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ON-SITE AIR BAG INVESTIGATION

CASE NUMBER - IN97-051
LOCATION - KENTUCKY
VEHICLE - 1996 BUICK CENTURY SPECIAL
CRASH DATE - December, 1997

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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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On-site air bag deployment investigation involving a 1996 Buick Century Special, four-door sedan, with automatic belts and driver's air bag, and a 1993 Plymouth Sundance, four-door sedan, with a driver's air bag

16. *Abstract*

This report covers an on-site investigation of an air bag deployment crash that involved a 1996 Buick Century Special (case vehicle) and a 1993 Plymouth Sundance (other vehicle). This crash is of special interest because the case vehicle's unrestrained driver (61-year-old female) sustained a moderate cervical fracture from interacting with her deploying driver air bag and facial injuries as a result of being redirected upwards into the sun visor and/or windshield's header. The case vehicle was traveling southwest while traversing a left-hand curve in the inside, southwestbound lane of a four-lane, undivided, state highway and was approaching a "Tee" intersection (i.e., there were two through lanes in each direction, but the inside northeastbound lane also served as a left-hand turn lane). The Plymouth had been traveling north in the inside, northbound lane of the same four-lane, undivided, state road. The Plymouth entered and began traversing the right-hand curve only to subsequently drift left-of-center near the apex of the curve. The crash occurred within the "Tee" intersection, in the southerly lane of the state roadway. The front left corner of the case vehicle was impacted by the front of the Plymouth, causing the case vehicle's driver (only) supplemental restraint (air bag) to deploy. The case vehicle's driver was seated with her seat track located between its middle and rearmost positions, and the tilt steering wheel was located in its upmost position. She was not using her available, active, three-point, lap-and-shoulder, safety belt system and sustained, according to her medical records, moderate to serious injuries which included: a tear drop fracture of C_2; fractures to her frontal (with depression), maxillary, nasal, right patella, and left metatarsal bones; a closed head injury; a vertically oriented, complex, facial laceration that extended from her upper lip, through her nasal area, into her orbits, and up onto her forehead; abrasions to her left chin and neck; and contusions to her torso and left foot. The driver's neck fracture was from interacting with her air bag but her facial injuries resulted from the air bag redirecting her upward movement into the sun visor and windshield header areas.

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This on-site investigation was brought to NHTSA's attention on December 11, 1997, by an officer of the investigating law enforcement agency. This crash involved a 1996 Buick Century Special (case vehicle) and a 1993 Plymouth Sundance (other vehicle). The crash occurred in December, 1997, at 3:15 p.m., in Kentucky, and was investigated by the applicable city police department. This crash is of special interest because the case vehicle's unrestrained driver [61-year-old, White (unknown if Hispanic) female] sustained a moderate cervical fracture from interacting with her deploying driver air bag and facial injuries as a result of being redirected upwards into the sun visor and/or windshield's header. This contractor inspected the scene and vehicles on 18-19 December, 1997. This contractor interviewed the driver for the other vehicle on April 12, 1998. The case vehicle's driver refused to cooperate in this investigation. This report is based on the Police Crash Report, an interview with the other vehicle's driver, a conversation with the investigating police officer, scene and vehicle inspections, occupant kinematic principles, occupant medical records, and this contractor's evaluation of the evidence.

SUMMARY

The case vehicle was traveling southwest while traversing a left-hand curve in the inside, southwestbound lane of a four-lane, undivided, state highway and was approaching a "Tee" intersection, intending to continue in a southerly travel path after exiting the curve (i.e., there were two through lanes in each direction, but the inside northeastbound lane also served as a left-hand turn lane). The Plymouth had been traveling north in the inside, northbound lane of the same four-lane, undivided, state road. The Plymouth entered and began traversing the right-hand curve, intending to continue in a northeasterly travel path. When the Plymouth drifted left-of-center, near the apex of the curve, the case vehicle's driver steered to the right, attempting to avoid the crash. The crash occurred within the "Tee" intersection, in the southerly lane of the state roadway; see **CRASH DIAGRAM** below.

The front left corner of the case vehicle was impacted by the front of the Plymouth, causing the case vehicle's driver (only) supplemental restraint (air bag) to deploy. As a result of the crash, the case vehicle rotated approximately 90 degrees counterclockwise while sliding broadside with the center of gravity moving in a southwesterly direction. The case vehicle's right rear tire impacted the southern curb of the "Tee" intersection and, as a result, the case vehicle rotated slightly clockwise before coming to rest heading in a southeasterly direction, straddling the outside, southwestbound lane, just south of the intersection. The Plymouth rapidly rotated approximately 270 degrees counterclockwise while moving northward and came to rest near the intersection straddling the inside southwestbound lane, heading in a east-northeasterly direction.

The 1996 Buick Century Special was a front wheel drive, four-door sedan (VIN: 1G4AG55M5T6------). Four wheel anti-lock brakes are standard for this model. Based on the vehicle inspection, the CDCs for the case vehicle were determined to be: **12-FLEW-2** (350) and **03-RBWN-1 (90)**. The integrated 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: 35.4 km.p.h. (22.0 m.p.h.), -34.8 km.p.h. (-21.6 m.p.h.), and +6.1 km.p.h. (+3.8 m.p.h.). The case vehicle was towed due to damage.

The case vehicle's contact with the Plymouth involved its front left. Direct damage began 28.5 centimeters (11.2 inches) left of the case vehicle's center and extended, a measured distance of 50.5 centimeters (19.9 inches), to the front left bumper corner. Maximum crush was measured as 39 centimeters (15.4 inches) at C_1. The wheelbase on the case vehicle's left side was shortened 31 centimeters (12.2 inches) while the right side remained essentially unchanged. The case vehicle's front bumper, bumper fascia, grille, hood, front left headlight and turn signal assemblies, and left fender were directly damaged and crushed rearward. The left front door was also directly damaged and crushed inward as the Plymouth rotated counterclockwise around the case vehicle's left front side. The case vehicle's left "A"-pillar sustained damage, but it was most likely induced. The case vehicle's left front tire was physically restricted and deflated from the frontal impact. The right rear tire was deflated and rotated inward from the curb impact. There was induced damage to the left "A"-pillar, the left front and rear doors, and to the right fender. Remote buckling was also found on the left front portion of the case vehicle's roof, over the driver's occupant space.

