INDIANA UNIVERSITY
TRANSPORTATION RESEARCH CENTER
School of Public and Environmental Affairs
222 West Second Street
Bloomington, Indiana 47403-1501
(812) 855-3908 Fax: (812) 855-3537

ON-SITE ADULT AIR BAG-RELATED FATALITY INVESTIGATION

CASE NUMBER - IN00-017
LOCATION - IOWA
VEHICLE - 1997 HYUNDAI SONATA GL
CRASH DATE - October, 2000

Submitted:

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Contract Number: DTNH22-94-D-17058

Prepared for:

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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 1997 Hyundai Sonata GL (case vehicle) and a 2001 Dodge Ram 2500 pick-up truck (other vehicle). This crash is of special interest because the case vehicle's front right passenger (22-year-old, female) sustained critical brain injuries from contacting her deploying front right passenger air bag, resulting in her death. The case vehicle was traveling north in outside northbound lane of a four-lane, divided, city trafficway (i.e., both the north and southbound roadways had two through lanes, and the roadways were separated by a curbed, grassy median). The Dodge was also traveling north in outside through lane of the same northbound roadway and had come to an abrupt stop because the traffic stopped in front of him. The crash occurred in the outside, through lane of the northbound roadway. The front of the case vehicle impacted the back of the Dodge, causing the case vehicle's driver and front right passenger supplemental restraints (air bags) to deploy. The case vehicle and the Dodge moved at most only a short distance before coming to rest near the point of impact, heading northward. The front right passenger was seated with her seat track located in its rearmost position and was not using her available, active, three-point, lap-and-shoulder, safety belt system. She sustained, according to her medical records, critical injuries which included: a critical nonanatomic brain injury, a diffuse axonal injury, bilateral intra-cerebral hemorrhages, small bilateral cerebral contusions, diffuse subarachnoid hemorrhages, a left pneumothorax, and abrasions to her right cheek and chin. This occupant's critical brain injuries were most likely caused by her contact with the case vehicle's front right passenger air bag. The case vehicle's driver (25-year-old, female) was seated with her seat track located between its middle and rearmost position, and the tilt steering wheel was located in its upmost position. She was restrained by her available, active, three-point, lap-and-shoulder, safety belt system and she sustained, according to her interview a minor contusion to her chest. The back left (23-year-old female) and back right (28-year-old female) passengers were seated, but their seat track was not adjustable. Neither back seat passenger was using their available, active, three-point, lap-and-shoulder, safety belt systems and, according to the interview with the driver, the back left passenger sustained a right shoulder strain and the back right passenger sustained a lower back strain.			
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BACKGROUND

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This on-site investigation was brought to NHTSA's attention on October 26, 2000 by an NHTSA regional office. This crash involved a 1997 Hyundai Sonata GL (case vehicle) and a 2001 Dodge Ram 2500 pick-up truck (other vehicle). The crash occurred in October, 2000, at 11:18 a.m., in Iowa and was investigated by the applicable city police department. This crash is of special interest because the case vehicle's front right passenger [22-year-old, White (non-Hispanic) female] sustained critical brain injuries from contacting her deploying front right passenger air bag, resulting in her death. This contractor inspected the scene and vehicles on 30-31 October, 2000. This contractor interviewed the driver for the case vehicle on November 17, 2000. This report is based on the Police Crash Report, interviews with both vehicle drivers and 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 north in outside northbound lane of a four-lane, divided, city trafficway and intended to continue traveling northbound (i.e., both the north and southbound roadways had two through lanes, and the roadways were separated by a curbed, grassy median). The Dodge was also traveling north in outside through lane of the same northbound roadway and had come to an abrupt stop because the traffic stopped in front of him for the traffic control signal. The case vehicle's driver braked, depositing 3.3 meters (10.8 feet) of skid marks, while attempting to avoid the crash. The crash occurred in the outside, through lane of the northbound roadway; see **CRASH DIAGRAM** below.

The front of the case vehicle impacted the back of the Dodge, causing the case vehicle's driver and front right passenger supplemental restraints (air bags) to deploy. The case vehicle and the Dodge moved at most only a short distance before coming to rest near the point of impact, heading northward.

