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ON-SITE AIR BAG FATALITY INVESTIGATION

CASE NUMBER - IN97-019
LOCATION - FLORIDA
VEHICLE - 1994 BUICK CENTURY SPECIAL
CRASH DATE - January, 1997

Submitted:

March 11, 1999

Revised Submission:

March 13, 2000

Contract Number: DTNH22-94-D-17058

Prepared for:

U.S. Department of Transportation
National Highway Traffic Safety Administration
National Center for Statistics and Analysis
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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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16. *Abstract* This report covers an on-site investigation of an air bag deployment crash that involved a 1994 Buick Century Special (case vehicle) and a 1997 Mercury Grand Marquis LS (vehicle #2). This crash is of special interest because the case vehicle's unrestrained driver (56-year-old female) sustained a lacerated aorta as a result of contacting her driver air bag module's lower cover flap and deploying driver air bag. The case vehicle was traveling south in a left-hand curve in the inside through lane of a six-lane, divided U.S. trafficway (i.e., the north and south roadways each had two through lanes, while the southbound roadway also had both right-hand and left-hand turn lanes). Vehicle #2 was traveling east in the eastbound lane of an intersecting, two-lane, undivided, county road and was attempting to cross the southbound roadway and turn left and travel north on the northbound roadway. The crash occurred in the inside southbound through lane of the four-leg intersection of the two trafficways. The front of the case vehicle impacted the left side of vehicle #2, causing the case vehicle's driver supplemental restraint system (air bag) to deploy. After impacting vehicle #2, the case vehicle continued south-southeastward [still in contact with vehicle #2, for an additional 14 meters (45 feet)] along the curving inside southbound through lane where it came to rest in its original lane heading south-southeast. Vehicle #2 rotated approximately 80 degrees counterclockwise while being pushed southward by the case vehicle. Vehicle #2 came to rest in the intersection heading north. The case vehicle's driver was seated with her seat track located in its middle position, and the steering wheel was located in its middle position. She was not wearing her available, passive, three-point, lap and shoulder belt and sustained, according to her autopsy, fatal chest injuries which included: a major laceration to her aorta (with hemorrhage not confined to her mediastinum), multiple bilateral rib fractures, and a fractured sternum. These injuries resulted from her impacting her air bag module's cover flaps and air bag. In addition, she sustained multiple abrasions and contusions to her head, neck, and upper torso.			
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TABLE OF CONTENTS

BACKGROUND

IN97-019

This on-site investigation was brought to NHTSA's attention on May 23, 1997 by an accident reconstructionist employed by a law firm that is representing the family of the deceased case vehicle's driver. This crash involved a 1994 Buick Century Special (case vehicle) and a 1997 Mercury Grand Marquis LS (vehicle #2). The crash occurred in January, 1997, at 12:45 p.m., in Florida and was investigated by the applicable state police agency. This crash is of special interest because the case vehicle's unrestrained driver (56-year-old female) sustained a lacerated aorta as a result of contacting her driver air bag module's lower cover flap and deploying driver air bag. This contractor inspected the scene and case vehicle on July 7, 1997. Vehicle #2 had already been repaired and, thus, was not inspected. The son of the case vehicle's driver was interviewed on July 7, 1997 and, again, on February 5, 1999. Vehicle #2's driver was interviewed on February 2, 1999. This summary is based on the Police Crash Report, a conversation with the investigating police officer, interviews with the son of the case vehicle's driver and the driver of vehicle #2, inspections of the scene and the case vehicle, occupant kinematic principles, the autopsy of the case vehicle's driver, and this contractor's evaluation of the evidence.

SUMMARY

The case vehicle was traveling south in a left-hand curve in the inside through lane of a six-lane, divided U.S. trafficway and intended to continue its southbound path of travel (i.e., the north and south roadways each had two through lanes, while the southbound roadway also had both right-hand and left-hand turn lanes). Vehicle #2 was traveling east in the eastbound lane of an intersecting, two-lane, undivided, county road and was attempting to cross the southbound roadway and turn left and travel north on the northbound roadway. The case vehicle's driver made no avoidance maneuvers prior to the crash. The crash occurred in the inside southbound through lane of the four-leg intersection of the two trafficways.

The front of the case vehicle impacted the left side of vehicle #2, causing the case vehicle's driver supplemental restraint system (air bag) to deploy. The case vehicle continued south-southeastward along the curving inside southbound through lane where it came to rest in its original lane heading south-southeast. Vehicle #2 rotated approximately 80 degrees counterclockwise while being pushed southward by the case vehicle. Vehicle #2 came to rest in the intersection heading north.

