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ON-SITE AIR BAG INVESTIGATION

CASE NUMBER - IN97-014
LOCATION - LOUISIANA
VEHICLE - 1996 SUBARU IMPREZA
CRASH DATE - May, 1997

Submitted:

March 1, 1999
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May 14, 1999, August 24, 2001,
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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.

Technical Report Documentation Page

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15. *Supplementary Notes* On-site air bag deployment investigation involving a 1996 Subaru Impreza, 2-door coupe, with active belts and dual front air bags, a 1986 GMC pickup, and a 1997 Mercedes-Benz, 4-door sedan			
16. *Abstract* This report covers an on-site investigation of an air bag deployment crash that involved a 1996 Subaru Impreza (case vehicle), a 1986 GMC Sierra pick-up (vehicle #2), and a 1997 Mercedes Benz E420 (vehicle #3). This crash is of special interest because the case vehicle's, unrestrained, front right passenger (7-year-old female) sustained critical brain injuries as a result of contacting her deploying front right passenger air bag, resulting in her death. The case vehicle was traveling north in the outside lane of a five-lane, divided, city trafficway (i.e., both the north and south roadways had two through lanes; the southbound roadway had a left-hand turn lane). Vehicle #2 had been traveling south in the left-turn lane of the southbound roadway and was making a left turn at a "Tee" intersection across the northbound roadway. Vehicle #3 was stopped, heading west, in the westbound lane of the intersecting, two-lane, undivided, city street. The front of the case vehicle impacted the right side of vehicle #2 causing the case vehicle's driver and front right passenger supplemental restraints (air bags) to deploy. Vehicle #2 was redirected east-northeastward after the impact and its left side impacted the front left corner of vehicle #3. The case vehicle's driver (37-year-old female) was seated with her seat track located in its forward-most position and her tilt steering wheel was in its up-most position. She was not wearing her available, active, three-point, lap and shoulder belt and sustained, according to her interview and medical records moderate injuries which included: a metatarsal fracture to her right foot, contusions to her right knee and left forearm, and abrasions to right chin and lips. The front right passenger was seated, and her seat track is believed to have been located between its middle and forward-most positions. She was not wearing her available, active, three-point, lap and shoulder belt. She sustained, according to her medical records, critical injuries which included: a critical nonanatomic brain injury, subdural hematoma, cerebral edema, and massive subarachnoid hemorrhage; a dislocation to her first cervical vertebra; a laceration to her superior vena cava; bilateral corneal abrasions and retinal detachments; and multiple abrasions and contusions about her head, face, neck, chest, right arm, left elbow, knees, and left ankle.			
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SELECTED PHOTOGRAPHS (Continued)

CASE SUMMARY

TRC/IU REMOTE/ON-SITE AIR BAG REPORT/INVESTIGATION

SCI Team #2, TRC/IU Case Number IN97-014

Louisiana

May, 1997

This on-site investigation was brought to NHTSA's attention on May 6, 1997 by a sergeant with the investigating police department. This crash involved a 1996 Subaru Impreza (case vehicle), a 1986 GMC Sierra 1500 pick-up truck (vehicle #2), and a 1997 Mercedes Benz E420 (vehicle #3). The crash occurred in May, 1997, at 3:59 p.m., in Louisiana and was investigated by the applicable city police department. This crash is of special interest because the case vehicle's, unrestrained, front right passenger (7-year-old female) sustained critical brain injuries as a result of contacting her deploying front right passenger air bag, resulting in her death. This contractor inspected the scene on May 6, 1997 and the vehicles on May 7, 1997. This contractor interviewed the case vehicle's driver on May 8, 1997. This report is based on the Police Crash Report, interviews with the investigating police officer and all three vehicle drivers, scene and vehicle inspections, occupant kinematic principles, occupant medical records, and this contractor's evaluation of the evidence.

The case vehicle was traveling north in the outside lane of a five-lane, divided, city trafficway and intended to continue northbound through a "Tee" intersection (i.e., both the north and southbound roadways had two through lanes, while the southbound roadway had a left-hand turn lane). Vehicle #2 had been traveling south in the left-turn lane of the southbound roadway and was making a left turn at the "Tee" intersection across the northbound roadway, intending to travel east on the intersecting roadway. Vehicle #3 was stopped, heading west, in the westbound lane of the intersecting, two-lane, undivided, city street and was waiting for traffic to clear to execute a left turn and go south. In an attempt to avoid the crash, the case vehicle's driver tried to steer to the right and braked (with lock-up), leaving approximately 4.2 meters (14 feet) of a right tire skid, which negated her right steering maneuver. According to the driver of vehicle #2, no avoidance maneuvers were attempted. Based on the scene evidence, the driver of vehicle #3 made no avoidance maneuvers. The crash occurred in the southbound roadway of the "Tee" intersection of the two trafficways.

The front of the case vehicle impacted the right center cab area of vehicle #2 causing the case vehicle's driver and front right passenger supplemental restraints (air bags) to deploy. The case vehicle rotated clockwise approximately 60 degrees after impact and came to rest in the outside lane, heading primarily east. Vehicle #2 was redirected east-northeastward after the impact with the case vehicle. Vehicle #3's front left corner was impacted by the left side of vehicle #2 causing a toolbox and a bicycle in the bed (i.e., pickup) of vehicle #2 to be thrown onto and over the front hood of vehicle #3. Vehicle #2 impacted vehicle #3 on the east leg of the "Tee" intersection. Vehicle #2 came to rest on the east leg of the "Tee" intersection, most likely heading southeast. The driver of vehicle #2 backed away (i.e., toward the northwest) 1.8-2.4 meters (6-8 feet) in an attempt to flee the scene. Vehicle #2 was found in the outside northbound lane, heading southeast. The front of Vehicle #3 rotated approximately 15 degrees counterclockwise, and vehicle #3 was moved a few feet eastward (i.e., backwards) as a result of the impact. Vehicle #3 came to rest heading west-southwest.

According to the case vehicle's driver, the front right passenger [daughter, 122 centimeters and 27 kilograms (48 inches, 60 pounds)] was also restrained by her available, active, three-point, lap and shoulder belt. Based on the police and the interior vehicle inspection, the front right passenger was not using her safety belt. An inspection of the front right passenger's seat belt webbing, "D"-ring, and latch plate showed no evidence of loading. In addition, the autopsy photographs showed no evidence of belt pattern bruising or abrasions to the front right passenger's shoulder, neck, chest, or abdomen.

