

TRANSPORTATION RESEARCH CENTER

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**ON-SITE AIR BAG INVESTIGATION**

CASE NO. - IN97-001  
LOCATION - TEXAS  
VEHICLE - 1995 GEO METRO  
CRASH DATE - December, 1996

Submitted:

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

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16. Abstract This report covers an on-site investigation of an air bag deployment crash that involved a 1995 Geo Metro (case vehicle) which ran-off-road and impacted the ground. This crash is of special interest because the case vehicle's, unrestrained, "on-lap", right front passenger [i.e., 2-year-old male who was sitting on the lap of another (child) right front passenger] was decapitated as a result of striking the deploying front right air bag. The case vehicle was traveling north in the northbound lane of a two-lane, undivided, city street and was approaching the top of a "Tee" intersection. The driver of the case vehicle braked, but the case vehicle continued through the north end of the Tee intersection. The front undercarriage of the case vehicle impacted the ground causing both the driver and front right supplemental restraint systems (air bags) to deploy. The case vehicle's driver (35-year-old female) was seated with her seat track located between its middle and forward-most positions, and the case vehicle was not equipped with a tilt steering wheel. She was not wearing her available, active, three-point, lap and shoulder belt and did not sustain any physical injuries; however, according to her medical records she was emotionally traumatized. The right front passenger in the case vehicle (6-year-old male) was seated with his seat track located between its middle and rearmost positions and was not wearing his available, active, three-point, lap and shoulder belt. He sustained, according to the driver's interview and his medical records, minor abrasions to his forehead and the left side of his face from the deploying front right air bag. The "on-lap" right front passenger in the case vehicle (2-year-old male) was not using the available, active, three-point, lap and shoulder belt. He sustained, according to his autopsy, a fatal head decapitation at the upper most part of the neck at atlanto-occipital joint. In addition, he sustained: contusions to his heart, his lungs--bilaterally, and the cecum (i.e., large intestine); a liver laceration; a closed left distal humerus fracture; superficial abrasions to the anterior upper neck below the decapitation margin; and abrasions to his left elbow and both forearms. All of these injuries were caused by the deploying front right air bag except for the cecal contusion and liver laceration which were caused by the hands of the right front passenger.					
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**CASE SUMMARY**  
**TRC/IU ON-SITE AIR BAG INVESTIGATION**  
SCI Team #2, TRC/IU Case Number IN97-001  
Texas  
December, 1996

This on-site investigation was brought to NHTSA's attention on January 3, 1997 by the Auto Safety Hotline in Washington, D.C. This contractor inspected the scene and vehicle on 6-7 January 1997. The crash occurred in December, 1996, at 9:26 p.m., in Texas and was investigated by the applicable city police department. This crash involved a 1995 Geo Metro, four-door sedan, that ran off the road at a Tee-intersection and impacted the ground. This crash is of special interest because the Metro's other front seated occupant [i.e., a child (2 year-old male) sitting on the lap of another child who was seated in the right front seat position] was decapitated by the deploying front right air bag. This investigation is based on the Police Crash Report, interviews with the Metro's driver and the investigating police officer, scene and vehicle inspections, occupant kinematic principles, occupant medical records, and this contractor's evaluation of the evidence.

The case vehicle (Metro) was traveling north in the northbound lane of a two-lane, undivided, city street and was intending to continue traveling north until the driver realized that she was approaching the "dead end" of a Tee-intersection. The case vehicle's driver braked, depositing approximately 12 meters (39 feet) of skidmarks, in her attempt to avoid going off the end of the roadway. The crash occurred when the case vehicle departed the roadway, bottoming out, and then vaulted approximately 4.7 meters (15.5 feet) in the air prior to striking the ground again and coming to rest. At final rest the case vehicle was heading north, approximately 8.4 meters (27.5 feet) north of the north edge line of the crossing roadway. Based on National Transportation Safety Board (NTSB) calculations, the case vehicle was traveling at 68 km.p.h. (42 m.p.h.) prior to braking.