The damage to the case vehicle was primarily above the bumper resembling an underride impact pattern. The underride type damage resulted in the air bag deploying late during the duration of the impact. This late deployment occurred due to the prolonged change in time (Delta T) relative to the change in speed (magnitude of Delta V–i.e., ramp versus spike). Initially the case vehicle was believed to have traveled a measured distance of 114 centimeters (44.9 inches) under the back bumper and bed of the Dodge pick-up truck before contacting the back part of the transmission's differential housing. This was later discounted because there was no corresponding evidence (i.e., differential imprint) on the case vehicle.

The 1997 Hyundai Sonata GL was a front wheel drive, four-door sedan (VIN: KMHCF24TXVU------). The case vehicle was not equipped with anti-lock brakes. Based on the vehicle inspection the CDC for the case vehicle was determined to be: **12-FDMW-2 (0).** The WinSMASH reconstruction program, missing vehicle algorithm, was used on the case vehicle's highest severity impact because the crush profile for the Dodge could not be determined. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 21.5 km.p.h. (13.4 m.p.h.), -21.5

km.p.h. (-13.4 m.p.h.), and 0.0 km.p.h. (0.0 m.p.h.). Although this crash has an underride type crush pattern, these results appear to be reasonable. The case vehicle was towed due to damage.

The case vehicle's contact with the Dodge involved the vast majority of its front–primarily above the bumper. Direct damage began 51 centimeters (20.1 inches) left of the vehicle's center and extended, a measured distance of 122 centimeters (48.0 inches), along the front bumper to the front right bumper corner. Residual maximum crush at bumper level was a measured as 4 centimeters (1.6 inches) at C_6, and the residual maximum crush above the bumper was measured as 33 centimeters (13.0 inches) from C_4 to C_5. The case vehicle's wheelbase was unaltered from the crash. The case vehicle's front bumper fascia, grille, hood, right fender, and right headlight and turn signal assemblies were directly damaged and crushed rearward. The hood had two indentations from the tow hitch attached to the back of the Dodge. The right side of the windshield's glazing was cracked and holed. This contractor believes that as the windshield's glazing flexed outward from contact by the occupant's head, the upper portion of the right windshield wiper was bent outward while the more rigid lower portion of the wiper holed the windshield. None of the case vehicle's tires were damaged, deflated, or physically restricted. The right fender and hood sustained induced damage as well. No obvious induced damage or remote buckling was noted to the remainder of the case vehicle's exterior.

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 the air bag fabric 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 approximately 13 centimeters (5.1 inches) wide, sewn internally and extending from the 1-5 and 7-11 o'clock positions. The driver's air bag had two vent ports, approximately 3 centimeters (1.2 inches) in diameter, located at the 10:30 and 1:30 o'clock positions. The deployed driver's air bag was round with a diameter 66 centimeters (26.0 inches). An inspection of the driver's air bag fabric revealed what appeared to be a skin transfer on the upper left quadrant of the air bag's fabric. The skin transfer was located 23 centimeters (9.1 inches) down from the top of the air bag and 14-15 centimeters (5.5-5.9 inches) left of center.

The front right passenger's air bag was located in the middle of the instrument panel. An inspection of the front right air bag module's cover flap and the air bag fabric revealed that the cover flap opened at the designated tear points and there was no evidence of damage during the deployment to the air bag's fabric. The inspection did reveal what appeared to be contact scuffs (possibly skin) to the two front corners of the front right air bag module's cover flap. The front right passenger's air bag was designed with two tethers, each approximately 48 centimeters (18.9 inches) in width. The top tether was located 6 centimeters (2.4 inches) down from the top horizontal seam and the bottom tether was located 30 centimeters (11.8 inches) below the top tether. The front right air bag was not designed with pre-cut vent ports. The deployed front right air bag was rectangular with a height of approximately 58 centimeters (22.8 inches) and a width of approximately 49 centimeters (19.3 inches).

An inspection of the front right passenger's air bag fabric revealed contact evidence readily apparent on the top and front surfaces. On the top surface there was an 8 centimeter (3.1 inch)

curvilinear skin transfer. On the front surface there were numerous areas of blood at and between the two tether seams in the middle of the bag. Furthermore, there was an obliquely oriented skin transfer [3 centimeters (1.2 inches) high and 29 centimeters (11.4 inches) in width] along the lower leftward portion of the air bag's front surface that may well have come from contact with the front right passenger's left hand and/or forearm as it was deflected away by the deploying air bag.