The case vehicle's driver tried to steer right and braked, attempting to avoid the crash. As a result of these attempted avoidance maneuvers and the nonuse of her available safety belts, the front right passenger moved forward just prior to impact. The case vehicle's impact with vehicle #2 not only deployed the front right passenger air bag, but thrust her forward, upward, and slightly leftward toward the 350 degree Direction of Principal Force. As the air bag began to deploy the front right passenger loaded it causing the air bag to deform the module's cover flap. The top mounted air bag's upward and outward excursion pushed the front right passenger into the windshield where she starred it with her left upper forehead and scalp and deposited grease smears. In addition, she contacted the glove box door with her knees. As the air bag continued to expand, the front right passenger was propelled backward and slightly upward where she most likely contacted the roof over the front right seat. She continued rearward until her movement was stopped by the front right seat back.

During the front right passenger's rearward movement, the case vehicle rotated clockwise as a result of the impact. After impacting the seat back the front right passenger most likely rebounded forward toward the center instrument panel which had by now rotated in front of her. In addition, she contacted the center dash cup holder and steering column-mounted windshield wiper selector wand. At final rest the front right passenger was most likely laying on her left side with her lower torso on the seat cushion and her upper torso over the center console or possibly on the driver's right leg.

The front right occupant was transported by ambulance to the hospital. She sustained critical injuries and was pronounced dead 4 hours and 46 minutes post-crash. The injuries sustained by the case vehicle's front right passenger included: a critical nonanatomic brain injury, subdural hematoma, cerebral edema, and massive subarachnoid hemorrhage; a dislocation to her first cervical vertebra; a laceration to her superior vena cava; bilateral corneal abrasions and retinal detachments; and multiple abrasions and contusions about her head, face, neck, chest, right arm, left elbow, knees, and left ankle.

The case vehicle was an all wheel drive 1996 Subaru Impreza, two-door coupe (VIN: JF1GM2255TG------). The case vehicle was not equipped with anti-lock brakes. Vehicle #2 is a rear wheel drive 1986 GMC Sierra 1500, ½-ton, regular cab pick-up truck (VIN: 1GTDC14H8GF------). Vehicle #3 is a rear wheel drive 1997 Mercedes Benz E420, four-door sedan (VIN: WDBJF72F2VA------). The case vehicle and vehicle #2 were both towed due to damage. Vehicle #3 was drivable but the police had it towed to the police garage due to the seriousness of the crash. Based on the vehicle inspections, the CDCs were determined to be: **12-FDEW-1 (350)** for the case vehicle [maximum crush was 4 centimeters (1.6 inches)] and **02-RZEW-3 (60)** for vehicle #2 [maximum crush was 22 centimeters (8.7 inches)]. The WinSMASH reconstruction program, damage only algorithm, was used on the case vehicle's highest severity

impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 16.6 km.p.h. (10.3 m.p.h.), -16.4 km.p.h. (-10.2 m.p.h.), and +2.9 km.p.h. (+1.8 m.p.h).

The case vehicle's driver air bag was located in the steering wheel hub. An inspection of the air bag module's cover flaps revealed that the cover flaps opened at the designated tear points, and there was no evidence of damage to the air bag or the cover flaps. An inspection of the front right passenger's air bag, which was located in the top of the instrument panel, revealed that the cover flap opened at the designated tear points, and the cover flap had been deformed by the deploying air bag. An inspection of the driver's air bag revealed skin evidence to the upper portion of the air bag. Furthermore, there appeared to be a spot of blood towards the bottom of the driver's air bag. An inspection of the driver side air bag module's cover flap revealed no evidence of occupant contact. An inspection of the front right passenger's top mounted air bag revealed a extremely large area of skin transfer on the top and whole front portion of the air bag while the inspection of the air bag module's cover flap revealed no evidence of occupant contact. The glove box door showed contact evidence from the front right passenger's knees, the windshield was cracked and smudged, the roof above the front right seat was smudged, and their was hair on the center dash cup holder and the steering column-mounted windshield wiper selector wand.

According to the case vehicle's driver (i.e., mother), immediately prior to the crash the front right passenger was seated upright with her back against the seat back, her feet hanging down, and both her hands in her lap. However, the exact position of the front right passenger's seat track and seat back are unknown since the driver is not sure and both were moved by the police while removing this passenger's seat belt. The driver believes that the seat track was located between its middle and forward-most positions with the seat back in the upright position.

The case vehicle's driver (37-year-old female) was seated in an upright posture with her back against the seat back, her left foot on the clutch, her right foot on the brake, and both hands on the steering wheel bracing herself. Her seat track was located in its forward-most position, the seat back was upright, and her tilt steering wheel was located in its up-most position (it should be noted that the driver didn't even know of this option). The case vehicle's driver [165 centimeters and 55 kilograms (65 inches, 122 pounds)] was not wearing her available, active, three-point, lap and shoulder belt. The driver was transported by ambulance to the hospital. She sustained moderate injuries and was treated and released. According to her interview and medical records, the injuries sustained by the case vehicle's driver included: a metatarsal fracture to her right foot, contusions to her right knee and left forearm, and abrasions to right chin and lips.

TRC/IU ON-SITE AIR BAG INVESTIGATION

TRC/IU CASE NO. IN97-014

VEHICLE - 1996 SUBARU IMPREZA
LOCATION - LOUISIANA

CRASH DATA

Location/Street:	City Street
State:	Louisiana
Area/Type:	Urban, commercial
Crash Date/Time:	May, 1997, @ 3:59 p.m.
Investigating Police Agency:	City police department
Crash Type:	Vehicle / Vehicle- Acute angle
Occupant Injury Severity (air bag vehicle):	Nonanatomic brain injury (AIS-5)

AMBIENT CONDITIONS

Light Conditions:	Daylight
Weather Condition:	Clear
Precipitation:	None
Road Surface:	Dry
Temperature:	82 degrees F (27.8 degrees C) @ nearest metropolitan airport

ROADWAY

	Case Vehicle	**Vehicle #2**	**Vehicle #3**
Location:	City street	City street	City street
Number of Travel Lanes:	Five-lanes, divided; southbound roadway had two through lanes	Five-lanes, divided; northbound roadway had two through lanes and one left-hand turn lane	Two-lanes, undivided
Lane width:	3.5 m (11.6 ft) for southbound, outside, through lane	3.6 m (11.9 ft) for northbound, left-hand turn lane	4.0 m (13.0 ft) for westbound lane
Surface Type:	Bituminous	Bituminous	Bituminous
Median:	10.2 m (33.7 ft)	10.2 m (33.7 ft)	None