The case vehicle's driver [163 centimeters and 64 kilograms (64 inches, 142 pounds)] was not wearing her available, automatic (passive), three-point, lap and shoulder belt. In addition, there was no evidence of belt pattern bruising and/or abrasions to the driver's body, and the inspection of the driver's seat belt webbing and latch plate showed no evidence of loading.

The case vehicle's driver made no known pre-crash avoidance maneuvers. As a result and independent of the nonuse of her available safety belts, her pre-impact body position did not change just prior to impact. Based on the vehicle inspection and occupant kinematic principles, the case vehicle's impact with vehicle #2, not only deployed the driver's air bag, but thrust the driver forward and slightly rightward toward the +10 degree direction of principal force (PDOF). Because of the driver's short stature (see above), she was positioned within or close to the excursion limits of the air bag prior to impact. As a result of her position and the nonuse of her safety belts, the case

vehicle's driver was contacted in the upper center chest by the driver air bag module's cover flaps, specifically the lower cover flap because a greenish tint was deposited by her clothing. In addition she was contacted in the upper and central chest and neck by the deploying air bag. As the momentum of the case vehicle's driver loaded the steering wheel and column, her chest also loaded the steering wheel rim. As the air bag continued to expand, the case vehicle's driver was lifted upwards into the driver's sun visor where her head contacted and deposited skin and hair as she scuffed the driver's sun visor before being knocked back into her seat back. The driver then rebounded back forward into the steering wheel as the two vehicles remained in contact with each other to their respective final rest positions. It should also be noted that the steering column was moved inward approximately 2 centimeters (0.8 inches). At final rest, the driver was found unbelted and slumped forward over the steering wheel.

The case vehicle's driver was transported by ambulance to the hospital. She sustained fatal injuries and, according to her autopsy, was pronounced dead 79 minutes post-crash. The injuries sustained by the case vehicle's driver included: a major laceration to her aorta (with hemorrhage not confined to her mediastinum), multiple bilateral rib fractures, a fractured sternum, abrasions and contusions to her forehead, anterior neck abrasions, contusions to her whole chest and left anterior shoulder, abrasions to her middle chest and upper abdomen, and contusions to her right upper back and posterior right upper arm.

The case vehicle was a front wheel drive 1994 Buick Century Special, four-door sedan (VIN: 1G4AG55M9R6------). The case vehicle was equipped with four-wheel, anti-lock brakes. Vehicle #2 is a rear wheel drive 1997 Mercury Grand Marquis LS, four-door sedan (VIN: 2MELM75W1VX------). Both vehicles were towed from the scene due to damage. Based on the vehicle inspection, the CDC for the case vehicle is: **12-FDEW-1 (+10)** [maximum crush at C_6 was 16 centimeters (6.3 inches)]. Based on police photographs, the CDC for vehicle #2 was estimated as: **09-LPEW-2 (+260)**. The WinSMASH reconstruction program, missing vehicle algorithm, was used on the highest severity impact to the case vehicle. The preliminary Total, Longitudinal, and Lateral Delta Vs are, respectively: 19.0 km.p.h. (11.8 m.p.h.), -18.7 km.p.h. (-11.6 m.p.h.), and -3.3 km.p.h. (-2.1 m.p.h.).

The case vehicle was equipped with a supplemental restraint system (SRS) that consisted of a frontal air bag at the driver's position only. The driver air bag was located in the steering wheel hub. An inspection of the air bag module's cover flaps and air bag 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. The driver's air bag was designed without any tethers, and the driver's air bag had two vent ports, approximately 2.0 centimeters (0.8 inches) in diameter, located at the 3 and 9 o'clock positions. The deployed driver's air bag was oblong, measuring 65 centimeters (25.6 inches) wide and 57 centimeters (22.4 inches) high. There was what appeared to be skin, cloth transfers, and some unknown body fluid on the driver's air bag. Furthermore, there was cloth transfers on the driver air bag module's lower cover flap and striations and possible cloth transfers on the upper cover flap. There was skin and hair scuffing on the driver's sun visor, a skin transfer on the left "A"-pillar, and a scuff on the lower left instrument panel of the case vehicle.

The exact posture of the case vehicle's driver is unknown; although, based on her normal seating position, she was most likely sitting upright, with her back against the seat back, her left foot on the floor, her right foot either on the accelerator pedal or moving towards the brake pedal, and both hands on the steering wheel. The vehicle inspection showed that her seat track was located in its middle position, her seat back in the upright position, and the tilt steering wheel was located in its middle position.