Initially, the middle undercarriage of the case vehicle impacted the end of the Tee-intersection. Subsequently, the front undercarriage impacted the ground causing the case vehicle's driver side and front right passenger side supplemental restraints (air bags) to deploy. This impact to the case vehicle was minor (1-8 m.p.h.).

The case vehicle's other front seated occupant [91 centimeters and 10.7 kilograms (36 inches, 23.5 pounds)] was seated on the lap of the right front occupant, and thus, was not wearing the available, active, three-point, lap and shoulder belt. An inspection of the front right air bag, which was located in the top of the instrument panel, revealed that the primary area of contact to the bag was to the top and along the right side seam. Furthermore, there are distinct finger-like outlines on the left side of the front right air bag module's cover flap; however, these markings were later determined not to be skin after NTSB laboratory examination.

The case vehicle's driver (i.e., primary care giver) braked attempting to avoid the crash. As a result of this attempted avoidance maneuver and the nonuse of any safety belts, the "on-lap" right front passenger moved forward toward the right dash and immediately in front of the air bag just prior to impact. Based on the available evidence, the right front passenger, who was behind the "on-lap" passenger, was holding onto him at the waist. When the case vehicle's front undercarriage impacted the ground, the impact not only deployed the front right air bag, but thrust this occupant forward and upward where the deploying air bag struck the "on-lap" right front passenger in the face and head. The force of the air bag tore this occupant's head off his torso, which was still being held

by the right front passenger. The "on lap" occupant's head was sequentially thrown rearward striking (1) the top of the integral headrest, (2) the backlight header, (3) the backlight, (4) the rear center high-mounted stop lamp housing, and (5) the back ledge prior to rebounding/rolling forward and hitting the bottom of the right rear passenger door panel where it came to rest on the floor behind the right front seat.

The case vehicle's "on-lap" occupant was transferred directly to a funeral home, but he was taken later to a large metropolitan city for an autopsy. The other injuries sustained by the case vehicle's "on-lap" passenger included: heart, lung (bilateral), and colon contusions, a liver laceration, fractured left distal humerus, and abrasions to his anterior neck and bilateral arms.

The case vehicle was a 1995 Geo Metro (VIN: 2C1MR5293S6-----). The case vehicle was not equipped with anti-lock brakes. The Metro was driveable but was towed from the scene. The deployment CDC was determined to be: **12-UFDS-1** for the case vehicle (i.e., all crush was below the front bumper). A printout of the case vehicle's Sensing Diagnostic Module (i.e., SDM), obtained by a General Motors safety analyst, showed the Delta V as 16.9 km.p.h. (10.53 m.p.h.). According to the GM analyst, this was the minimum threshold needed to deploy the vehicle's air bags.

Immediately prior to the crash the case vehicle's other front seated occupant was sitting on the lap of the right front passenger, leaning forward, his feet on hanging down over the seat, and the location of his hands is unknown. The right front seat track was located between its middle and rearmost positions, and the seat back was slightly reclined.

Immediately prior to the crash the case vehicle's driver (35-year-old female) was seated upright with her back against the seat back, her left foot on the floor, her right foot on the brake, and both hands on the steering wheel. Her seat track was located between its middle and forward-most positions, the seat back was completely upright, and the vehicle was not equipped with a tilt steering wheel.

The case vehicle's driver [157 centimeters and 59 kilograms (62 inches, 130 pounds)] was not wearing her available, active, three-point, lap and shoulder belt. This determination was confirmed by the SDM readout, obtained by a General Motors safety analyst on scene. An inspection of the driver side air bag revealed numerous blood smears; however, these smears probably came from the other front seated occupant. In addition, there did not appear to be contact evidence on the driver side air bag module's cover flap. The case vehicle's driver was transported by ambulance to the hospital where she was treated and released. According to her medical records, she was emotionally/mentally injured, but was not physically injured.