ROADWAY (Continued)

	Case Vehicle	Vehicle #2	Vehicle #3
Shoulders:	None	None	None
Vertical alignment:	Level (0.7% positive to the north)	Level (0.4% negative to west)	Level (1.7% positive to east)
Horizontal alignment:	Straight	Straight	Straight
Estimated Coefficient of Friction:	.75	.70	.65
Traffic Density:	Moderate to heavy	Moderate to heavy	Moderate to heavy

TRAFFIC CONTROLS

	Case Vehicle	Vehicle #2	Vehicle #3
Signals:	None	None	None
Signs:	None	None	Stop sign
Markings:	Dashed white lines separating inside and outside through lanes; solid white edge line on outside lane; solid yellow line separating inside lane and median	Dashed white lines separating inside and outside through lanes; solid white edge line on outside lane; solid white line separating outside lane and turn lane; solid yellow line separating turn lane and median; white left turn arrow	None
Speed Limit:	64 km.p.h. (40 m.p.h.)	64 km.p.h. (40 m.p.h.)	56 km.p.h. (35 m.p.h.)

VEHICLES

	Case Vehicle	Vehicle #2	Vehicle #3
Year:	1996	1986	1997
Make:	Subaru	GMC	Mercedes Benz
Model:	Impreza	Sierra 1500, ½-ton, regular cab	E420
Body Type:	Two-door coupe; five-passengers	Two-door pick-up; three-passengers	Four-door sedan; five-passengers

VEHICLES (Continued)

	Case Vehicle	**Vehicle #2**	**Vehicle #3**
V.I.N.	JF1GM2255TG------	1GTDC14H8GF------	WDBJF72F2VA------
Color:	Dark blue	Light blue	Bronze
Mileage:	15,381 km (9,557 miles)	136,905 km (85,069 miles)	12,538 km (7,791 miles)
Engine:	1.8 liters, H-4	5.0 liters, V-8	4.2 liters, V-8
Transmission:	Five-speed manual	Four-speed manual	Five-speed automatic
Steering:	Power-assisted, rack-and-pinion	Power-assisted, worm and gear	Power-assisted, rack-and-pinion
Brakes:	Power-assisted, four-wheel disc	Power-assisted, hydraulic, front disc, rear drum	Power-assisted, four-wheel disc
Padding:	Steering wheel and hub, sun visors, dash, "A"-pillars, side door surfaces	Sun visors, dash, "A"-pillars, side door surfaces	Steering wheel and hub, sun visors, dash, "A"-pillars, side door surfaces
Active Restraints:	Three-point, manual, lap and shoulder belts in front and rear outboard seating positions; lap belt only at rear center position	Three-point, manual, lap and shoulder belts in front outboard seating positions; lap belt only at front center position	Three-point, manual, lap and shoulder belts in front and rear outboard seating positions; lap belt only at rear center position
Passive Restraints:	Factory installed driver and front right passenger supplemental restraint systems (air bags)	None	Factory installed driver and front right passenger and front and door mounted supplemental restraint systems (air bags)
Anti-lock Brakes:	No	No	Yes, four-wheel
Defects:	None	None	None
Fleet:	Private vehicle	Private vehicle	Private vehicle
Tow Status:	Towed due to damage	Towed due to damage	Towed, but not due to damage

VEHICLE DAMAGE

EXTERIOR	**Case Vehicle**	**Vehicle #2**
Deployment Impact		
Event number:	One	One
Object Struck:	Vehicle #2	Case vehicle
Damage location		
Damaged Plane:	Front	Right side
Vertical Location		
On Plane:	Front bumper	Above sill
Direct Begins:	Bumper corner to bumper corner	64.0 cm (25.2 in) behind right front axle
Length Direct:	147.0 cm (57.9 in)	251.0 cm (98.8 in)
Field L:	140.0 cm (55.1 in)	259.0 cm (102.0 in)
C_1:	0.5 cm (0.2 in)	0.0 cm (0.0 in)
C_2:	0.5 cm (0.2 in)	12.0 cm (4.7 in)
C_3:	0.5 cm (0.2 in)	4.0 cm (1.6 in)
C_4:	1.0 cm (0.4 in)	20.0 cm (7.9 in)
C_5:	2.0 cm (0.8 in)	16.0 cm (6.3 in)
C_6:	4.0 cm (1.6 in)	0.0 cm (0.0 in)
D:	0.0 cm (0.0 in)	-23.5 cm (9.3 in)
Maximum Crush:	4.0 cm (1.6 in)	25.0 cm (9.8 in)
Location:	C_6	Between C_4-C_5
CDC:	12-FDEW-1 (350)	02-RZEW-3 (60)
Damaged Components:	Front bumper, grille, hood, both front head-lights, right and left fenders	Right door and quarter panel

INTERIOR	**Case Vehicle**	**Vehicle #2**
Damaged Components:	Dual air bags, and windshield	None
Other Evidence of Occupant Contact:	Glove box, center in-trument panel, steering column-mounted wind-shield wiper selector wand	Not inspected
Manual Restraint System Failures:	None	Not inspected
Seat Performance Failures:	None	Not inspected
REPAIR		
Cost Estimate:	Unknown	Unknown

VEHICLE VELOCITY ESTIMATES

HIGHEST DELTA "V"	Case Vehicle	Vehicle #2
Reconstruction Program:	WinSMASH	WinSMASH
Program Algorithm:	Damage only	Damage only
Barrier Equivalent Delta V:	12.4 km.p.h. (7.7 m.p.h.)	14.5 km.p.h. (9.0 m.p.h.)
Total Delta "V":	16.6 km.p.h. (10.3 m.p.h.)	11.5 km.p.h. (7.1 m.p.h.)
Longitudinal Delta "V":	-16.4 km.p.h. (-10.2 m.p.h.)	-5.8 km.p.h. (-3.6 m.p.h.)
Lateral Delta "V":	+2.9 km.p.h. (+1.8 m.p.h.)	-10.0 km.p.h. (-6.2 m.p.h.)