CRASH CIRCUMSTANCES

The case vehicle was traveling south in a left-hand curve in the inside through lane of a six-lane, divided U.S. trafficway (**Figure 1**) and intended to continue its southbound path of travel through an approaching four-leg intersection (i.e., the north and south roadways each had two through lanes, while the southbound roadway also had both right-hand and left-hand turn lanes). Vehicle #2 was traveling east in the eastbound lane of an intersecting, two-lane, undivided, county road and was attempting to cross the southbound roadway and turn left and travel north on the northbound roadway. The ambient conditions were daylight, cloudy, no precipitation, and no view obstructions.

Figure 1: On-scene view of case vehicle's southward travel path in inside southbound lane; Note: case vehicle and vehicle #2 at respective final rest positions (case photo #02)

The southbound lanes were bituminous, traveled and worn, with an estimated dry coefficient of friction of 0.70%. The roadway had a 4.0% negative grade to the south and was gently curved to the left with a radius of 1,727 meters (5,665 feet). The two through lanes were divided by a single broken white centerline, with raised pavement markers, and bordered by single solid white edge lines. The right (west) turn lane was bordered by alternating, intersecting driveways and firm, grassy shoulders. The left (east) turn lane abutted a grass median [7 meters (23 feet) wide, narrowing near the intersection]. There were posted speed limit signs [80 km.p.h. (50 m.p.h.)]. The surrounding area was primarily commercial, with some undeveloped areas.

The pavement on the west leg of the intersection was bituminous, traveled and worn, with an estimated dry coefficient of friction of 0.70%. The roadway had a 2.0% grade positive to the east and contained a severe curve left with a 12.2 meter (40 foot) radius immediately west of the intersection's mouth. The lanes of the county roadway were divided by a double solid yellow centerline, with raised pavement markers, and bordered by single solid white edge lines. The pavement was bordered by firm, grassy shoulders. Speed limit signs of 48 km.p.h. (30 m.p.h.) were posted for this roadway.

Vehicle #2 had stopped at the four-leg intersection before crossing the southbound roadway to make its left turn. There was no documented scene evidence nor law enforcement narrative indicating the case vehicle's driver attempted any avoidance maneuvers. The crash occurred in the inside southbound through lane of the four-leg intersection of the two trafficways.

The front of the case vehicle (**Figure 2**) impacted the left side of vehicle #2 (**Figure 3**), causing the case vehicle's driver supplemental restraint system (air bag) to deploy. After impacting vehicle #2, the case vehicle continued south-southeastward along the curving inside southbound through lane where it came to rest, still in contact with vehicle #2, in its original lane heading south-southeast. The case vehicle traveled an additional 13.7 meters (45 feet) from impact to final rest. Vehicle #2, meanwhile, rotated approximately 80 degrees counterclockwise while being pushed southward by the case vehicle. Vehicle #2 came to rest in the intersection heading north (**Figure 4**). The case vehicle and vehicle #2 were both towed due to disabling damage.

Figure 2: Case vehicle's frontal damage; Note: damage above bumper is primarily to right (case photo #07)

Figure 3: On-scene view from vehicle #2's eastward travel path showing case vehicle (at left) and vehi-cle #2 (at right) at respective final rest positions; Note: vehicle #2 rotated approximately 80 degrees counterclockwise to final rest (case photo #05)

Figure 4: On-scene close-up of case vehicle (fore-round) and vehicle #2 (background) at final rest near inside southbound lane (case photo #03)

CASE VEHICLE

The case vehicle was a front wheel drive, 1994 Buick Century Special, six-passenger, four-door sedan (VIN: 1G4AG55M9R6------) equipped with a 3.1 liter, SFI, OHV, V-6, 12-valve gasoline engine and a three-speed automatic transmission, with overdrive. Braking was achieved by power-assisted, four-wheel disc brakes equipped with a four-wheel, anti-lock system. The case vehicle's wheel base was 266 centimeter (104.9 inches), and the odometer reading at inspection was 92,992 kilometers (57,784 miles).

The case vehicle's interior contained a front, split bench seat with separate back cushions and adjustable head restraints at the outboard positions. The automatic transmission's selection lever was mounted on the right side of the steering column. General Motors's door-mounted, automatic (passive), three-point, lap and shoulder belt system was present and not in use on either front door.

There was a center lap belt in the front and rear seats and active, three-point, lap and shoulder belts at the rear outboard seating positions. None of the outboard seating positions were equipped with shoulder belt upper anchorage adjusters. The rear seat was a forward facing, nonadjustable, bench seat. A rigid plastic knee bolster was present on the driver's side and was slightly deformed from occupant contact, located to the left of the steering column.