Immediately prior to the crash the case vehicle's right front passenger (6-year-old male) was seated slightly reclined with his back against the seat back, his feet on hanging down over the seat, and his hands around the waist of the occupant in his lap. His seat track was located between its middle and rearmost positions, and the seat back was slightly reclined.

The case vehicle's right front passenger (unknown height and weight) was not wearing his available, active, three-point, lap and shoulder belt. An inspection of the right front safety belt showed no evidence of usage in this crash. The case vehicle's right front passenger (i.e., nephew of driver) was also transported by ambulance to the hospital where he was treated and released. According to the interviewee and his medical records, the right front passenger sustained abrasions to his forehead and the left side of his face from the air bag.

# TRC/IU ON-SITE AIR BAG INVESTIGATION

TRC/IU CASE NO. IN97-001  
VEHICLE - 1995 GEO METRO  
LOCATION - TEXAS

## ACCIDENT DATA

Location/Street:	City Street
State:	Texas
Area/Type:	Urban, residential
Accident Date/Time:	December, 1996, @ 9:26 p.m.
Investigating Police Agency:	City police department
Accident Type:	Car - ran-off-road/Ground
Occupant Injury Severity (air bag vehicle):	Decapitation (AIS-6)

## AMBIENT CONDITIONS

Light Conditions:	Darkness, road lighted
Weather Condition:	Cloudy
Precipitation:	None at time of crash
Road Surface:	Wet
Temperature:	Unknown, no climatological observations were recorded

## ROADWAY

### Case Vehicle

Location:	City street
Number of Travel Lanes:	Two-lanes, undivided



**ROADWAY (CONTINUED)****Case Vehicle**

Width:	4.95 meters (16.2 feet)
Surface Type:	Bituminous
Median:	None
Shoulders:	None, concrete curbs
Vertical alignment:	+6.8%
Horizontal alignment:	Straight
Estimated Coefficient of Friction:	.65 (Note: This value was measured by NTSB personnel at the scene by skid testing)
Traffic Density:	No other traffic

**TRAFFIC CONTROLS****Case Vehicle**

Signals:	None
Signs:	Regulatory STOP sign
Markings:	None (no center or edge lines)
Speed Limit:	48 km.p.h. (30 m.p.h.)

**VEHICLES****Case Vehicle**

Year:	1995
Make:	Geo
Model:	Metro
Body Type:	Four-door sedan

## VEHICLES (CONTINUED)

	<u>Case Vehicle</u>
V.I.N.	2C1MR5293S6-----
Color:	Dark blue
Mileage:	25,637 km (15,930 miles)
Engine:	1.3 liters, I4
Transmission:	Three-speed automatic
Steering:	Power-assisted, rack-and-pinion
Brakes:	Power-assisted, front disc, rear drum
Padding:	Steering wheel and hub, sunvisors, dash, "A"-pillars, side door surfaces
Active Restraints:	Three-point, manual, lap and shoulder belts in front and rear outboard seating positions
Passive Restraints:	Factory installed driver and front right supplemental restraint systems (air bags)
Anti-lock Brakes:	Option, not equipped
Defects:	None
Fleet:	Private vehicle
Tow status:	Towed due to damage

VEHICLE DAMAGE<sup>1</sup>EXTERIORCase VehicleDeployment Impact

Event number:	One
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<sup>1</sup> This value represents cross member movement and was reported to this contractor by a contact at the National Transportation Safety Board. The source of the measurement is unknown, but the source was NTSB, General Motors engineers, or a combination thereof.