COLLISION SEQUENCE

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

Figure 1: Case vehicle's travel path in outside north-bound lane; Note: deflection and final rest marks in "Tee" intersection (case photo #02)

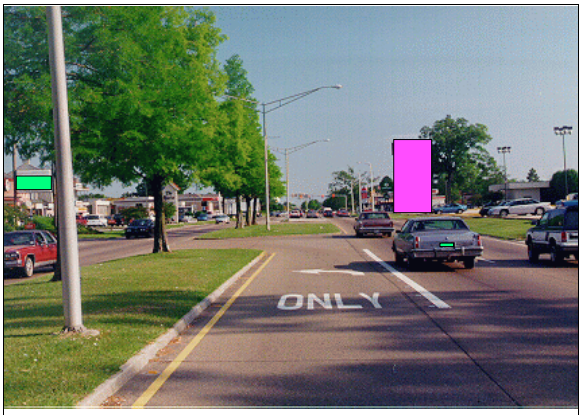

Figure 2: Vehicle #2's southward travel path in left-hand turn lane (case photo #06)

PRE-CRASH: The case vehicle (Impreza) was traveling north in the outside lane (**Figure 1**) of a five-lane, divided, city trafficway and intended to continue in its northward direction of travel (i.e., both the north and southbound roadways had two through lanes, while the southbound roadway had a left-hand turn lane). Vehicle #2 had been traveling south in the left-turn lane (**Figure 2**) of the southbound roadway and was making a left turn across the northbound roadway (**Figure 3** below), intending to travel east on an intersecting roadway. Vehicle #3 was stopped, heading west, in the westbound lane of the intersecting, two-lane, undivided, city street and was waiting to execute a left turn. In an attempt to avoid the crash, the case vehicle's driver tried to steer to the right and braked (with lock-up), leaving approximately 4.2 meters (14 feet) of a right tire skid, which negated her right steering maneuver. The case vehicle continued essentially straight ahead prior to impact. The driver of vehicle #2 made no pre-crash avoidance maneuvers and thus, vehicle #2 proceeded with its left turn prior to impact. The driver of vehicle #3 made no pre-crash avoidance maneuvers, and vehicle #3 remained at a stop prior to impact. The crash occurred in the southbound roadway of the "Tee" intersection of the two trafficways (**Figure 4** below).

COLLISION SEQUENCE (Continued)

Figure 3: West-northwestward view of vehicle #2's travel path from left-hand turn lane into impact; Note: case vehicle's final rest position heading southwest (case photo #09)

Figure 4: On-scene westward view from eastbound lane of all three vehicles at final rest; Note: case vehicle at left, vehicle #3 in center, and vehicle #2 toward right (case photo #12)

Figure 5: Case vehicle's frontal damage showing rightward shift of left front headlight and hood and hood's under riding interaction with right side of vehicle #2 (case photo #16)

Figure 6: Vehicle #2's right side damage viewed from front of right (case photo #60)

CRASH: The front of the case vehicle (**Figure 5**) impacted the right side of vehicle #2 (**Figure 6** and **Figure 7** below), causing both the driver and front right passenger supplemental restraint systems (air bags) to deploy (**Figure 8** below). The case vehicle, subsequently, rotated clockwise approximately 60 degrees after impact and came to rest in the outside lane, heading primarily east (**Figure 4**). Vehicle #2 was redirected east-northeastward after the impact with the case vehicle and contacted vehicle #3 which was still stopped waiting for traffic to clear. Vehicle #3's front left corner was impacted by the left side of vehicle #2 causing a toolbox and a bicycle in the bed (i.e., pickup) of vehicle #2 to be thrown onto and over the front hood of vehicle #3. Vehicle #2 came to rest on the east leg of the "Tee" intersection most likely heading southeast. The driver of vehicle #2 backed away (i.e., toward the northwest) 1.8-2.4 meters (6-8 feet) in an attempt to flee the scene. Vehicle #2 was found in the outside northbound lane, heading southeast. The front of Vehicle #3 rotated approximately 15 degrees counterclockwise, and vehicle #3 was moved a few feet eastward (i.e., backwards) as a result of the impact. Vehicle #3 came to rest heading west-southwest (**Figure 4**).

COLLISION SEQUENCE (Continued)

Figure 7: Vehicle #2's damaged right side viewed from back of right (case photo #63)

Figure 8: Case vehicle's front seating area showing deployed driver and front right passenger air bags (case photo #15)

POST-CRASH:

Occupants: Both the driver and front right passenger of the case vehicle remained inside the vehicle at final rest. The driver was conscious, and able to exit the case vehicle without any assistance. The front right passenger was unconscious and was unable because of her injuries to exit the case vehicle. Neither the case vehicle's driver nor the front right passenger were restrained by their available, active, three-point lap and shoulder belts (see discussion below under FRONT RIGHT PASSENGER KINEMATICS).

Both the driver and front right passenger of vehicle #2 remained inside their vehicle at final rest. Both were conscious, but they were unable to exit their vehicle due to both doors being jammed closed. Both the driver and front right passenger of vehicle #2 were restrained by their available, active, three-point lap and shoulder belts.

For vehicle #3, both the driver and rear right passenger remained inside the vehicle at final rest. Both were conscious, and the driver was able to exit the vehicle #3 without any assistance, while the rear right passenger (3-year-old female) required assistance because of her age. The driver was properly restrained by her available, active, three-point lap and shoulder belt, and the rear right passenger was secured in a child safety seat, properly restrained by the available, active, three-point lap and shoulder belt.

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

Rescue: The driver was transported by ambulance to a medical facility where she was treated and released. According to her interview and medical records, the case vehicle's driver sustained moderate injuries which included: a metatarsal fracture to her right foot, contusions to her right knee and left forearm, and abrasions to her right chin and lips.

COLLISION SEQUENCE (Continued)

POST-CRASH:

Rescue: Continued)

The front right passenger was transported by ambulance to a medical facility where she was pronounced dead 4 hours and 46 minutes post crash--survival did not extend beyond the emergency room. Based on her medical and autopsy records, the front right passenger sustained critical injuries, which included: a critical nonanatomic brain injury with subdural hematoma, cerebral edema, and massive subarachnoid hemorrhage; a dislocation to her first cervical vertebra; a laceration to her superior vena cava; bilateral corneal abrasions and retinal detachments; and multiple abrasions and contusions about her head, face, neck, chest, right arm, left elbow, knees, and left ankle.