The case vehicle's 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 during the deployment to the air bag. However, there appeared to be scrapes and cloth transfers on the driver air bag module's lower cover flap. The driver's air bag was designed with one tether. The driver's air bag had two vent ports, approximately 2 centimeters (0.8 inches) in diameter, located at the 3 and 9 o'clock positions. The deployed driver's air bag was round with a diameter of 52 centimeters (20.5 inches). An inspection of the driver's air bag revealed a copious amount of blood on the fabric, both front and back. On the front surface, there were spots in the center of the air bag's fabric and across the lower portion located between the 4 and 8 o'clock positions; although, the spots reached the 4 o'clock position, they stop short of the 8 o'clock position. On the back surface there were several blood spots near the 10:30 o'clock position and two bloody areas, one near the 1:30 o'clock position and the other, obliquely oriented, between the 4 and 5 o'clock positions. Most of the blood was found on the right half of the air bag.

Inspection of the case vehicle's interior revealed a bent steering wheel rim near the 6 o'clock position, and there were scuffs on: the driver's knee bolster left of the steering column, the driver's sun visor, the roof directly above the driver's seating position, and the interior surface of the driver's door.

The 1993 Plymouth Sundance was a front wheel drive, four-door sedan (VIN: 1P3XP28D6PN------). The Plymouth was also equipped with a driver (only) air bag. Based on the vehicle inspection, the CDC for the Plymouth was determined to be: **12-FDEW-4 (10)** [maximum crush was 92 centimeters (36.2 inches) at C_1]. The integrated WinSMASH reconstruction program, damage only algorithm, was used on the Plymouth's highest severity impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 34.0 km.p.h. (21.1 m.p.h.), -33.4 km.p.h. (-20.8 m.p.h.), and -5.9 km.p.h. (-3.7 m.p.h.). The Plymouth was towed due to damage.

The Plymouth's 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 during the deployment to the air bag or the cover flaps. The driver's air bag was designed with two tethers, each 7 centimeters (2.8 inches) in width. The driver's air bag had two vent ports, approximately 3 centimeters (1.2 inches) in diameter, located at the 11:30 and 12:30 o'clock positions. The deployed driver's air bag was round with a diameter of 57 centimeters (22.4 inches). An inspection of the front surface of the driver's air bag revealed large blood spots on and just to the left of the air bag's center distributed circularly between the 8 and 11 o'clock positions. Furthermore, there was a single blood spot on the perimeter of the front surface near the 11 o'clock position. Finally, there was a large blood spot on the front surface at the perimeter located between the 5:30 and 6:30 o'clock positions. This spot extended onto the back surface of the air bag.

A limited inspection of the Plymouth's interior revealed scratching to the lower and left portions of the steering wheel rim as well as contact evidence on the driver's knee bolster and left instrument panel. Furthermore, there was contact evidence on the driver's sun visor and left windshield's header.

The exact posture of the case vehicle's driver [171 centimeters and 70 kilograms (67.5 inches and 155 pounds)] immediately prior to the crash is unknown, but she was most likely seated in a reclined posture with her back against the seat back, her left foot on the floor, her right foot easing off the accelerator, and one or both hands on the steering wheel. According to the vehicle inspection, her seat track was located between its middle and rearmost positions, the seat back was slightly reclined, and the tilt steering wheel was located in its upmost position.

The case vehicle's driver was not using her available, active, three-point, lap-and-shoulder, safety belt system. Furthermore, there was no evidence of belt pattern bruising and/or abrasions to the driver's body. However, the inspection of the driver's seat belt webbing, "D"-ring, and latch plate showed evidence of loading, but the driver's safety belt was intentionally cut and used, post-crash, to secure the damaged left front door to the left "B" pillar; thus, the stretching of the belt webbing was post-crash induced.

The case vehicle's driver steered to the right, 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 to her left just prior to impact. The case vehicle's impact with the Plymouth enabled the case vehicle's driver to continue forward, upward, and slightly leftward toward the case vehicle's 350 degree Direction of Principal Force as the case vehicle decelerated. In this contractor's opinion, the driver most likely loaded the deploying driver's air bag primarily with her chest (i.e., as opposed to impacting her in the center of her face and forehead), but the outward portions of the air bag also contacted her left chin, left upper neck, and abdomen. Furthermore, the driver's loading the air bag, momentarily blocking the air bag's excursion, caused the air bag to expand against and bend the left portion of the steering wheel rim toward the left instrument panel, a measured distance of 7.6 centimeters (3.0 inches). Because the primary impact location was on the driver's torso, the air bag's contact to the driver's chin caused a mild hyperextension to her neck (i.e., there were no abrasions noted above her chin).

Because of a combination of factors (which included): the tilt steering wheel being located in its upmost position, the driver's upward movement, and the air bag's primary impact location on the driver's chest, the unrestrained driver continued forward, ramping over the steering wheel rim and air bag and striking the left sun visor and/or windshield's header. Because the driver's head had been hyper extended by its interaction with the deploying air bag, the central part of her face impacted the sun visor and/or header (as opposed to her head striking the roof, hyper extending her neck, and allowing her face to impact the sun visor and/or header).

Simultaneous to the sun visor/header strike, the driver's right knee loaded the driver's knee bolster and/or underneath surface of the steering column. When the case vehicle reached maximum engagement, it rotated counterclockwise and slid toward the southwest. The driver first moved backwards contacting the roof over her seating position with the top of her head and depositing contact evidence. Next, the driver moved toward the left interior door surface and seat back. When the case vehicle's right rear tire and wheel contacted the southerly curb, the driver most likely moved towards the deflating driver's air bag and front right passenger seating area. The copious blood evidence on the air bag and on the center armrest was mostly deposited as the driver was approaching her final rest position. Although the exact final rest position of the driver is unknown, the huge blood deposit on the center arm rest coupled with the preponderance of the blood on the right side of the air bag's fabric indicates that she was most likely leaning towards the front center seating position at final rest.