VEHICLE DAMAGE

The front of the case vehicle impacted the left side of vehicle #2 and involved the entire 162 centimeter (63.8 inch) undeformed end width. Direct contact damage to the case vehicle included the hood's front edge, the front fascia, the grille, the front right headlamp assembly, the front right and front left turn signals and side markers, and the front bumper. The maximum crush, 16 centimeters (6.3 inches), was located at C_6. Indirect damage was sustained by the right fender. The CDC for the case vehicle was determined to be: **12-FDEW-1 (+10 degrees)**. The WinSMASH reconstruction program, missing vehicle algorithm, was used on the case vehicle's highest severity impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 19.0 km.p.h. (11.8 m.p.h.), -18.7 km.p.h. (-11.6 m.p.h.), and -3.3 km.p.h. (-2.1 m.p.h.). Neither the right or left front tire was displaced, and there was no evidence of intrusion to the case vehicle's interior.

An examination of the case vehicle's interior revealed evidence of skin and hair scuffing to the front left sun visor, slight deformation to the top of the steering wheel rim, skin transfer to the left upper "A" pillar, scuffing on the left lower instrument panel to the left of the steering column, cloth transfers to both the upper and lower cover flaps of the driver's air bag module, and skin and cloth transfers to the air bag fabric.

AUTOMATIC RESTRAINT SYSTEM

The case vehicle was equipped with General Motors's door-mounted, automatic (passive), three-point, lap and shoulder belt system. Neither front outboard safety belt was in use (i.e., the latch plate tongues were not engaged in the inboard buckle mechanisms). In addition to the automatic belt system, the case vehicle was equipped with a Supplemental Restraint System (SRS) that consisted of a front air bag at the driver's position only. The air bag deployed as a result of the case vehicle's frontal impact with the left side of vehicle #2. This air bag was mounted in the steering wheel hub, and the air bag module's cover flaps were in a symmetrical "H"-configuration, with dimensions of 20 centimeters (7.9 inches) at the horizontal seams and 7 centimeters (2.8 inches) at the vertical seams. An inspection of the air bag module's cover flaps and air bag 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. The driver's air bag was designed without tethers, and the driver's air bag had two vent ports, approximately 2.0 centimeters (0.8 inches) in diameter, located at the 3 and 9 o'clock positions. The deployed driver's air bag was oblong, measuring 65 centimeters (25.6 inches) wide and 57 centimeters (22.4 inches) high.

Inspection of the driver's air bag revealed what appeared to be skin, cloth transfers, and some unknown body fluid on the driver's air bag. Specifically, a long, green, cloth transfer (**Figure 5**) was noted in the upper left quadrant beginning on the center vertical axis and 15 centimeters (6 inches) up from the center horizontal axis. This transfer ended 18 centimeters (7.1 inches) to the left of center and 23 centimeters (9.1 inches) up from the horizontal axis. Also noted in the upper left quadrant was a possible skin transfer, approximately 4 centimeters (1.6 inches) left of the vertical center and 8 centimeters (3.1 inches) above the center horizontal axis. Finally, another skin transfer and a brown foreign substance were noted in the lower right quadrant, 1.3 centimeters (0.5 inches) left of center and 10 centimeters (3.9 inches) below the horizontal axis.

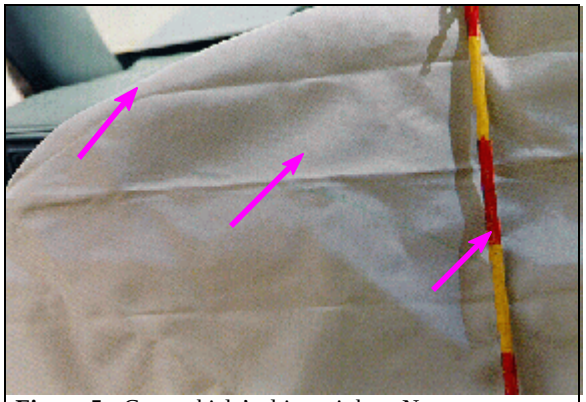


Figure 5: Case vehicle's driver air bag; Note: green cloth transfer from top of bottom yellow mark towards top left corner (case photo #19)

Figure 6: Case vehicle driver air bag module's lower cover flap; Note: green cloth transfer to flap (case photo #22)