The driver of vehicle #2 was transported directly to jail and charged with driving while intoxicated and vehicular homicide. According to the driver he was not treated by a physician, but had sustained a bump to the left side of his head, momentary unconsciousness, and a small cut on his back from flying glass. The front right passenger of vehicle #2 was transported to the hospital by ambulance but left the hospital prior to treatment. The driver and rear right passenger of vehicle #3 were not injured and subsequently were not treated.

Removal: Following the police investigation, all three vehicles were towed from the scene to a police garage; however, only vehicle #3 was drivable.

HUMAN FACTORS/OCCUPANT DATA

DRIVERS:	**Case Vehicle**	**Vehicle #2**	**Vehicle #3**
Age:	37-year-old	35-year-old	29-year-old
Sex:	Female	Male	Female
Height:	165 cm (65 in)	168 cm (66 in)	157 cm (62 in)
Weight:	55 kgs (122 lbs)	82 kgs (180 lbs)	48 kgs (105 lbs)
Occupation:	Housewife	Electricians aid	Housewife
Active Restraint System/Usage:	Three-point lap and shoulder/ Not used	Three-point lap and shoulder/ Used	Three-point lap and shoulder/ Used
Usage Source:	Vehicle inspection, Interviewee, and Police Crash Report	Vehicle inspection, Interviewee, and Police Crash Report	Vehicle inspection, Interviewee, and Police Crash Report
Passive Restraint System/Usage:	Factory installed air bag/air bag deployed	Not equipped	Factory installed air bags/air bags did not deploy

HUMAN FACTORS/OCCUPANT DATA (Continued)

DRIVERS:	**Case Vehicle**	**Vehicle #2**	**Vehicle #3**
Usage Source:	Vehicle inspection and Police Crash Report	Not applicable	Vehicle inspection, Interviewee, and Police Crash Report
Eyeglasses/contacts:	None	None	Contacts
Vehicle Familiarity:	14,484 km (9,000 mi) total	3,219 km (2,000 mi) total	12,538 km (7,791 mi) total
Route Familiarity:	Daily	Weekly	Twice weekly
Trip Plan:	Store to home	Relatives to drop off passenger	Tanning salon to home
Manner of Leaving Scene:	Ambulance	Police squad car	Husband picked up
Blood alcohol level:	Not tested	.22 mg/dl	Not tested
Type of Medical Treatment:	Treated and released	None	None

OTHER VEHICLE PASSENGERS:	**Case Vehicle Front Right Passenger**	**Vehicle #2 Front Right Passenger**	**Vehicle #3 Rear Right Passenger**
Age:	7-year-old	29-year-old	3-year-old
Sex:	Female	Male	Female
Height:	135 cm (53 in)	168 cm (66 in)	99 cm (39 in)
Weight:	22 kg (48 lbs)	77 kgs (170 lbs)	14 kgs (30 lbs)
Active Restraint System/Usage:	Three-point lap and shoulder/ Not used	Three-point lap and shoulder/ Used	Three-point lap and shoulder/ Used with child safety seat
Usage Source:	Vehicle inspection and Police Crash Report	Vehicle inspection, Interviewee, and Police Crash Report	Vehicle inspection, Interviewee, and Police Crash Report
Passive Restraint System/Usage:	Factory installed air bag/air bag deployed	Not equipped	Not equipped
Usage Source:	Vehicle inspection, Interviewee, and Police Crash Report	Not applicable	Not applicable

HUMAN FACTORS/OCCUPANT DATA (Continued)

OTHER VEHICLE PASSENGERS:	Case Vehicle Front Right Passenger	Vehicle #2 Front Right Passenger	Vehicle #3 Rear Right Passenger
Eyeglasses/contacts:	None	None	Not applicable
Manner of Leaving Scene:	Ambulance	Ambulance	Dad picked up
Type of Medical Treatment:	Treated but subsequently expired	None	None

CASE VEHICLE DRIVER INJURIES

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Fracture distal right fourth metatarsal	852200.2 moderate	Foot controls (i.e., brake or accelerator pedal)	Probable	Emergency room records
2	Abrasion, small, superficial, right lower jaw	290202.1 minor	Air bag, driver's	Certain	Emergency room records
3	Abrasion lips	290202.1 minor	Air bag, driver's	Certain	Interviewee (same person)
4	Contusion {bruise} left forearm	790402.1 minor	Air bag, driver's	Probable	Interviewee (same person)
5	Contusion {bruise} right knee	890402.1 minor	Steering column	Probable	Interviewee (same person)

CASE VEHICLE FRONT RIGHT PASSENGER INJURIES

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Nonanatomic brain injury, comatose, pupils fixed and dilated, flaccid, no response to painful stimuli	160824.5 critical	Air bag, front right passenger's	Certain	Emergency room records
2	Hematoma, subdural[1], small {shallow}, bilateral frontal lobes {bifrontal}	140654.5 critical	Air bag, front right passenger's	Certain	Emergency room records

[1] See the material on page 18 pertaining to subdural hematomas.

CASE VEHICLE FRONT RIGHT PASSENGER INJURIES (Continued)

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
3	Edema, cerebral, moderate {prominent} with compressed ventricles and basal cisterns[2]; third ventricle not identifiable [Aspect = Unknown][3]	140672.4 severe	Air bag, front right passenger's	Certain	Emergency room records
4	Hemorrhage, subarachnoid involving entire surface of cerebellum	140466.3 serious	Air bag, front right passenger's	Probable	Autopsy
5 6	Hemorrhage, subarachnoid, massive, diffuse, involving entire surface of brain including basal cisterns[4] along the tentorium[5] and interhemispheric fissures; hemorrhage in Sylvian fissure[5] and/or right temporal lobe	140684.3 140684.3 serious	Air bag, front right passenger's	Probable	Autopsy
7	Dislocation, atlanto-occipital (i.e., at first[6] cervical vertebrae)	650208.2 moderate	Air bag, front right passenger's	Certain	Autopsy

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[2] The following terms are defined in DORLAND'S ILLUSTRATED MEDICAL DICTIONARY as follows:
cistern (sis'tern): a closed space serving as a reservoir for fluid; see also *cisterna*.
basal c.: cisterna interpeduncularis.
c. of fossa of Sylvius: cisterna fossae lateralis cerebri.
interpeduncular c.: cisterna interpeduncularis.
c. of lateral fossa of cerebrum: cisterna fossae lateralis cerebri.