The driver was transported by ambulance to a local hospital. She sustained a serious injury and was hospitalized seven days post-crash. According to her available medical records, the injuries sustained by the case vehicle's driver included: a tear drop fracture of C_2; fractures to her frontal bone (with depression), maxillary, nasal, right patella, and left metatarsal bones; a closed head injury; a vertically oriented, complex, facial laceration that extended from her upper lip, through her nasal area, into her orbits, and up onto her forehead; abrasions to her left chin and neck; and contusions to her torso and left foot. This occupant's medical records indicated that her facial injuries were from her air bag, but based on this contractor's special crash investigative experience, this injury pattern is inconsistent with direct air bag induced injuries. However, it is probable, that because the driver was unrestrained, the impact and the air bag enabled her upward movement into the sun visor and windshield header areas.

Immediately prior to the crash the Plymouth's driver [27-year-old, White (non-Hispanic) male; 185 centimeters and 113 kilograms (73 inches, 250 pounds)] was seated but leaning to his left with his left elbow on the window sill and his back against the seat back, his left foot on the floor, his right foot on the accelerator, and both hands on the steering wheel. According to his interview, the driver's seat track was located in its middle position, and the seat back was upright. According to the vehicle inspection, his seat track was located between its middle and rearmost positions, and his seat back was slightly reclined. The vehicle was not equipped with a tilt steering wheel.

According to the interview with the Plymouth's driver, he was restrained by his available, active, three-point, lap-and-shoulder, safety belt system; however, his medical records and the contact evidence on the sun visor/header area of the Plymouth indicated that he was not restrained.

Because of the severity of the crash and the post-crash extraction of the driver, the inspection of the driver's seat belt webbing, "D"-ring, and latch plate was inconclusive concerning the driver's restraint usage. The driver claimed belt pattern bruising but his contusions are explainable from other contact sources.

Based on the available evidence, the Plymouth's driver made no pre-crash avoidance maneuvers (i.e., the driver has no recollection of the crash; the Police Crash Report is silent on this issue). As a result and independent of the nonuse of his available safety belts, the driver's pre-impact body position did not change just prior to impact. The Plymouth's impact with the case vehicle enabled the Plymouth's driver to continue forward, upward, and slightly rightward toward the Plymouth's 10 degree Direction of Principal Force as the vehicle decelerated. The Plymouth's driver loaded his deploying driver air bag with his torso. The driver's left knee impacted the knee bolster to the left of the steering column. The driver continued upward as the vehicle approached maximum engagement, striking the left sun visor and left windshield header with his head. As the Plymouth rotated approximately 270 degrees counterclockwise to final rest, the driver most likely loaded the interior surface of the driver's door with the left side of his torso before rebounding back towards the steering wheel and left instrument panel. According to the Plymouth's driver, he recalls "waking up," slumped over the steering wheel with his left knee "in" the instrument panel.

The driver was transported by ambulance to the hospital. He sustained moderate injuries and was hospitalized three days post-crash. According to his interview and a limited review of his medical records, the injuries sustained by the Plymouth's driver included: a moderate nonanatomic brain injury; an open, comminuted, left patellar fracture; a chin laceration; a dislocated right index finger; torso contusions; and an abrasion to his left shin. This occupant's primary brain and extremity injuries were not related to his interaction with the driver's air bag, and the air bag most likely prevented this occupant from sustaining any serious chest or abdominal injuries.

CRASH CIRCUMSTANCES

The case vehicle was traveling southwest while traversing a left-hand curve in the inside, southwestbound lane of a four-lane, undivided, state highway and was approaching a "Tee" intersection (**Figure 1**), intending to continue in a southerly travel path after exiting the curve (i.e., there were two through lanes in each direction, but the inside northeastbound lane also served as a left-hand turn lane). The Plymouth had been traveling north in the inside, northbound lane of the same four-lane, undivided, state road. The Plymouth entered and began traversing the right-hand curve, intending to continue in a northeasterly travel path (**Figure 2** below). When the Plymouth drifted left-of-center, near the apex of the curve, the case vehicle's driver steered to the right, attempting to avoid the crash. The

Figure 1: Case vehicle's southwestward travel path in left-hand curve in inside southwestbound lane (case photo #03)

crash occurred within the "Tee" intersection, in the southerly lane of the state roadway; see **CRASH DIAGRAM** below.

Figure 2: Plymouth's northward travel path in inside northbound lane (case photo #07)

The state highway was curved (decreasing radius approaching the apex) to the right for northbound traffic and level at the area of impact. The pavement was relatively new bituminous, and the width of the inside southwestbound travel lane was 3.0 meters (9.8 feet) and the width of the inside northbound travel lane was 3.9 meters (12.8 feet). The roadway was bordered by barrier curbs. Pavement markings consisted of a double solid yellow centerline for both the northbound and southwestbound traffic, and the directional lanes were divided by a dashed white line. The estimated coefficient of friction was 0.75. Traffic controls consisted of white left-turn arrows painted on the inside northbound lane and a LARGE ARROW warning sign (Manual on Uniform Traffic Control Devices, W1-2L) was located on the northwest roadside prior to the apex of the curve for southwestbound traffic. The speed limit was 56 km.p.h. (35 m.p.h.) for both vehicles, but no regulatory speed limit sign was posted near the crash site. At the time of the crash the light condition was daylight, the atmospheric condition was cloudy, and the road pavement was dry. According to the Plymouth's driver, traffic density was light, and the site of the crash was urban residential. In addition, there was an intersecting city street at the crash site, but it was not related to the crash.