Inspection of the case vehicle's interior revealed a spider web-type impact to the right windshield's glazing from contact by the front right passenger's head. Furthermore, there was contact near the left side of the front right sun visor, most likely from the front right passenger's left hand and a smear toward the top of the right "A"-pillar, most likely from the front right passenger's right hand. Likewise, there was a smear on the right front window's glazing also most likely from the front right passenger's right hand. In addition, there was blood on the front right passenger's seat and a makeup transfer on the back side of the front right passenger's head rest from contact by the back right passenger.

The 2001 Dodge Ram 2500 was a four wheel drive, 4x4, conventional cab pickup (VIN: 3B7KF26Z71M------). Based on the vehicle inspection the CDC for the Dodge was determined to be: **06-BYLW-1 (180)**. The WinSMASH reconstruction program, missing vehicle algorithm, was used on the Dodge's highest severity impact because the crush profile for the Dodge could not be determined. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 14.1 km.p.h. (8.8 m.p.h.), +14.1 km.p.h. (+8.8 m.p.h.), and 0.0 km.p.h. (0.0 m.p.h.). The Dodge was driven from the scene.

Immediately prior to the crash the case vehicle's front right passenger [170 centimeters and 66 kilograms (67 inches, 145 pounds)] was seated in an upright posture with her torso turned slightly to the left and her left shoulder near the seat back, both of her feet were on the floor, and both of her arms were extended forward **attempting** to brace herself against the front right instrument panel. Her seat track was located in its rearmost position, and the seat back was sightly reclined.

The case vehicle's front right passenger was not using her available, active, three-point, lap-and-shoulder, safety belt system. Furthermore, there is no evidence that indicates the presence of belt pattern bruising and/or abrasions to the front right passenger's body. In addition, the inspection of the front right passenger's seat belt webbing, "D"-ring, and latch plate showed no evidence of loading.

The case vehicle's driver braked, attempting to avoid the crash. As a result of this attempted avoidance maneuver and the nonuse of her available safety belts, the front right passenger moved forward and slightly upward just prior to impact as the case vehicle pitched slightly downward from the heavy braking. The case vehicle's impact and subsequent underride with the Dodge enabled the case vehicle's front right passenger to continue forward and upward toward the **0** degree Direction of Principal Force as the case vehicle decelerated. As previously mentioned, the delayed deployment of the case vehicle's air bag system allowed the front right passenger to move further forward towards the front right instrument panel and air bag module. As a result of this forward motion, this contractor believes that the front right passenger responded by simultaneously

putting her hands forward toward the instrument panel. As a result, either the edges of the deploying air bag module's cover flap or more likely the fabric of the deploying air bag deflected her hands away from the instrument panel. This contractor believes that her left hand was deflected upwards toward the top of the right windshield, near the left side of the passenger's sun visor, while her right hand may have been deflected upwards into the right "A"-pillar. It should be noted that although this contractor strongly suspects that this occupant's hand and/or forearms interacted with the vehicle's air bag module and/or interior structures, the ***available*** medical records do not discuss whether or not there were any injuries to her hands and/or forearms. As the air bag was deploying, the air bag's fabric contacted the still forward-moving front right passenger in her face and chin lifting her head forward and upwards into the windshield. Based on the available evidence it is most likely that the front right passenger's head and/or face pushed the top portion of the air bag's fabric backwards into the windshield as she traveled into it. This contractor believes this assertion because of three factors. First, there were tiny puncture holes in the top of the air bag's fabric that were most likely caused by the windshield's glazing. Second, there was no evidence of hair or skin on the windshield's glazing, and third, the ***available*** medical records make no mention, either positively or negatively, of any injuries to the occupant's forehead and/or scalp. As the front right passenger's torso was sliding forward into the air bag and windshield, her knees most likely contacted the lower instrument panel causing her lower extremities to move downward onto the floorboard as the front right passenger's head and torso rebounded rearward. At final rest the front right passenger's legs and lower torso were crumpled on the floor with her upper torso leaning back against the seat cushion. In addition, her torso was slightly turned to the left and her head arched back over the seat cushion.

The ***available*** medical records indicated that the front right passenger sustained critical brain injuries, but some uncertainty exists as to whether those injuries resulted from the deploying air bag or from the impact with the windshield. It does not appear that the front right passenger was lifted upwards into the front header and/or sun visor area because of the lack of physical contact evidence in those areas and the occupant's known final rest position (discussed above). This contractor believes that the heavy pre-crash braking combined with the front right passenger's lack of restraint use enabled her to move forward headfirst into the deploying air bag causing her brain to absorb the full force of the deploying air bag. The air bag redirected her upward into the relatively "soft" windshield glazing prior to her rebound backwards.