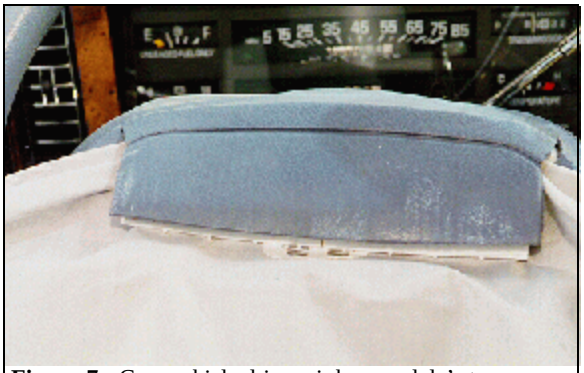


Figure 7: Case vehicle driver air bag module's top cover flap; Note: vertical upward striations on flap (case photo #21)

Furthermore, there were green cloth transfers on the driver air bag module's lower cover flap, with the heaviest transfers to the flap's left side (**Figure 6**), and striations and faint green cloth transfers on the upper cover flap (**Figure 7**). There was skin and hair scuffing on the driver's sun visor (**Figure 8** below), a skin transfer on the left "A"-pillar, and a scuff on the lower left instrument panel of the case vehicle.

CASE VEHICLE DRIVER KINEMATICS

The case vehicle's driver [56-year-old female; 163 centimeters and 64 kilograms (64 inches, 142 pounds)] was not wearing her available, automatic (passive), three-point, lap and shoulder belt. In addition, there was no evidence of belt pattern bruising and/or abrasions to the driver's body, and the inspection of the driver's seat belt webbing and latch plate showed no evidence of loading.

The exact posture of the case vehicle's driver is unknown; although, based on her normal seating position, she was most likely sitting upright, with her back against the seat back, her left foot on the floor, her right foot either on the accelerator pedal or moving towards the brake pedal, and both hands on the steering wheel. The vehicle inspection showed that her seat track was located in its middle position, her seat back in the upright position, and the tilt steering wheel was located in its middle position.

Figure 8: Case vehicle's front seating area showing deployed driver air bag, top cover flap, and contact to driver's sun visor (case photo #26)

The case vehicle's driver made no known pre-crash avoidance maneuvers. As a result and independent of the nonuse of her available safety belts, her pre-impact body position did not change just prior to impact. Based on the vehicle inspection and occupant kinematic principles, the case vehicle's impact with vehicle #2, not only deployed the driver's air bag, but thrust the driver forward and slightly rightward toward the +10 degree direction of principal force (PDOF). Because of the driver's short stature (see above), she was positioned within or close to the excursion limits of the air bag prior to impact (**Figure 9**). As a result of her position and the nonuse of her safety belts, the case vehicle's driver was contacted in the upper center chest by the driver air bag module's cover flaps, specifically the lower cover flap because a greenish tint was deposited by her clothing (**Figure 6** above). In addition, she was contacted in the upper and central chest and neck by the deploying air bag. As the momentum of the case vehicle's driver loaded the steering wheel and column, her chest also loaded the steering wheel rim. As the air bag continued to expand, the case vehicle's driver was lifted upwards into the driver's sun visor where her head contacted and deposited skin and hair as she scuffed the driver's sun visor (**Figure 8**) before being knocked back into her seat back. The driver then rebounded back forward into the steering wheel as the two vehicles remained in contact with each other to their respective final rest positions. It should also be noted that the steering column was moved inward approximately 2 centimeters (0.8 inches). At final rest, the driver was found unbelted and slumped forward over the steering wheel.

Figure 9: Seat position of case vehicle's driver with police officer demonstrating the close proximity of driver to driver's air bag (case photo #29)

CASE VEHICLE DRIVER INJURIES

The case vehicle's driver was transported by ambulance to the hospital. She sustained fatal injuries and, according to her autopsy, was pronounced dead 79 minutes post-crash. The injuries sustained by the case vehicle's driver included: a major laceration to her aorta (with hemorrhage not