Figure 3: Case vehicle's front left damage with contour gauge present (case photo #11)

Figure 4: Case vehicle's frontal damage viewed from left of front; Note: direct damage to left front door and induced damage to left "A"-pillar (case photo #13)

The front left corner of the case vehicle (**Figures 3** and **4**) was impacted by the front of the Plymouth (**Figure 5** below), causing the case vehicle's driver (only) supplemental restraint (air bag) to deploy. As a result of the crash, the case vehicle rotated approximately 90 degrees counterclockwise while sliding broadside with the center of gravity moving in a southwesterly direction. The case vehicle's right rear tire impacted the southern curb (**Figure 6** below) of the "Tee" intersection and, as a result, the case vehicle rotated slightly clockwise before coming to

rest heading in a southeasterly direction, straddling the outside, southwestbound lane, just south of the intersection. The Plymouth rapidly rotated approximately 270 degrees counterclockwise while moving northward and came to rest near the intersection straddling the inside southwestbound lane, heading in a east-northeasterly direction (**Figure 7**).

Figure 5: Plymouth's frontal damage viewed from left of front; Note: left front door and both left "A" and "B"-pillars were severed by an extrication tool (case photo #38)

Figure 6: On-scene east-northeasterly view of case vehicle's final rest position against southern curb; Note: wheel impact to curb dislodged hub cab (case photo #50)

Figure 7: On-scene north-northwesterly view of case vehicle's (against curb) and other vehicle's (straddling southwestbound lane) final rest positions (case photo #46)

CASE VEHICLE

The 1996 Buick Century Special was a front wheel drive, six-passenger, four-door sedan (VIN: 1G4AG55M5T6------) equipped with a 3.1L, V-6 engine and a four-speed automatic transmission. Four wheel anti-lock brakes are standard for this model. The case vehicle's wheelbase was 266 centimeters (104.9 inches), and the odometer reading at inspection was 63,172 kilometers (39,253 miles).

Inspection of the vehicle's interior revealed a split (60/40) bench front seat with adjustable head restraints; a non-adjustable back bench seat without head restraints for the back outboard seating positions; automatic, three-point (presumably), lap-and-shoulder, safety belt systems at the front outboard positions; continuous loop, three-point, lap-and-shoulder, safety belt systems at the back outboard positions; and two-point, lap belt systems at the front and back center seating positions. The front seat belt systems were not equipped with manually operated height adjusters for the "D"-rings. The vehicle was equipped with a knee bolster for the driver only. Automatic restraint was provided by a Supplemental Restraint System (SRS) that consisted solely of a frontal air bag for the driver's seat position. The driver's air bag deployed as a result of the case vehicle's front left impact with the Plymouth.

The case vehicle's contact with the Plymouth involved its front left. Direct damage began 28.5 centimeters (11.2 inches) left of the case vehicle's center and extended, a measured distance of 50.5 centimeters (19.9 inches), to the front left bumper corner (**Figure 3** above). Maximum crush was measured as 39 centimeters (15.4 inches) at C_1. The wheelbase on the case vehicle's left side was shortened 31 centimeters (12.2 inches) while the right side remained essentially unchanged. The case vehicle's front bumper, bumper fascia, grille, hood, front left headlight and turn signal assemblies, and left fender were directly damaged and crushed rearward. The left front door was also directly damaged and crushed inward as the Plymouth rotated counterclockwise around the case vehicle's left front side. The case vehicle's left "A"-pillar sustained damage, but it was most likely induced. The case vehicle's left front tire was physically restricted and deflated from the frontal impact (**Figure 8**). The right rear tire was deflated and rotated inward from the curb impact. There was induced damage to the left "A"-pillar, the left front and rear doors, and to the right fender. Remote buckling was also found on the left front portion of the case vehicle's roof, over the driver's occupant space.

Figure 8: Close-up of case vehicle's corner impact showing damage to left front wheel assembly (case photo #14)

Figure 9: Contact evidence on case vehicle's driver knee bolster and left instrument panel; Note: blood splatter on driver's seat and interior surface of driver's door (case photo #25)

Figure 10: Sun visor and roof area on case vehicle's driver side showing contact evidence on sun visor from driver's face and roof from driver's scalp (case photo #28)

Inspection of the case vehicle's interior revealed a bent steering wheel rim near the 6 o'clock position, and there were scuffs on: the driver's knee bolster left of the steering column (**Figure 9**), the driver's sun visor, the roof directly above the driver's seating position (**Figure 10** and **Figure 11** below), and the interior surface of the driver's door.

Based on the vehicle inspection, the CDCs for the case vehicle were determined to be: **12-FLEW-2** (350) and **03-RBWN-1 (90)**. The integrated 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: 35.4 km.p.h. (22.0 m.p.h.), -34.8 km.p.h. (-21.6 m.p.h.), and +6.1 km.p.h. (+3.8 m.p.h.). The case vehicle was towed due to damage.

Figure 11: Sun visor on case vehicle's driver side showing deformation from impact by driver's face (case photo #33)

AUTOMATIC RESTRAINT SYSTEM

The case vehicle was equipped with a Supplemental Restraint System (SRS) that contained a front air bag at the driver (only) position. The air bag deployed as a result of the frontal impact with the Plymouth. The case vehicle's driver air bag was located in the steering wheel hub. The module cover consisted of essentially symmetrical "H"-configuration cover flaps made of thick vinyl with overall dimensions of 20 centimeters (7.9 inches) at the horizontal seam and 5.5 centimeters (2.2 inches) vertically for the upper flap and 5 centimeters (2.0 inches) vertically for the lower flap. 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 during the deployment to the air bag. However, there appeared to be scrapes and cloth transfers on the driver air bag module's lower cover flap. The driver's air bag was designed with one tether. The driver's air bag had two vent ports, approximately 2 centimeters (0.8 inches) in diameter, located at the 3 and 9 o'clock positions. The deployed driver's air bag was round with a diameter of 52 centimeters (20.5 inches). An inspection of the driver's air bag revealed a copious amount of blood on the fabric, both front and back. On the front surface (**Figure 12**), there were spots in the center of the air bag's fabric and across the lower portion located between the 4 and 8 o'clock positions; although, the spots reached the 4 o'clock position, they stop short of the 8 o'clock position. On the back surface the were several blood spots near the 10:30 o'clock position and two bloody areas, one near the 1:30 o'clock position and the other, obliquely oriented, between the 4 and 5 o'clock positions. Most of the blood was found on the right half of the air bag.