**VEHICLE DAMAGE (CONTINUED)**

**EXTERIOR** (Continued)**Case Vehicle**Deployment Impact (Continued)

Object Struck:	Ground
Damage location	
Damaged Plane:	Undercarriage
Longitudinal Location	
On Plane:	Front
Direct Begins:	Not applicable
Length Direct:	135 cm ( 53.1 in) across entire front undercarriage
Field L:	Not applicable
C <sub>1</sub> :	Not applicable
C <sub>2</sub> :	Not applicable
C <sub>3</sub> :	Not applicable
C <sub>4</sub> :	Not applicable
C <sub>5</sub> :	Not applicable
C <sub>6</sub> :	Not applicable
D:	Not applicable
Maximum Crush:	15 cm ( 5.9 in) <sup>1</sup>
Location:	Not applicable
CDC:	12-UFDW-2
Damaged Components:	Front bumper, air dam, radiator, radiator supports, front cross member

Nondeployment Impact

Event number:	Two
Object Struck:	Ground
Damage location	
Damaged Plane:	Undercarriage
Longitudinal Location	
On Plane:	Front
Direct Begins:	Not applicable
Length Direct:	Not distinguishable
Field L:	Not applicable
C <sub>1</sub> :	Not applicable
C <sub>2</sub> :	Not applicable
C <sub>3</sub> :	Not applicable
C <sub>4</sub> :	Not applicable
C <sub>5</sub> :	Not applicable

### VEHICLE DAMAGE (CONTINUED)

**EXTERIOR** (Continued)**Case Vehicle****Nondeployment Impact** (Continued)

C <sub>6</sub> :	Not applicable
D:	Not applicable
Maximum Crush:	Unknown
Location:	Not applicable
CDC:	00-UFDW-1
Damaged Components:	Front bumper, air dam, front cross member
<b><u>INTERIOR</u></b>	
Damaged Components:	Driver and front right air bag modules, right front seat back, and right roof
Other Evidence of Occupant Contact:	Center high-mounted stop lamp (i.e., CHMSL), backlight, and back ledge
Manual Restraint System Failures:	None
Seat Performance Failures:	None
<b><u>REPAIR</u></b>	
Cost Estimate:	\$ 6,242.56

### VEHICLE VELOCITY ESTIMATES

**Highest Delta "V"****Case Vehicle**

Reconstruction Program:	None
Program Algorithm:	Not applicable
Travel Speed:	68 km.p.h. ( 42 m.p.h.)
Total Delta "V":	Not applicable
Longitudinal Delta "V":	Not applicable

VEHICLE VELOCITY ESTIMATES (CONTINUED)

Highest Delta "V"Case Vehicle

Lateral Delta "V":

Not applicable

The reported travel speed is based on computations done by the NTSB investigator who was on-site with this contractor.

COLLISION SEQUENCE

The following is based on the Police Accident Report, interviews with the case vehicle's driver and the investigating police officer, scene and vehicle inspections, occupant medical records, and this contractor's evaluation of the evidence.

**PRE-CRASH:** The case vehicle (Metro) was traveling north in the northbound lane of a two-lane, undivided, city street and intended to continue in its northward direction of travel when the case vehicle's driver suddenly realized<sup>2</sup> that she was approaching a STOP sign at a Tee intersection. The driver of the case vehicle attempted to brake, depositing 11.9 meters (39 feet) of skid marks. Despite the attempted avoidance maneuver, the case vehicle continued straight ahead prior to departing the north end of the "Tee" intersection. The crash occurred off the roadway, just beyond the curb, north of the Tee intersection.

**CRASH:** The front undercarriage of the case vehicle impacted the ground causing both the driver and front right supplemental restraint systems (air bags) to deploy. The case vehicle's undercarriage damage and lack of direct damage to the front bumper indicates that the case vehicle bottomed out. The case vehicle subsequently vaulted, reimpacting the ground approximately 4.7 meters (15.5 feet) farther north. After the second impact with the ground, the case vehicle came to rest approximately 8.4 meters (27.5 feet) north of the north edge line of the crossing roadway.

**POST-CRASH:**

**Occupants:** All three of the case vehicle's occupants [driver, right front passenger, and other front seated passenger (i.e., "on-lap")] remained inside the vehicle at final rest. According to the investigating police officer, the case vehicle's driver and right front passenger were conscious and able to exit the case vehicle without any assistance. The "on-lap" right front was decapitated by the deploying front right air bag and was unable to exit the case vehicle.