confined to her mediastinum), multiple bilateral rib fractures, a fractured sternum, abrasions and contusions to her forehead, anterior neck abrasions, contusions to her whole chest and left anterior shoulder, abrasions to her middle chest and upper abdomen, and contusions to her right upper back and posterior right upper arm.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Laceration, major[1], aorta just below subclavian arteries[2] with hemorrhage not confined to mediastinum	420218.6 untreatable	Driver module's cover flap	Probable	Autopsy
2	Fractured ribs, bilaterally, left 2nd through 9th, anteriorly, and right 3rd through 6th, anteriorly	450240.4 severe	Steering wheel rim	Probable	Autopsy
3	Fracture sternum at level of fourth ribs	450802.2 moderate	Driver module's cover flap	Certain	Autopsy
4	Abrasion mid-upper forehead	290202.1 minor	Driver's sun visor	Probable	Autopsy
5	Contusion[3], 10.2 cm (4 in) in diameter, mid-frontal region	190402.1 minor	Driver's sun visor	Probable	Autopsy
6	Abrasions x 2, mid-lower anterior neck	390202.1 minor	Air bag, driver's	Certain	Autopsy
7	Contusions {bruises} whole chest including: 15.2 cm (6 in) in diameter right upper chest, 6.4 cm (2.5 in) in diameter inner lower quadrant right breast, and multiple left breast	490402.1 minor	Driver module's cover flap	Probable	Autopsy
8	Abrasions, multiple, 11.9 x 5.1 cm (11 x 2 in) middle and lower middle chest	490202.1 minor	Air bag, driver's	Certain	Autopsy
9	Abrasion (continuation of lesion above) upper abdomen	590202.1 minor	Air bag, driver's	Certain	Autopsy
10	Contusions (at least four), 6.4 cm (2.5 in) in diameter right upper back	690402.1 minor	Driver's head restraint system	Probable	Autopsy
11	Contusion (at least one) left shoulder	790402.1 minor	Steering wheel rim	Probable	Autopsy

[1] There were 2,250 cc of bilateral hemothoraces (1.6 liters in left pleural cavity and 650 cc in right pleural cavity) most likely resulting from the partial aortic laceration.

[2] See article on aortic lacerations following **CRASH DIAGRAM**.

[3] This lesion was most likely a subgaleal hematoma that was situated underneath the forehead and over the frontal lobes of the brain since it was only discovered upon reflection of this occupant's scalp.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
12	Contusions {bruises} x 2, posterior right upper arm	790402.1 minor	Driver's seat back support, right side	Probable	Autopsy

VEHICLE #2

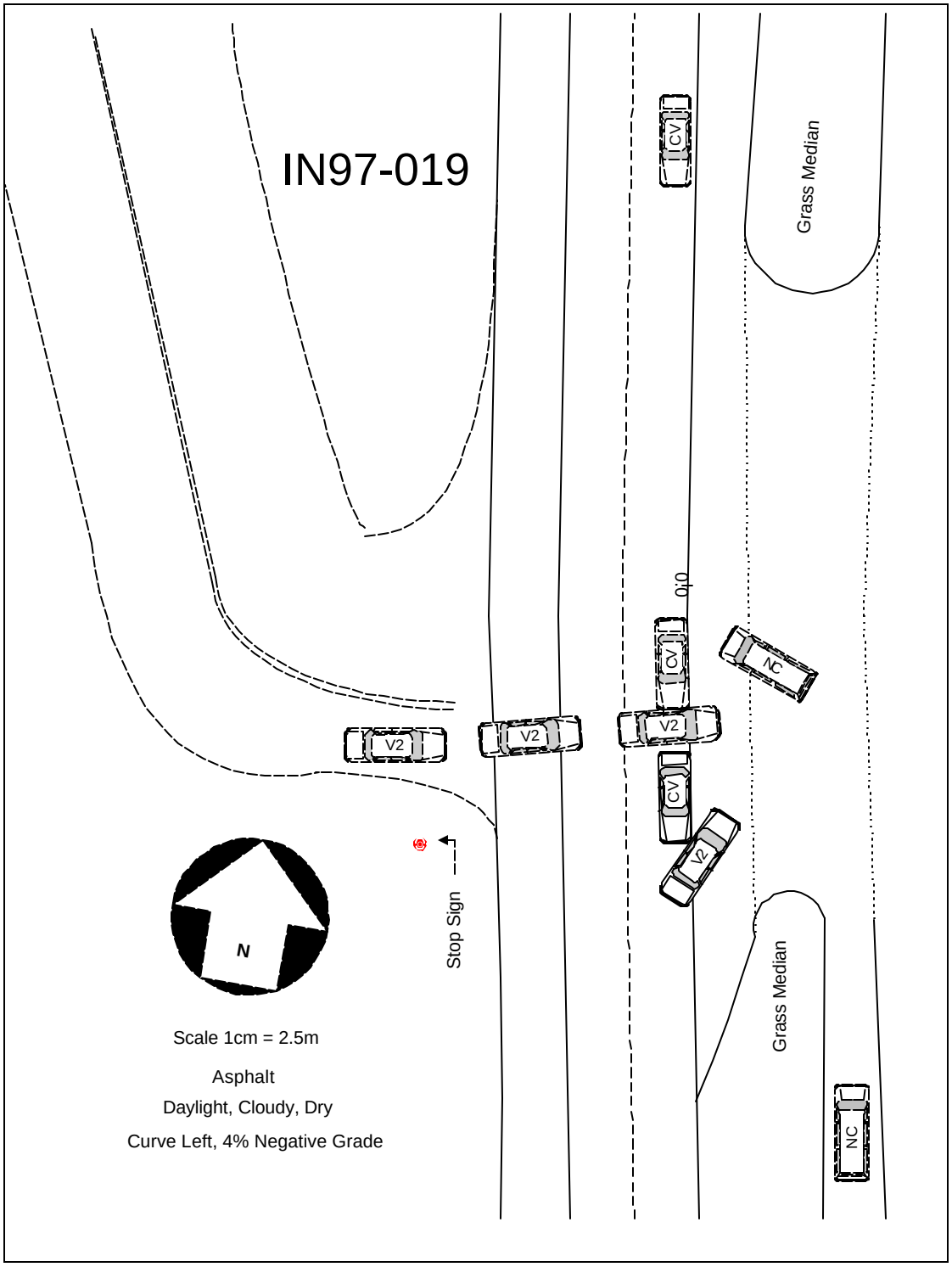
Vehicle #2 was a rear wheel drive, 1997 Mercury Grand Marquis LS, six-passenger, four-door sedan (VIN: 2MELM75W1VX------) equipped with a 4.6 liter, SOHC, SEFI, V-8, 16-valve, gasoline engine and a four-speed automatic transmission. Four-wheel, anti-lock brakes are an option for this model, but it is unknown if vehicle #2 was so equipped. Vehicle #2's wheelbase was 291 centimeters (114.4 inches), and the odometer reading is unknown because this vehicle had been repaired and, thus, was not inspected. Based on the VIN, vehicle #2 was equipped with active safety belts and driver and front right passenger supplemental restraints (air bags).

