the path of the air bag with her neck and chest exposed from submarining the lap belt, and her left shoulder exposed due to the slight CW rotation of her upper torso. She sustained a 2.5 x 0.1 (1.0 x 0.1") interrupted vertical laceration on the anterior inferior left cheek, possibly from the driver's right hand as a result of a fling injury from the driver's air bag. The redesigned front right passenger's air bag deployed from the mid-instrument panel area and struck the 8-year-old under the chin. The expansion of the air bag against the underside of her chin and upper chest redirected her rearward and hyper-extended her neck. She sustained a 20.0 x 14.5 cm (7.9 x 5.7") patterned abrasion distributed on the anterior chin, anterior neck, anterior upper chest and anterior left shoulder with a 4.5 x 2.0 cm (1.8 x 0.8") triangular shaped deep abrasion on the anterior right neck and a fracture dislocation between C1 and C2 with cord contusion. She rebounded rearward into the seat back. The rearward acceleration caused a subdural hemorrhage over the occipital poles and superior convexities of the cerebellum. The rebound also most likely produced a 0.4 cm (0.2") oval abrasion on the sacrum and a 3.5 x 3.3 cm (1.3 x 1.3") rectilinear contusion on the vertex of the scalp.

As the vehicle rotated to final rest, she was redirected laterally to the right. She most likely struck her head and right arm on the interior surface of the right front door. She sustained a subarachnoid hemorrhage over the occipital poles and superior convexities of the cerebellum and a 4.3 x 2.1 cm (1.7 x 0.8") contusion on the medial right upper arm.

The front right child passenger also sustained minor facial contusions and abrasions. Based on the crash configuration, kinematic pattern, and injury data, the specific mechanisms were uncertain. It was possible they were unrelated to the crash.

The 8-year-old came to rest in the front right seat and was removed from the vehicle by a witness to the crash. The witness stated that she opened the right front door and removed the seat belt prior to removing the child from the vehicle. The front right child passenger was placed in the rear seat of a patrol car when it arrived on-scene. She was transferred to an ambulance and transported to a local hospital. She expired two hours following the crash. The autopsy report stated the cause of death was generalized trauma.

In the autopsy report, the Medical Examiner identified the patterned abrasion under the chin, jaw, and upper chest as suggestive of air bag injury which resulted in the injuries of the head and neck. The ME identified the injuries to the torso, predominantly on the right side, as being from an impact to the interior right front door surface.