<sup>2</sup> It is thought that the case vehicle's driver believed that she was on a "through" street and thus, was not expecting a STOP sign.

## COLLISION SEQUENCE (CONTINUED)

## POST-CRASH:

## Occupants: (Continued)

The case vehicle's driver and right front passenger were not using their available, active, three-point lap and shoulder belts. The "on-lap" right front passenger was also not restrained.

**Police:** The investigating police agency was notified of the crash within five minutes post-crash and arrived on-scene one minute later. Traffic control procedures were established and emergency medical and towing services were called to assist.

**Rescue:** The driver and right front passenger were transported by ambulance to a medical facility where they were treated and released. The "on-lap" right front passenger was transported by hearse to the county morgue. The case vehicle's driver did not sustain any physical injuries as a result of this crash, but she was emotionally traumatized. The right front passenger sustained minor facial injuries from the deploying front right air bag, which included: abrasions to his forehead and the left side of his face. The "on-lap" right front passenger sustained a fatal head decapitation at the upper most part of the neck at atlanto-occipital joint. In addition, he sustained: contusions to (a) the right atrium of his heart, around the terminal part of the inferior vena cava, (b) his lungs, bilaterally, including the right middle and lower lobes and interlobar surfaces and left upper and lower lobes, and (c) the cecum (i.e., large intestine); a laceration along the falciform ligament at inferior border of the liver; a closed fracture to the left distal humerus; superficial abrasions to the anterior upper neck below the decapitation margin, extending to the right infraclavicular region and the right base of his neck; and abrasions to his left elbow and left anteromedial forearm and right mid-lateral forearm. All of these injuries were caused by the deploying front right air bag except for the cecal contusion and laceration of the liver ligament which were caused by the hands of the right front passenger.

**Removal:** Following the police investigation, the case vehicle was towed from the scene.

## HUMAN FACTORS/OCCUPANT DATA

<b><u>Case Vehicle:</u></b>	<b><u>DRIVER</u></b>
Age:	35-year-old
Sex:	Female
Height:	157 cm (62 in)
Weight:	59 kg (130 lbs)

**HUMAN FACTORS/OCCUPANT DATA (CONTINUED)**

**Case Vehicle:****DRIVER** (Continued)

Occupation:	Packer
Active Restraint System/Usage:	Three-point lap and shoulder/Not used
Usage Source:	Vehicle inspection
Passive Restraint System/Usage:	Factory installed air bag/air bag deployed
Usage Source:	Vehicle inspection and Police Crash Report
Eyeglasses/contacts:	None
Vehicle Familiarity:	Twenty-three months at an unknown annual rate of usage
Route Familiarity:	Very infrequently
Trip Plan:	Social/recreational to home
Manner of Leaving Scene:	Ambulance
Type of Medical Treatment:	Treated and released

**Case Vehicle****Right front Passenger****Out of Position "On-Lap"  
Right Front Passenger**

Age:	6-year-old	2-year-old
Sex:	Male	Male
Height:	Unknown	91 cm (36 in)
Weight:	Unknown	11 kg (23.5 lbs)
Active Restraint System/Usage:	Three-point lap and shoulder/Not used	Three-point lap and shoulder/Not used
Usage Source:	Vehicle inspection	Vehicle inspection, Police Crash Report, and autopsy
Passive Restraint System/Usage:	Factory installed air bag/air bag deployed	Factory installed air bag/air bag deployed

## HUMAN FACTORS/OCCUPANT DATA (CONTINUED)

<u>Case Vehicle</u>	<u>Right front Passenger</u>	<u>Out of Position "On-Lap" Right Front Passenger</u>
Usage Source:	Vehicle inspection and Police Crash Report	Vehicle inspection, Police Crash Report, and autopsy
Eyeglasses/contacts:	None	None
Manner of Leaving Scene:	Ambulance	Hearse
Type of Medical Treatment:	Treated and released	Postmortem examination

## CASE VEHICLE DRIVER INJURIES

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
0	Not physically injured <sup>3</sup>	0 No injury	Not applicable	Not applicable	Emergency room visit