Figure 10: Vehicle #2's left side damage; Note: maximum crush near left rear door handle indicates PDOF acted aft of vehicle's center of gravity (case photo #34)

Figure 11: Vehicle #2's left side damage viewed from front showing area of maximum crush near left rear door's handle; Note: since PDOF was aft of vehicle #2's center of gravity, vehicle rotated counterclockwise after impact (case photo #31)

Available police photographs show the direct damage to vehicle #2 at the left front door, the left rear door, the forward edge of the left rear wheel well, and the left rocker panel (**Figures 10** and **11**). There may have been some slight intrusion to the second seat left position in this vehicle. Based on the police photographs, the CDC for vehicle #2 was estimated as: **09-LPEW-2 (+260 degrees)**. The WinSMASH reconstruction program, missing vehicle algorithm, was used on vehicle #2's highest severity impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 15.4 km.p.h. (9.6 m.p.h.), 2.7 km.p.h. (1.7 m.p.h.), 15.2 km.p.h. (9.4 m.p.h.).

Vehicle #2's driver [89-year-old male; 168 centimeters and 64 kilograms (66 inches, 140 pounds)] was wearing his available, active, three-point, lap and shoulder belt. He was treated by EMTs on-scene for a small laceration {cut} to his left elbow. He refused transport to a medical facility and did not seek medical attention at a later time. The elbow laceration was his only injury.


IN97-019
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CV
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Stop Sign
N
Grass Median
NC
Scale 1cm = 2.5m
Asphalt
Daylight, Cloudy, Dry
Curve Left, 4% Negative Grade

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 Five: Blunt Trauma Injuries of the Trunk and Extremities, ***The Aorta***, pages 113-116.

> The heart is suspended in the pericardial sac by the aorta, pulmonary artery, and superior vena cava. Any force that violently compresses the anterior chest and forces the heart downward may exert sufficient traction on the aorta to tear it transversely. The superior vena cava and the pulmonary artery are rarely torn. Aortic lacerations are most commonly seen in automobile accidents, less commonly in falls. In automobile accidents, the victim, usually the driver sustains the injury when the chest forcibly strikes the steering wheels, and the front seat passenger when the chest strikes the dashboard. Aortic lacerations may also occur in side impact crashes.
>
> Bursting rupture of the ascending portion and arch of the aorta occur when a violent force compresses the heart and intrapericardial portion of the ascending aorta, producing a sudden rise in intracardiac and intraluminal pressure which results in a transverse tear of the aorta immediately above the cusps of the aortic value. This usually involves only a portion of the aorta's circumference. Death rapidly ensues from severe hemorrhage. These injuries are associated with fractures of the upper ribs and sternum.
>
> Most traumatic injuries of the aorta involve the descending portion just distal to the origin of the left subclavian artery. The arch of the aorta is anchored by the great vessels arising from the aortic arch, that is, the right innominate[4], left common carotid, and subclavian arteries, and the ligamentum arteriosum[5] (which connects the left pulmonary artery to the arch of the aorta). Partial or complete lacerations of the descending aorta occur at almost precisely the same location: immediately distal to the left subclavian artery, at the junction of the aortic arch and the descending aorta. The precise mechanism of this injury is not known. The relatively constant location of aortic lacerations, the relative fixation of the descending aorta just below the aortic isthmus[6], the relative fixation of the aortic arch by the vessels, and the constant association of the aortic laceration with deceleration injuries[7], such as automobile collisions, suggest that the abrupt deceleration of the body and resulting forceful compression of the anterior chest and underlying mediastinal structures causes the heart and great vessels to be jerked away from the posterior chest wall to which the