[3] Aspect "Unknown" is the best fit because while the first and second ventricles are "Right" or "Left", the third and fourth ventricles and basilar cisterns are centrally or inferiorly located in the brain.

[4] The following terms are defined in DORLAND'S ILLUSTRATED MEDICAL DICTIONARY as follows:
cisterna (sis-ter'na) **pl.** ***cister'nae***: a cistern -- a closed space serving as a reservoir for lymph or other body fluid, especially one of the enlarged subarachnoid spaces containing cerebrospinal fluid.
c. basa'lis: c. interpeduncularis.
c. fos'sae latera'lis ce'rebri: cistern of lateral fossa of cerebrum -- the space between the arachnoid and the lateral cerebral fossa; called also *c. fossae Sylvii*, and *cistern of fossa of Sylvius*.
c. fos'sae Syl'vii: c. fossae lateralis cerebri.
c. interpeduncula'ris: interpeduncular cistern -- a dilatation of the subarachnoid space between the cerebral peduncles; called also *basal cistern*.
cister'nae subarachnoidea'les: subarachnoidal cisterns -- localized enlargements of the subarachnoid space, occurring in areas where the dura mater and arachnoid do not closely follow the contour of the brain with its covering pia mater, and serving as a reservoirs of cerebrospinal fluid.

[5] The following terms are defined in DORLAND'S ILLUSTRATED MEDICAL DICTIONARY as follows:
fissure (fish'ur): any cleft or groove, normal or otherwise; especially a deep fold in the cerebral cortex which involves the entire thickness of the brain wall. Compare *sulcus*.
sulcus (sul'kas) pl. ***sul'ci (sul'si)***: a groove, trench, or furrow; a general term for such a depression, especially one of those on the surface of the brain, separating the gyri. Compare *fissure*.
tentorial (ten-tor'e-al): pertaining to the tentorium of the cerebellum.
tentorium (ten-tor'e-am): an anatomical part resembling a tent or a covering.
t. cerebel'li, t. of cerebellum: the process of dura mater that supports the occipital lobes and covers the cerebellum. Its internal border is free and bounds the tentorial notch; its external border is attached to the skull and encloses the transverse sinus behind.

[6] An atlanto-axial dislocation also fits this description, Using the AIS Uncertainty Rule, the atlanto-occipital lesion was chosen because it has the lower A.I.S. (i.e., "2" < "3"). It is unknown if there was any lesion to the spinal cord.

CASE VEHICLE FRONT RIGHT PASSENGER INJURIES (Continued)

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
8	Laceration, small, superior vena cava with associated bilateral hemothoraces (200 cc left, 100 cc right)	421804.3 serious	Air bag, front right passenger's	Probable	Autopsy
9 10	Abrasions to right and left corneas	240602.1 240602.1 minor	Air bag, front right passenger's	Certain	Emergency room records
11 12	Detachment of right and left retinas	241002.2 241002.2 moderate	Air bag, front right passenger's	Certain	Emergency room records
13	Contusion underlying scalp (most likely subgaleal) from left forehead to top of head	190402.1 minor	Windshield	Probable	Autopsy
14	Abrasions right cheek	290202.1 minor	Air bag, front right passenger's	Certain	Autopsy
15 16 17	Contusions {bruises} right and left cheeks, right lower lip, and left side of mouth	290402.1 290402.1 290402.1 minor	Air bag, front right passenger's	Certain	Autopsy
18	Abrasions right, left, and anterior neck (i.e., ear to ear)	390202.1 minor	Air bag, front right passenger's	Certain	Autopsy
19	Contusion {hematoma} right, left, and anterior neck with extreme swelling	390402.1 minor	Air bag, front right passenger's	Certain	Autopsy
20	Abrasions, superficial, oblique, from right shoulder to left nipple and anterior upper chest	490202.1 minor	Air bag, front right passenger's	Certain	Autopsy
21	Contusion from right shoulder extending across chest and into left chest	490402.1 minor	Air bag, front right passenger's	Certain	Autopsy
22	Abrasions right arm	790202.1 minor	Air bag, front right passenger's	Certain	Interviewee (driver)
23	Contusion right upper arm and proximal forearm	790402.1 minor	Air bag, front right passenger's	Certain	Autopsy
24	Contusion {hematoma} on knuckles of right hand	790402.1 minor	Right instrument panel	Probable	Autopsy
25	Contusions (2 hematomas}, left elbow	790402.1 minor	Center console	Possible	Autopsy
26	Abrasions bilateral knees	890202.1 minor	Glove box	Certain	Interviewee (driver)

CASE VEHICLE FRONT RIGHT PASSENGER INJURIES (Continued)

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
27	Contusions bilateral knees, two on right, one on left	890402.1 minor	Glove box	Certain	Autopsy
28	Contusion {hematoma} left ankle	890402.1 minor	Right instrument panel and below	Probable	Autopsy

CASE VEHICLE DRIVER KINEMATICS

The following is based on this investigators on-site investigation, interviews with involved persons and occupant kinematic principles.

Immediately prior to the crash she was seated upright with her back against the seat back, her left foot on the clutch, her right foot on the brake, and both hands on the steering wheel, bracing for the impending crash. According to the case vehicle's driver, her seat track was located in its forward-most position, and the tilt steering wheel was located in its up-most position. According to the vehicle inspection, the location of the driver's seat track is unknown because it was moved prior to this investigator's inspection; however, the tilt steering wheel was located in the up-most position. According to the vehicle inspection and the driver's interview, she was not wearing her available, active, three-point, lap and shoulder belt.

The case vehicle's driver tried to steer right and braked (with lock-up which negated her right steering maneuver), attempting to avoid the crash. Based on the police investigation, the case vehicle went essentially straight ahead. As a result of these attempted avoidance maneuvers and the nonuse of her available safety belts and the fact that she was bracing (i.e., feet on floor, both hands on steering wheel), she most likely moved forward and very slightly to her left, just prior to impact.

Based on the vehicle inspection and occupant kinematic principles, the case vehicle's primary impact with vehicle #2, not only deployed the driver's air bag, but thrust the driver forward and slightly leftward toward the 350 degree Direction of Principal Force.

Figure 9: Case vehicle's driver air bag showing contact to upper center front of air bag and blood drops on bottom center (case photo 28)

An inspection of the driver's air bag revealed evidence of contact to the upper center portion of the air bag (**Figure 9**). There was no evidence of contact to the driver air bag module's cover flap. The deploying air bag contacted the driver in the face and forearms knocking her back and to the left into her seat back as the case vehicle rotated clockwise to final rest. The driver's face and arm contact with the air bag caused her facial abrasions (lip and chin) and left forearm abrasion.