Figure 12: Case vehicle's deployed driver air bag showing evidence (i.e., blood) of contact (case photo #34)

CASE VEHICLE DRIVER KINEMATICS

The exact posture of the case vehicle's driver [171 centimeters and 70 kilograms (67.5 inches and 155 pounds)] immediately prior to the crash is unknown, but she was most likely seated in a reclined posture with her back against the seat back, her left foot on the floor, her right foot easing off the accelerator, and one or both hands on the steering wheel. According to the vehicle inspection, her seat track was located between its middle and rearmost positions, the seat back was slightly reclined, and the tilt steering wheel was located in its upmost position.

The case vehicle's driver was not using her available, active, three-point, lap-and-shoulder, safety belt system. Furthermore, there was no evidence of belt pattern bruising and/or abrasions to the driver's body. However, the inspection of the driver's seat belt webbing, "D"-ring, and latch plate showed evidence of loading, but the driver's safety belt was intentionally cut and used, post-crash, to secure the damaged left front door to the left "B" pillar; thus, the stretching of the belt webbing was post-crash induced.

The case vehicle's driver steered to the right, 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 to her left just prior to impact. The case vehicle's impact with the Plymouth enabled the case vehicle's driver to continue forward, upward, and slightly leftward toward the case vehicle's 350 degree Direction of Principal Force as the case vehicle decelerated. In this contractor's opinion, the driver most likely loaded the deploying driver's air bag primarily with her chest (i.e., as opposed to impacting her in the center of her face and forehead), but the outward portions of the air bag also contacted her left chin, left upper neck, and abdomen. Furthermore, the driver's loading the air bag, momentarily blocking the air bag's excursion, caused the air bag to expand against and bend the left portion of the steering wheel rim toward the left instrument panel, a measured distance of 7.6 centimeters (3.0 inches). Because the primary impact location was on the driver's torso, the air bag's contact to the driver's chin caused a mild hyperextension to her neck (i.e., there were no abrasions noted above her chin).

Because of a combination of factors (which included): the tilt steering wheel being located in its upmost position, the driver's upward movement, and the air bag's primary impact location on the driver's chest, the unrestrained driver continued forward, ramping over the steering wheel rim and air bag and striking the left sun visor and/or windshield's header (**Figures 10** and **11** above). Because the driver's head had been hyper extended by its interaction with the deploying air bag, the central part of her face impacted the sun visor and/or header (as opposed to her head striking the roof, hyper extending her neck, and allowing her face to impact the sun visor and/or header). The scenario preferred by this contractor is based on two factors. First, the lesion to the driver's cervical spine, although a moderate injury, was a relatively minor fracture (i.e., a review of the driver's medical records indicates that the lesion was an avulsion or "chip" type fracture of the anterior-inferior body of C_2) with good alignment of the vertebral bodies post-injury. Second, there were no reported lesions to the driver's scalp to support the contention that the top of the driver's head was the initial point of impact that forced the driver's head backward, producing the hyperextension of the driver's neck and allowing the driver's face (i.e., specifically the jaw) to rotate upwards causing the moderate to serious facial lesions.

Simultaneous to the sun visor/header strike, the driver's right knee loaded the driver's knee bolster and/or underneath surface of the steering column (**Figure 9** above). When the case vehicle reached maximum engagement, it rotated counterclockwise and slid toward the southwest. The driver first moved backwards contacting the roof over her seating position with the top of her head and depositing contact evidence (**Figures 10** and **11** above). Next, the driver moved toward the left interior door surface and seat back. When the case vehicle's right rear tire and wheel contacted the southerly curb, the driver most likely moved towards the deflating driver's air bag and front right passenger seating area. The copious blood evidence on the air bag and on the

center armrest was mostly deposited as the driver was approaching her final rest position. Although the exact final rest position of the driver is unknown, the huge blood deposit on the center arm rest coupled with the preponderance of the blood on the right side of the air bag's fabric indicates that she was most likely leaning towards the front center seating position at final rest (**Figure 13**).

Figure 13: On-scene close-up of case vehicle's front seating area showing driver's deployed, bloodied, air bag and blood evidence on center arm rest (case photo #49)

CASE VEHICLE DRIVER INJURIES

The driver was transported by ambulance to a local hospital. She sustained a serious injury and was hospitalized seven days post-crash. According to her available medical records, the injuries sustained by the case vehicle's driver included: a tear drop fracture of C_2; fractures to her frontal bone (with depression), maxillary, nasal, right patella, and left metatarsal bones; a closed head injury; a vertically oriented, complex, facial laceration that extended from her upper lip, through her nasal area, into her orbits, and up onto her forehead; abrasions to her left chin and neck; and contusions to her torso and left foot. This occupant's medical records indicated that her facial injuries were from her air bag, but based on this contractor's special crash investigative experience, this injury pattern is inconsistent with direct air bag induced injuries. However, it is probable, that because the driver was unrestrained, the impact and the air bag enabled her upward movement into the sun visor and windshield header areas.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Closed head injury[1] with disorientation but unknown if loss of consciousness, GCS = 14 reported	115099.7 unknown	Sun visor and/or windshield header, driver's (air bag-related)	Probable	Hospitalization records

[1] This contractor was unable to obtain some of this occupant's initial records of medical treatment. As a result, there is insufficient information to encode this lesion more accurately.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
2	Fracture, teardrop[2], C_2, resulting from hyperextension[3]	650230.2 moderate	Air bag, driver's	Probable	Hospitalization records
3	Fracture right orbital roof (i.e., frontal bone) that extended into the frontal sinus and was described as depressed and small	150404.3 serious	Sun visor and/or windshield header, driver's (air bag-related)	Probable	Hospitalization records
4	Fracture maxillary sinus[4], not further specified but most likely right [Aspect = Unknown]	250800.2 moderate	Sun visor and/or windshield header, driver's (air bag-related)	Probable	Hospitalization records
5	Fracture, non-displaced, superior portion of right patella	852400.2 moderate	Knee bolster, driver's	Certain	Hospitalization records
6	Fracture, open[5], nose	251004.2 moderate	Sun visor and/or windshield header, driver's (air bag-related)	Probable	Hospitalization records
7	Fractures left 2nd, 3rd, 4th, and 5th metatarsal bones	852200.2 moderate	Foot well/toe pan	Certain	Hospitalization records
8	Avulsion left upper lip	290802.1 minor	Sun visor and/or windshield header, driver's (air bag-related)	Probable	Hospitalization records
9	Laceration, 3 cm (1.2 in) left upper eyelid	297602.1 minor	Sun visor and/or windshield header, driver's (air bag-related)	Probable	Hospitalization records

[2] The word teardrop refers to a fracture involving the anterior-inferior portion of the vertebral body. In this patient her imaging records indicated that the fracture was avulsive in nature, implying that a connecting ligament to the anterior-inferior portion of the body was torn away.