## CASE VEHICLE RIGHT FRONT PASSENGER INJURIES

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Abrasion left side of face	290202.1 Minor	Air bag, front right	Certain	Emergency room visit
2	Abrasion forehead, location not further specified	290202.1 Minor	Air bag, front right	Certain	Interviewee (driver)

## CASE VEHICLE "ON-LAP" RIGHT FRONT PASSENGER INJURIES

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Decapitation at upper most part of neck at atlanto-occipital joint--including:	311000.6 untreatable	Air bag, front right	Certain	Autopsy

<sup>3</sup> The case vehicle's driver was treated and release at a medical facility. Although no physical injury was noted, she was emotionally traumatized.



## CASE VEHICLE "ON-LAP" RIGHT FRONT PASSENGER INJURIES (CONTINUED)

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1 Cont'd.	<p>Transection of cervical spinal cord in posterior cranial fossa</p> <p>Transection of common carotid arteries in upper neck, bilaterally</p> <p>Transection of esophagus</p> <p>Transection of trachea</p> <p>Subdural hemorrhage, patchy, minimal--more on right than left</p> <p>Subarachnoid hemorrhage, patchy, over right cerebral hemisphere</p> <p>Fracture posterior part of atlas(i.e., C<sub>1</sub>)</p> <p>Abrasions, small, lower lip</p> <p>Lacerations to mucosal surface of lower lip</p> <p>Abrasions, superficial, bilateral lower face, undersurface of chin, and left lateral head including mastoid area below earlobe and lateral left earlobe</p>				
2	Contusion right atrium of hear around terminal part of inferior vena cava	441002.3 serious	Air bag, front right	Certain	Autopsy
3	Contusions bilateral lungs including right middle and lower lobes and interlobar surfaces and left upper and lower lobes	441410.4 severe	Air bag, front right	Certain	Autopsy
4	Contusion, mild, cecum (i.e., large intestine)	540810.2 moderate	Hands of right front passenger	Possible	Autopsy
5	Laceration, small, along falciform ligament at inferior border of liver	541822.2 moderate	Hands of right front passenger	Possible	Autopsy
6	Fracture, closed, left distal humerus	752602.2 moderate	Air bag, front right	Probable	Autopsy
7	Abrasions, superficial, to anterior upper neck below decapitation margin extending to right infraclavicular region and right base of neck	390202.1 minor	Air bag, front right	Certain	Autopsy
8	Abrasions left elbow and left forearm, anteromedially, and right mid-lateral forearm	790202.1 minor	Air bag, front right	Certain	Autopsy

### CASE VEHICLE DRIVER KINEMATICS

Immediately prior to the crash she was seated upright with her back against the seat back, her left foot on the floor, her right foot on the brake, and both hands on the steering wheel. Her seat track was located between its middle and forward-most positions, and the case vehicle was not equipped with a tilt steering wheel. The case vehicle's driver was not wearing her available, active, three-point, lap and shoulder belt. This was based on the contractor's inspection of the belt system and the vehicle manufacturer's data recorder.

The case vehicle's driver braked [i.e., depositing 11.9 meters (39 feet) of skid marks] attempting to avoid the crash. As a result of this attempted avoidance maneuver and the nonuse of her available safety belts, she most likely moved slightly forward just prior to impact.

The case vehicle's primary impact with the ground not only deployed the driver's side air bag but thrust the driver forward and slightly upward. An inspection of the driver's air bag revealed blood smears on the lower center area; however, these blood spots almost certainly resulted from the injuries sustained by the case vehicle's "on-lap" right front passenger. There was no evidence of direct contact with the driver side air bag module's cover flap.

The case vehicle's subsequent vaulting action combined with the deploying air bag, sent the driver rebounding upwards and back into her seat back. As the vehicle landed following the vaulting action, the driver went forward most likely contacting the steering wheel hub prior to landing back down on her seat cushion. As the vehicle came to rest the driver was still primarily in her seat.