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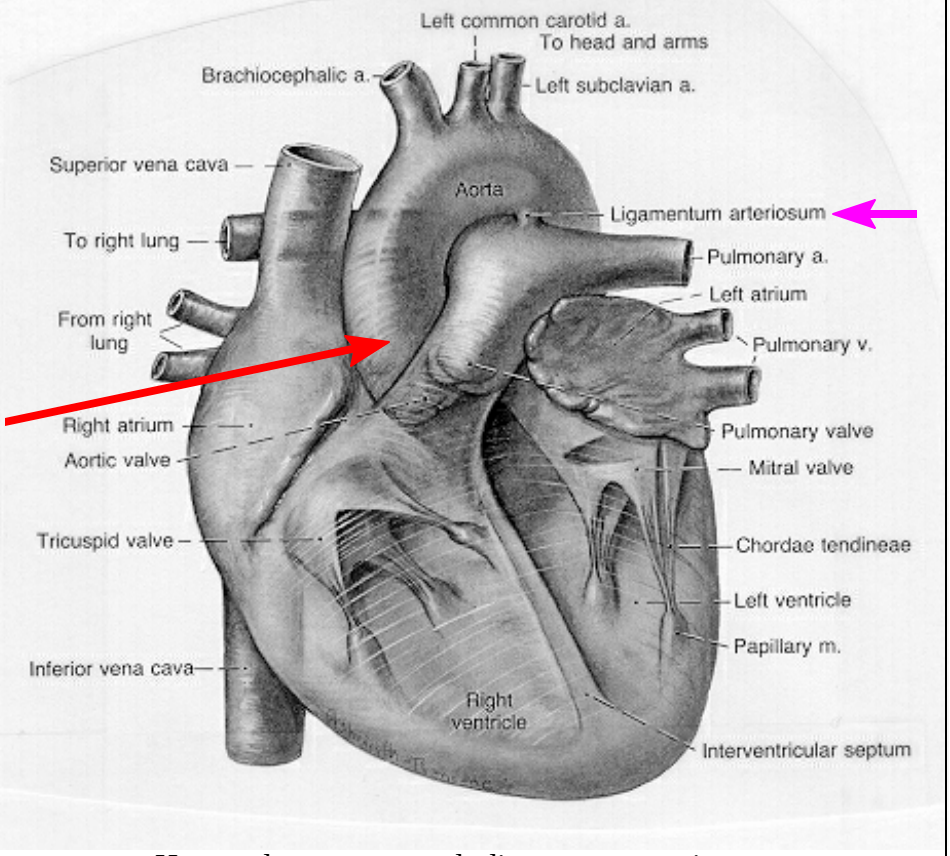
[4]Also called the brachiocephalic artery.

[5]The following term is defined in DORLAND'S ILLUSTRATED MEDICAL DICTIONARY as follows:
ligamenta arterio'sum – a short, thick, strong fibromuscular cord extending from the pulmonary artery to the arch of the aorta; it is the remains of the ductus arteriosus. Called also *ligament of Botallo*.

[6]The following terms are defined in DORLAND'S ILLUSTRATED MEDICAL DICTIONARY as follows:
isthmus (is'mas) -- a narrow connection between two larger bodies or parts; a general term for such a connecting structure or region. ***isthmus of aorta*** -- a narrow portion of the aorta, especially noticeable in the fetus, at the point where the ductus arteriosus is attached.

[7]The following term is defined in DORLAND'S ILLUSTRATED MEDICAL DICTIONARY as follows:
deceleration injury -- an injury sustained by sudden deceleration in the movement of the body, as in a motor vehicle accident; the brain is especially liable to such trauma.

thoracic aorta is attached. This traction on the ligament ductus arteriosus and descending aorta at its point of fixation is sufficient to lacerate the aorta immediately below the origin of the left subclavian artery.



Heart, valves, great vessels, ligamentum arteriosum