[3] The following terms are defined in DORLAND'S ILLUSTRATED MEDICAL DICTIONARY as follows:
extension (ek-sten′shen): the movement by which the two elements of any jointed part are drawn away from each other.
hyperextension (hi"per-ek-sten′shen): extreme or excessive extension of a limb or part.

[4] Based upon this contractor's experience and in this contractor's opinion, this lesion was mistakenly identified by the writer of this patient's discharge summary **and** is one-and-the-same as the lesion immediately preceding it.

[5] This contractor chooses to describe this lesion as an "open" nasal fracture. This description is a "best fit". According to one of this patient's operative records her lesion was described as follows: degloving of her face starting at left upper lip; skin is split, the lateral side of left nose with total nose being taken off including septum, nasal cartilages, and distal end of nasal bones; laceration proceeds up to frontal area and dissects over right glabella area. No blood loss information is available nor is there any information about blood replacement. The surgical repair starts from her left upper lip and travels vertically upwards to above the forehead.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
10	Laceration right canaliculus[6]	240408.1 minor	Sun visor and/or windshield header, driver's (air bag-related)	Probable	Hospitalization records
11 12	Laceration right upper and lower eyelids, involving an avulsion of right medial canthus[6] and a laceration of right canthal[6] tendon	297602.1 minor 297802.1 minor	Sun visor and/or windshield header, driver's (air bag-related)	Probable	Hospitalization records
13	Lacerations upper forehead	290602.1 minor	Sun visor and/or windshield header, driver's (air bag-related)	Probable	Hospitalization records
14	Abrasion left jaw, not further specified	290202.1 minor	Air bag, driver's	Certain	Emergency room records
15	Abrasion left upper neck	390202.1 minor	Air bag, driver's	Certain	Emergency room records
16 17	Contusions {bruises} right chest below breast and right abdomen down to and below waist	490402.1 minor 590402.1 minor	Air bag, driver's	Probable	Other: Driver's deposition
18	Contusion {ecchymosis} plantar surface of left foot	890402.1 minor	Foot well/toe pan	Certain	Follow-up medical clinic

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[6] The following terms are defined in DORLAND'S ILLUSTRATED MEDICAL DICTIONARY as follows:

angulus (ang′gu-les) pl. anguli (ang′gu-li): an angle; used as a general term in anatomical nomenclature to designate a triangular area or the angle of a particular structure or part of the body.

a. o′culi latera′lis/media′lis: lateral/medial angle of eye: the angles formed by the lateral and medial junctions of the superior and inferior eyelids.

canalicular (kan"e-lik′u-ler): resembling or pertaining to a canaliculus.

canaliculus (kan"e-lik′u-les) pl. canaliculi (kan"e-lik′u-li): an extremely narrow tubular passage or channel; used as a general term in anatomical nomenclature for various small channels.

c. lacrima′lis: the short passage in an eyelid, beginning in the punctum, that leads from the lacrimal lake to the lacrimal sac; called also *lacrimal duct* and *ductus lacrimalis*.

canthal (kan′thel): pertaining to a canthus.

canthus (kan′thes) pl. canthi (kan′thi): the angle at either end of the fissure between the eyelids; see *angulus oculi lateralis* and *angulus oculi medialis*.

inner c., nasal c.,: angulus oculi medialis.

outer c., temporal c.: angulus oculi lateralis.

punctum (pungk′tem): an extremely small spot, or point; used in anatomical nomenclature as a general term to designate an extremely small area, or point of projection.

p. lacrima′le: lacrimal point: the opening on the lacrimal papilla of an eyelid, near the medial angle of the eye, into which tears from the lacrimal lake drain to enter the lacrimal canaliculi.

The 1993 Plymouth Sundance was a front wheel drive, five-passenger, four-door sedan (VIN: 1P3XP28D6PN------) equipped with a 2.2L, I-4 engine and a five-speed manual transmission. The Plymouth was also equipped with a driver (only) air bag. The other vehicle's wheelbase was 247 centimeters (97.2 inches), and the odometer reading at inspection was 153,206 kilometers (95,198 miles).

Inspection of the vehicle's interior revealed adjustable front bucket seats with adjustable head restraints; a non-adjustable back bench seat without head restraints for the back outboard seating positions; continuous loop, three-point, lap-and-shoulder, safety belt systems at the front and back outboard positions; and a two-point, lap belt system at the back center position. The front seat belt systems were not equipped with manually operated height adjusters for the "D"-rings. The vehicle was equipped with a knee bolster for the driver only. Automatic restraint was provided by a Supplemental Restraint System (SRS) that consisted solely of a frontal air bag for the driver's seat position. The driver's air bag deployed as a result of the Plymouth's frontal impact with the case vehicle.

OTHER VEHICLE DAMAGE

The other vehicle's contact with the case vehicle involved the entire front of the vehicle. Direct damage began at the front left bumper corner and extended, a measured distance of 99 centimeters (39.0 inches), along the front bumper to the front right bumper corner. Maximum crush was measured as 92 centimeters (36.2 inches) at C_1 (**Figure 5** above). The wheelbase on the Plymouth's left side was shortened 27 centimeters (10.6 inches) while the right side was extended 2 centimeters (0.8 inches). The Plymouth's front bumper, bumper fascia, grille, hood, front left headlight and turn signal assemblies, and left fender were directly damaged and crushed rearward. The case vehicle's left front tire was physically restricted, and the two front tires and the right rear tire were deflated. The right headlight and turn signal assemblies sustained induced damage as well both the right and left fenders.