### CASE VEHICLE RIGHT FRONT PASSENGER KINEMATICS

Based on this occupant's medical records, the vehicle inspection, and occupant kinematic principles, immediately prior to the crash the right front passenger was seated upright with his back against the seat back, his feet sticking out from the seat cushion, and both arms around the "out-of-position" right front passenger that was sitting on his lap. The right front passenger's seat track was located between its middle and rearmost positions with the seat back in its upright position. The right front passenger (i.e., 6-year-old male) was not wearing his available, active, three-point, lap and shoulder belt. An inspection of the right front seat belt webbing, D-ring, and latch plate showed no evidence of loading or usage during either impact with the ground.

As a result of the case vehicle's attempted avoidance maneuver (i.e., locked wheel braking) and the nonuse of his available safety belts, the right front passenger moved forward, along with the "out-of-position" right front passenger (i.e., 2-year-old male) that was on his lap, just prior to impact.

The case vehicle's primary impact with the ground not only deployed the front right air bag but thrust the right front passenger, accompanied by the 2-year-old in front of him, further forward and slightly downward. The case vehicle's subsequent vaulting action combined with the deploying air bag and the movement of the "on-lap" occupant, sent this passenger rebounding upwards and back into his seat back, still holding onto the "on-lap" passenger's torso. An inspection of the right front passenger's air bag revealed skin and blood to the top and front right portion of the air bag. In

## CASE VEHICLE RIGHT FRONT PASSENGER KINEMATICS (CONTINUED)

addition, there appeared to be finger outlines on the left side of the front right air bag module's cover flap, but these marks were later determined not to be human skin by NTSB forensic personnel.

As the vehicle landed following the vaulting action, the right front passenger was still holding onto the torso of the now decapitated 2-year-old male. He was thrown forward but stopped short of contacting the dash. As the case vehicle came to rest the right front passenger was still partially in his seat. He was then directed by the driver to exit the case vehicle which he did after setting the "on-lap" right front passenger down on the seat to his left.

## CASE VEHICLE "ON-LAP" RIGHT FRONT PASSENGER KINEMATICS

Based on the medical records, the vehicle inspection, and occupant kinematic principles, prior to the crash the "out-of-position" right front passenger was sitting on the right front passenger's lap with his feet hanging down over the seat, his head most likely turned the right looking out the glazing at Christmas lights, and his hands in an unknown position. The right front seat track was located between its middle and rearmost position with the seat back in an upright position. Neither the "on-lap" 2-year-old passenger nor the 6-year-old right front passenger were using the available, active, three-point, lap and shoulder safety belt. An inspection of the right front seat belt webbing, D-ring, and latch plate showed no evidence of loading or usage during either impact with the ground. There was no seat belt pattern contusions or abrasions cited in this occupant's autopsy.

As a result of the case vehicle's attempted avoidance maneuver (i.e., locked wheel braking), the nonuse of his available safety belts, and strong likelihood<sup>4</sup> that the right front passenger (6-year-old male) had his hands around the waist of the "on-lap" right front passenger, his head and upper torso leaned further forward, relative to his waist which was also moving forward along with the right front passenger, just prior to impact.

The case vehicle's primary impact with the ground, not only deployed the front right air bag, but thrust the "on-lap" right front passenger and the right front passenger further forward and slightly downward. The case vehicle's subsequent vaulting action combined with the deploying air bag, sent this "on-lap" passenger's torso rebounding upwards and rearwards with the 6-year-old still holding the torso. The inspection of the front right air bag and air bag module's cover flap are discussed above.

As the vehicle landed following the vaulting action, the decapitated, "on-lap" right front passenger was still being held by the right front passenger, and he was thrown forward but stopped short of contacting the dash. As the case vehicle came to rest the torso of the "on-lap" right front passenger (2-year-old male) was still on the lap of the right front passenger (6-year-old male). According to the driver's interview, the "on-lap" right front passenger was placed down on the right front seat to the left of where the right front passenger had been sitting.