CASE VEHICLE DRIVER KINEMATICS (Continued)

At final rest the driver could not recall her exact seating position, but based on occupant kinematic principles, she most likely would have been seated toward the farthest left side of her bucket seat against her door.

CASE VEHICLE PASSENGER KINEMATICS

The following is based on this investigator's on-site investigation, interviews with involved persons and occupant kinematic principles.

Figure 10: Case vehicle's cracked right windshield and deformed front right air bag module's cover flap (case photo #40)

According to the case vehicle's driver (i.e., mother), immediately prior to the crash the front right passenger was seated upright with her back against the seat back, her feet hanging out over the seat cushion, and both arms on her sides. The exact position of the front right passenger's seat track and seat back are unknown since the driver is not sure and both were moved by the police while removing this passenger's seat belt. The driver believes that the seat track was located between its middle and forward-most positions with the seat back in the upright position. The case vehicle's driver is adamant that her daughter was restrained by her available, active, three-point, lap and shoulder belt; however, the physical evidence refutes this allegation. No evidence of loading was found on the front right safety belt, "D"-ring, latch plate, or ratchet assembly. The front right passenger air bag module's cover flap was deformed (**Figure 10**) by the expanding air bag because the bag's excursion was initially limited by the front right passenger's upper torso and neck. In addition, the front right passenger's head contacted and cracked the windshield and deposited a smudge on the roof.

Figure 11: Close-up on contacts on case vehicle's glove box from front right passenger's knees (case photo #46)

As a result of the case vehicle's attempted avoidance maneuvers (i.e., steering right and braking) and the nonuse of her available safety belts, the front right passenger moved forward and slightly leftward toward the 350 degree Direction of Principal Force just prior to impact. In addition, according to the case vehicle's driver, the last thing the front passenger said was "**Oh no**!" This indicates that (1) she saw the impending crash with vehicle #2, which was coming across the case vehicle's front from left-to-right, and (2) she had her head and torso turned leftward just prior to impact. This is consistent with the greater severity of injury to the front right passenger's right chest and right arm.

CASE VEHICLE FRONT RIGHT PASSENGER KINEMATICS (Continued)

Figure 12: Case vehicle's front right passenger air bag (case photo #34)

Figure 13: Close-up of case vehicle's front right passenger air bag showing skin deposits (case photo #35)

The case vehicle's primary impact with vehicle #2, not only deployed the front right passenger air bag, but lifted the front right passenger forward and slightly leftward enabling her knees to impact the glove box (**Figure 11** above). An inspection of the front right passenger's air bag revealed a wide area of contact evidence (i.e., skin and grease smears) on the top and front portion of the air bag (**Figures 12** and **13**). There was no evidence of contact on the air bag module's cover flap; although, the flap was deformed by the deploying air bag (**Figure 10** above). As indicated above, the air bag's deployment lifted her upwards into the windshield, starring it (**Figure 10** above) with her left upper forehead and scalp and pushing her against the windshield depositing an upward grease smear. As the air bag continued to expand, the front right passenger was propelled backward and slightly upward where she most likely contacted the roof over the front right seat (**Figure 14**). She continued rearward until her movement was stopped by the front right seat back.

Figure 14: Case vehicle's windshield and roof showing front right passenger's head contact to roof, above front right seat, rearward of header and sun visor (case photo #49)

During the front right passenger's rearward movement, the case vehicle rotated clockwise as a result of the impact. However, maximum engagement did not occur until after the case vehicle had underriden vehicle #2's left side. The air bag most likely began deploying at the moment of impact.

After impacting the seat back the front right passenger most likely rebounded forward toward the center instrument panel which had by now rotated in front of her. In addition, she contacted the center dash cup holder and steering column-mounted windshield wiper selector wand (**Figure 15** below) leaving hair deposits.

CASE VEHICLE FRONT RIGHT PASSENGER KINEMATICS (Continued)

According to the case vehicle's driver, during the crash she had her head turned to the right and witnessed the deploying air bag "pin" the front right passenger (i.e., her daughter) against the seat back. This investigator discounted this story because she was too busy attempting to avoid the crash to have noticed.