Figure 14: Contacts (i.e., scratches) along right side of Plymouth's steering wheel; Note: top of steering wheel has been rotated approximately 60 degrees clockwise in photo (case photo #53)

Figure 15: Contact evidence on Plymouth's driver knee bolster and left instrument panel; Note: contacts to interior surface of driver's door (case photo #52)

A limited inspection of the Plymouth's interior revealed scratching to the lower and left portions of the steering wheel rim (**Figure 14** above) as well as contact evidence on the driver's knee bolster and left instrument panel (**Figure 15** above). Furthermore, there was contact evidence on the driver's sun visor and left windshield's header (**Figures 16** and **17**).

Figure 16: Interior surface of Plymouth's roof, peeled back during extrication, showing contact evidence to driver's sun visor and left windshield header (case photo #55)

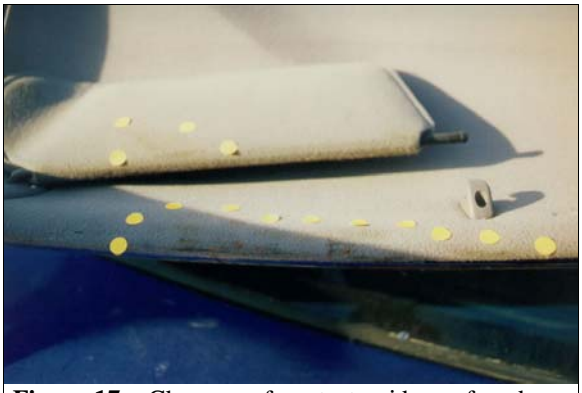


Figure 17: Close-up of contact evidence found on Plymouth's driver sun visor and left windshield header (case photo #56)

Based on the vehicle inspection, the CDC for the Plymouth was determined to be: **12-FDEW-4 (10)** [maximum crush was 92 centimeters (36.2 inches) at C_1]. The integrated WinSMASH reconstruction program, damage only algorithm, was used on the Plymouth's highest severity impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 34.0 km.p.h. (21.1 m.p.h.), -33.4 km.p.h. (-20.8 m.p.h.), and -5.9 km.p.h. (-3.7 m.p.h.). The Plymouth was towed due to damage.

Figure 18: Plymouth's deployed driver air bag showing blood evidence along left side of fabric (case photo #54)

OTHER VEHICLE AUTOMATIC RESTRAINT SYSTEM

The other vehicle was equipped with a Supplemental Restraint System (SRS) that contained a front air bag (only) at the driver seating position. The driver's air bag deployed as a result of the frontal impact with the case vehicle. The Plymouth's driver air bag was located in the steering wheel hub. The module cover consisted of essentially symmetrical "H"-configuration cover flaps made of thick vinyl with overall dimensions of 17 centimeters (6.7 inches) at the horizontal seam and 6 centimeters (2.4 inches) vertically for the upper flap and 7 centimeters (2.8 inches) vertically for the lower flap. 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 during the deployment to the air bag or the cover flaps. The driver's air bag was designed with two tethers, each 7 centimeters (2.8 inches) in width. The driver's air bag had two vent ports, approximately 3 centimeters (1.2 inches) in diameter, located at the 11:30 and 12:30 o'clock positions. The deployed driver's air bag was round with a diameter of 57 centimeters (22.4 inches). An inspection of the front surface of the driver's air bag revealed large blood spots on and just to the left of the air bag's center distributed circularly between the 8 and 11 o'clock positions (**Figure 18** above). Furthermore, there was a single blood spot on the perimeter of the front surface near the 11 o'clock position. Finally, there was a large blood spot on the front surface at the perimeter located between the 5:30 and 6:30 o'clock positions. This spot extended onto the back surface of the air bag.

OTHER VEHICLE DRIVER KINEMATICS

Immediately prior to the crash the Plymouth's driver [27-year-old, White (non-Hispanic) male; 185 centimeters and 113 kilograms (73 inches, 250 pounds)] was seated but leaning to his left with his left elbow on the window sill and his back against the seat back, his left foot on the floor, his right foot on the accelerator, and both hands on the steering wheel. According to his interview, the driver's seat track was located in its middle position, and the seat back was upright. According to the vehicle inspection, his seat track was located between its middle and rearmost positions, and his seat back was slightly reclined. The vehicle was not equipped with a tilt steering wheel.

According to the interview with the Plymouth's driver, he was restrained by his available, active, three-point, lap-and-shoulder, safety belt system; however, his medical records and the contact evidence on the sun visor/header area of the Plymouth indicated that he was not restrained. Because of the severity of the crash and the post-crash extraction of the driver, the inspection of the driver's seat belt webbing, "D"-ring, and latch plate was inconclusive concerning the driver's restraint usage. The driver claimed belt pattern bruising but his contusions are explainable from other contact sources.