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<sup>4</sup> This contractor cannot say with absolute certainty that the right front passenger (6-year-old male) had his hands around the "on-lap" right front passenger's (2-year-old male) waist, but based on the vehicle inspection and the injury information, this scenario "best fits" the available evidence.

### AIR BAG SYSTEM

	<u>DRIVER AIR BAG</u>	<u>FRONT RIGHT AIR BAG</u>
Air Bag Diameter ( seam-to-seam, deflated ):	Width: 63 cm ( 24.8 in) Height: 56 cm ( 22.0 in)	Width: 46 cm ( 18.1 in) Height: 45 cm ( 17.7 in)
Number of Vent Holes:	Two	None
Vent Hole Diameter:	3.5 cm (1.4 in)	Not applicable
Vent Hole Clock Positions:	Approximately 10:30 and 1:30 o'clock	Not applicable
Number of Air Bag Tethers:	Two, each 5 cm (2.0 in) wide	None
Number of Air Bag Module Cover Flaps:	Two	One
Upper Cover Flap Dimensions:	Width: 15 cm ( 5.9 in) Height: 6 cm ( 2.4 in)	Width: 35 cm ( 13.8 in) Height: 15 cm ( 5.9 in)
Lower Cover Flap Dimensions:	Width: 15 cm ( 5.9 in) Height: 8 cm ( 3.1 in)	Not applicable
Distance between Dash and leading (i.e., closest) edge of Module's Cover Flap:	<b>Not applicable</b>	6 cm (2.4 in)
Mount Location:	Steering wheel hub	Top instrument panel
Generant Residue:	No unusual amount found	No unusual amount found

### DIAGNOSTIC EVALUATION

One day following this investigators on-site investigation, General Motors had two people inspect the case vehicle. One was with GM's Engineering Safety Center and the other with ESIS GM Claims Unit. The latter was familiar with obtaining and deciphering stored information in GM vehicle's equipped with either a DERM (Diagnostic Energy Reserve Module) or SDM (Sensing Diagnostic Module). In this specific crash the case vehicle was equipped with an SDM.

According to the GM analysis, the SDM is able to take a snap shot of any near deployment events the case vehicle has incurred throughout its driving lifetime. These near deployment events would include anything from a 5 mph fender bender to an impact just below the vehicles threshold or higher, the latter causing deployment. Essentially the snapshot is taken at any deceleration event the case vehicle incurs higher than "**2gs**". The SDM also is capable of recording the driver's seat belt

## DIAGNOSTIC EVALUATION ( continued )

status at the last recorded event, any recorded air bag warnings that have been detected (pre- or post-crash), and when the warnings first appeared. Another important bit of information the SDM is capable of retaining is the maximum Delta V the case vehicle sustained during its deployment event (crash). The SDM also provides numerous bits of information that neither has any meaning nor is of any use to this investigation.

The SDM recorded and stored a CRASH EVENT which contains the following information:

- C The SIR Warning Light was OFF at the time of the deployment (i.e., no malfunctions).
- C The SIR Warning Light was not ON prior to the crash (i.e., no malfunctions).
- C There were no SIR systems codes stored in memory (i.e., no malfunctions).
- C The air bags deployed 45.0 milliseconds after the collision was first detected by the SDM.
- C The maximum change in velocity (Delta V) the SDM recorded was 10.53 m.p.h.
- C Several criteria were met which triggered the SDM to command the deployment of the air bags. This included the forward Auxiliary Discriminating Sensor (ADS) to close {"closing"} during the collision event.
- C The crash occurred on ignition cycle number 8033.
- C This was the first Deployment Crash Event for this vehicle.
- C The driver's seat belt was unlatched at the time the deployment occurred.

In addition to the Deployment Crash Event, the SDM also stored a Near-Deployment Event that occurred sometime during the same ignition cycle (8033) as the crash in question. The maximum Delta V for this event was 1.54 m.p.h. The driver seat belt was also unlatched during this event.