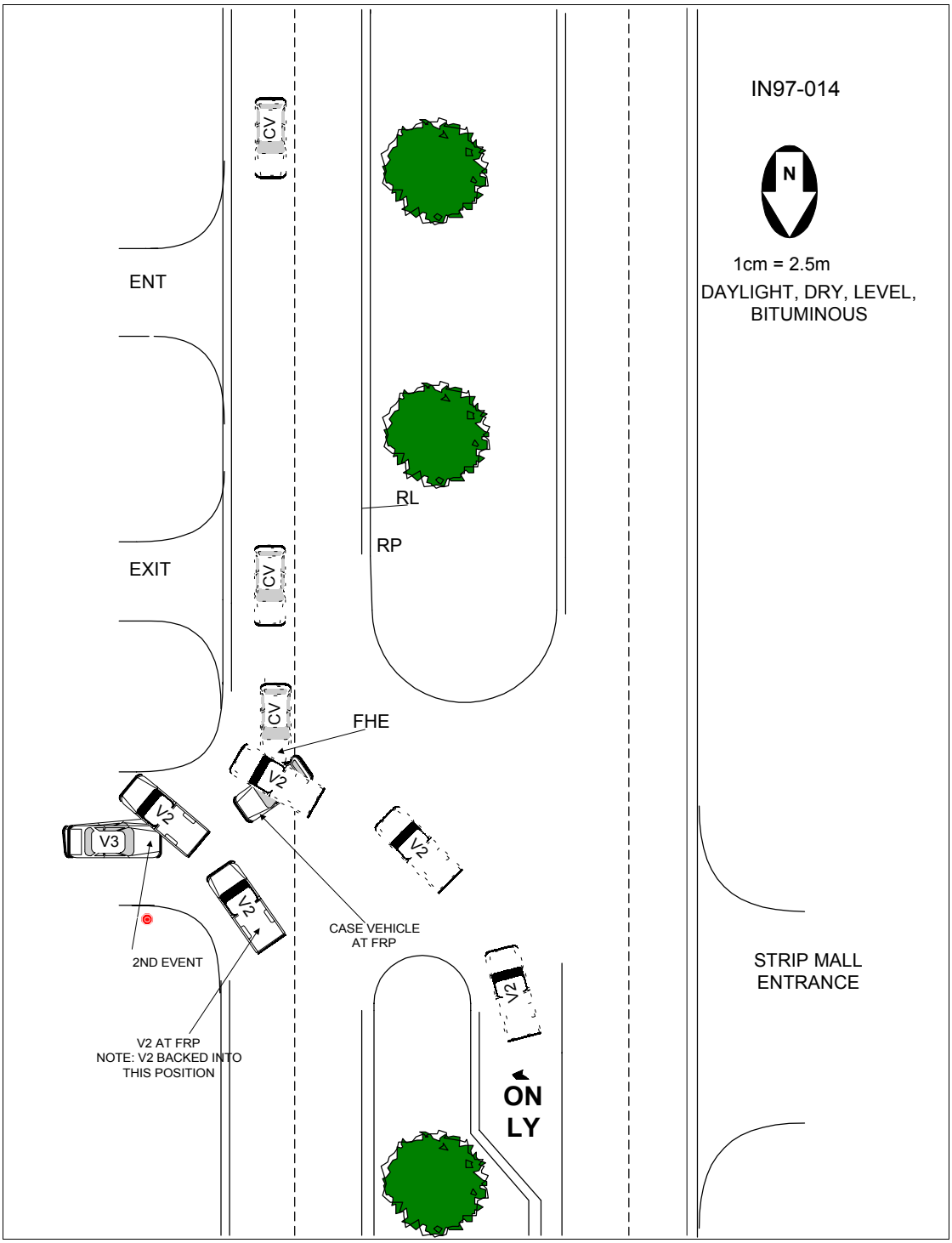
According to the driver, at final rest the front right passenger was slumped forward over her seat belt with the air bag partially on top of her head. Based on the contact evidence previously mentioned, the front right passenger was most likely laying on her left side with her lower torso on the seat cushion and her upper torso over the center console or possibly on the driver's right leg. She very well may have had the deflated air bag on top of her lower torso.

Figure 15: Close-up of contacts to case vehicle's center instrument panel and windshield wiper wand; Note: clump of front right passenger's hair in center instrument panel (case photo #43)

CASE VEHICLE AIR BAG SYSTEM

	DRIVER AIR BAG	FRONT RIGHT AIR BAG
Air Bag Diameter (seam-to-seam, deflated):	Width: 68 cm (26.8 in) Height: 65 cm (25.6 in)	Width: 53 cm (20.9 in) Height: 63 cm (24.8 in)
Number of Vent Holes:	Two	One
Vent Hole Diameter:	3 cm (1.2 in)	5 cm (2 in)
Vent Hole Clock Positions:	Approximately 10 and 2 o'clock	Not applicable
Number of Air Bag Tethers:	Two	None
Number of Air Bag Module Cover Flaps:	Two	One
Upper Cover Flap Dimensions:	Width: 16 cm (6.3 in) Height: 7 cm (2.8 in)	Width: 32 cm (12.6 in) Height: 16 cm (6.3 in)
Lower Cover Flap Dimensions:	Width: 15 cm (5.9 in) Height: 7 cm (2.8 in)	Not applicable
Distance between Dash and leading (i.e., closest) edge of Module's Cover Flap:	Not applicable	5 cm (2 in)
Mount Location:	Steering wheel hub	Top instrument panel
Generant Residue:	No unusual amount found	No unusual amount found

CRASH DIAGRAM



SUBDURAL HEMATOMAS

The following material is taken from the book: FORENSIC PATHOLOGY by Dominick J. DiMaio and Vincent J.M. DiMaio, CRC Press, Ann Arbor, 1993; Chapter Six: Trauma to the Skull and Brain: Craniocerebral Injuries, ***Impact Injuries***, pages 139 and 156, 158-161.

Acceleration/deceleration injuries are due to sudden movement of the head the instant after injury with resultant production of intracranial pressure gradients and the subjecting of the brain to both shearing and tensile forces. Two types of injuries are typically produced:

1. Subdural hematomas
2. Diffuse axonal injury

Subdural hematomas are secondary to tearing of the subdural bridging veins; diffuse axonal injury is secondary to injury to the axons. While in most instances, acceleration/deceleration injuries are associated with impact, impact is, strictly speaking, not necessary for the production of these injuries, just sudden angular rotation of the head.

Subdural Hematomas

The subdural hematoma is the most common lethal injury associated with head trauma. The high mortality associated with subdural hematomas is due in part to associated brain damage. Since a large number of the subdural hematomas are due to falls, it is not uncommon to find contrecoup contusions in association with subdural hematomas. Unlike epidural hematomas, subdural hematomas are often not associated with a fracture of the skull and may occur in the absence of cerebral contusions or any other visible brain injury....

Subdural hematomas can be acute, subacute, or chronic. Acute subdural hematomas manifest themselves clinically within 72 hours of injury, subacute in between 3 days and 2-3 weeks, and chronic over 3 weeks after injury. Subdural hematomas are caused by the stretching and tearing of the parasagittal bridging veins that drain the surface of the cerebral hemispheres into the dural venous sinuses. These injuries occur after the head impacts a hard surface and the brain is accelerated. This rapid acceleration causes the tearing of the bridging veins. The more rapid the acceleration and the shorter the time of acceleration, the more likely one will have a subdural hematoma rather than diffuse axonal injury. The reason that subdural hematomas are less common in motor vehicle accidents, in contrast to diffuse axonal injury, is that in a motor vehicle accident, the head typically strikes a yielding or energy-absorbing surface, thus extending the time interval in which the acceleration/deceleration occurs. This reduces the probability of a subdural hematoma occurring, because it requires a large acceleration over a short time. It does, however, predispose the brain to diffuse axonal injury.

In subdural hematomas, the onset of symptoms is usually rapid. ...Rapid development of a subdural hematoma with mass displacement of the brain with or without generalized cerebral edema may result in compression of the brain stem and development of secondary brain hemorrhage. These may develop in as little as 30 minutes after trauma.

In subdural hematomas, the blood presses on both the crests and depths of the gyri so that the cerebral convolutions retain their normal contours. The hematoma, however, causes displacement of the cerebral hemispheres with flattening of the convolutions of the opposite hemisphere as they are pressed against the dura and bone....