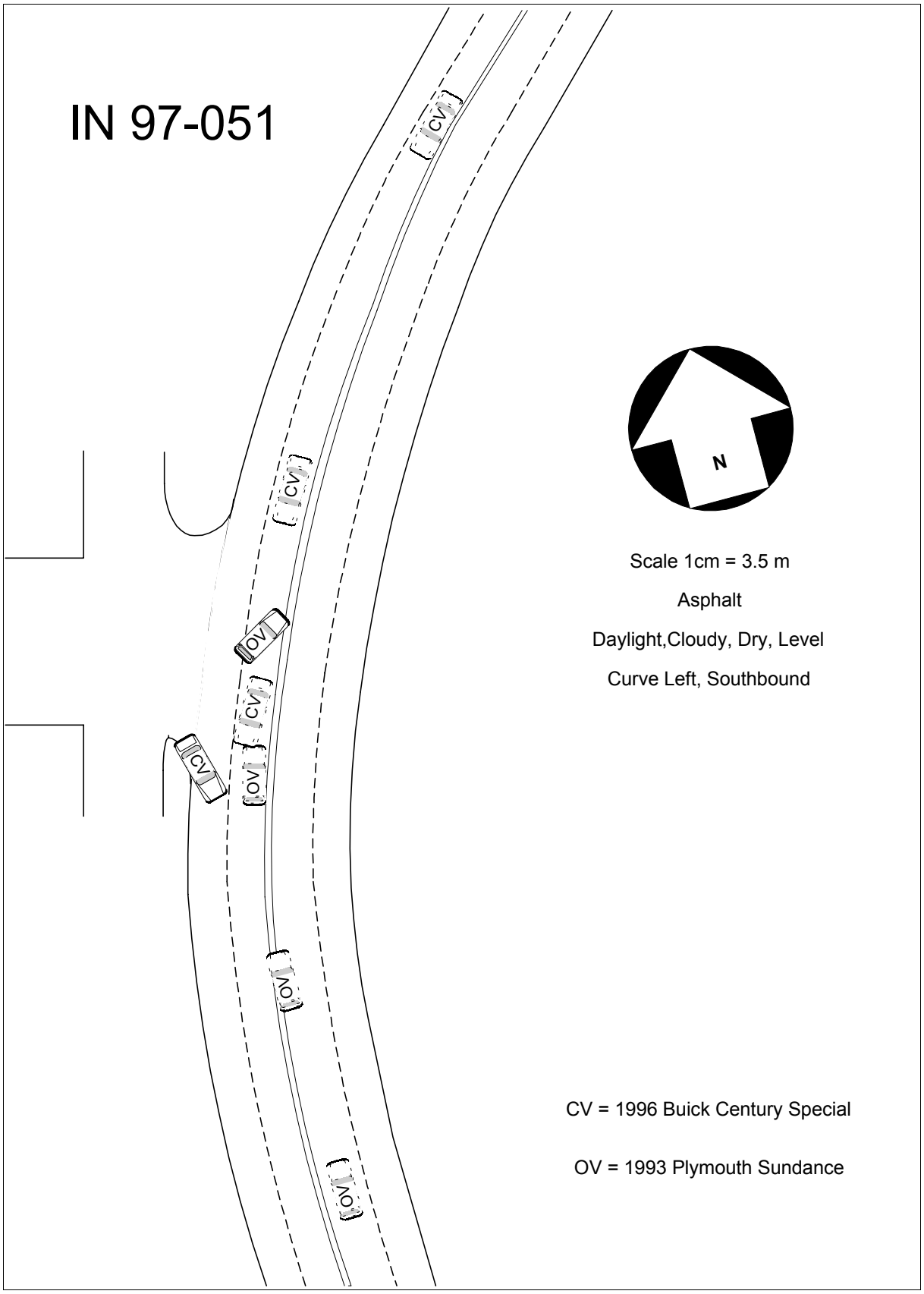
Based on the available evidence, the Plymouth's driver made no pre-crash avoidance maneuvers (i.e., the driver has no recollection of the crash; the Police Crash Report is silent on this issue). As a result and independent of the nonuse of his available safety belts, the driver's pre-impact body position did not change just prior to impact. The Plymouth's impact with the case vehicle enabled the Plymouth's driver to continue forward, upward, and slightly rightward toward the Plymouth's 10 degree Direction of Principal Force as the vehicle decelerated. The Plymouth's driver loaded his deploying driver air bag with his torso. The driver's left knee impacted the knee bolster to the left of the steering column. The driver continued upward as the vehicle approached maximum engagement, striking the left sun visor and left windshield header with his head. As the Plymouth rotated approximately 270 degrees counterclockwise to final rest, the driver most likely loaded the interior surface of the driver's door with the left side of his torso before rebounding back towards the steering wheel and left instrument panel. According to the Plymouth's driver, he recalls "waking up," slumped over the steering wheel with his left knee "in" the instrument panel.

The driver was transported by ambulance to the hospital. He sustained moderate injuries and was hospitalized three days post-crash. According to his interview and a limited review of his medical records, the injuries sustained by the Plymouth's driver included: a moderate nonanatomic brain injury; an open, comminuted, left patellar fracture; a chin laceration; a dislocated right index finger; torso contusions; and an abrasion to his left shin. This occupant's primary brain and extremity injuries were not related to his interaction with the driver's air bag, and the air bag most like prevented this occupant from sustaining any serious chest or abdominal 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 without loss of consciousness, GCS = 15, but amnesic to event	160410.2 moderate	Sun visor and/or windshield header, driver's	Probable	Hospitalization records
2	Fracture, open, comminuted, left patella	852400.2 moderate	Knee bolster, driver's, left of steering column	Certain	Hospitalization records
3	Laceration, small, chin[7], not further specified	290600.1 minor	Other noncontact injury source: flying glass	Probable	Emergency room records
4	Dislocation right index finger[8]	750800.1 minor	Left instrument panel and below	Possible	Interviewee (same person)
5	Contusion right chest, not further specified	490402.1 minor	Air bag, driver's	Probable	Interviewee (same person)
6 7	Contusion left side from armpit to hip	490402.1 minor 590402.1 minor	Interior surface, driver's door, excluding hardware or armrests	Certain	Interviewee (same person)
8	Abrasions left shin, not further specified	890202.1 minor	Left instrument panel and below	Certain	Interviewee (same person)

[7] According to this occupant's interview, the laceration was on his neck above his "Adam's Apple". According to the RANDOM HOUSE WEBSTER'S UNABRIDGED DICTIONARY, this terms is defined as follows:
Adam's apple: a projection of the thyroid cartilage at the front of the neck that is more prominent in men than in women.

[8] During the course of this occupant's hospitalization, he complained of pain in his right hand. This occupant's right hand was examined and no fracture or dislocation was found but swelling was noted.


IN 97-051
CV
CV
OV
CV
CV
OV
OV
OV
N
Scale 1cm = 3.5 m
Asphalt
Daylight,Cloudy, Dry, Level
Curve Left, Southbound
CV = 1996 Buick Century Special
OV = 1993 Plymouth Sundance