The front right occupant was transported by ambulance to a local hospital. She sustained critical brain injuries and was transferred, hospitalized, and subsequently pronounced dead four days post-crash. According to her medical records, the injuries sustained by the case vehicle's front right passenger included: a critical nonanatomic brain injury, a diffuse axonal injury, bilateral intra-cerebral hemorrhages, small bilateral cerebral contusions, diffuse subarachnoid hemorrhages, a left pneumothorax, and abrasions to her right cheek and chin. This occupant's critical brain injuries were most likely caused by her contact with the case vehicle's front right passenger air bag.

The case vehicle's driver [25-year-old, White (non-Hispanic) female; 170 centimeters and 73 kilograms (67 inches, 160 pounds)] was seated in an upright posture with her back against the

seat back, both feet on the brake, and both hands on the steering wheel. Her seat track was located between its middle and rearmost position, the seat back was upright, and the tilt steering wheel was located in its upmost position.

The case vehicle's driver was restrained by her available, active, three-point, lap-and-shoulder, safety belt system. The driver was not transported by ambulance to the hospital. According to her interview, she sustained a minor contusion to her chest, but she did not seek medical treatment.

The case vehicle's back left passenger [23-year-old, White (non-Hispanic) female; 170 centimeters and 91 kilograms (67 inches, 200 pounds)] was seated in an upright posture, but she was leaning forward away from her seat back, with her feet on the floor, and both arms on the driver's seat back. Her seat track and seat back were not adjustable.

The case vehicle's back left passenger was not using her available, active, three-point, lap-and-shoulder, safety belt system. According to the interview with the case vehicle's driver, the back left passenger sustained minor injuries and was treated later by a private physician. The back left passenger sustained a right shoulder strain.

The case vehicle's back right passenger [28-year-old, White (non-Hispanic) female; 165 centimeters and 64 kilograms (65 inches, 140 pounds)] was seated in an upright posture, but she was leaning forward away from her seat back, with her left leg folded under her, her right foot on the floor, and both arms on the front right passenger's seat back. Her seat track and seat back were not adjustable.

Figure 1: Case vehicle's travel path in outside lane of northbound roadway–arrow marks approximate point of impact (case photo #01)

The case vehicle's back right passenger was not using her available, active, three-point, lap-and-shoulder, safety belt system. The back right passenger was not transported by ambulance to the hospital. She sustained a minor injury and was treated later by a private physician. The back right passenger sustained a lower back strain.

Figure 2: On-scene view looking south in outside northbound lane showing Dodge at final rest (case photo #56)

CRASH CIRCUMSTANCES

The case vehicle was traveling north in outside northbound lane of a four-lane, divided, city trafficway (**Figure 1**) and intended to continue traveling northbound (i.e., both the north and southbound roadways had two through lanes, and the roadways were separated by a curbed, grassy

median). The Dodge was also traveling north in outside through lane of the same northbound roadway and had come to an abrupt stop because the traffic stopped in front of him for the traffic control signal (**Figure 2** above). The case vehicle's driver braked, depositing 3.3 meters (10.8 feet) of skid marks, while attempting to avoid the crash (**Figure 3**). The crash occurred in the outside, through lane of the northbound roadway; see **CRASH DIAGRAM** below.

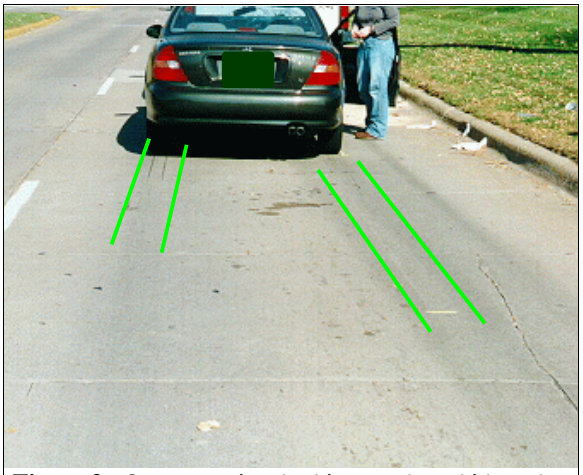


Figure 3: On-scene view looking north at skid marks deposited (highlighted) by case vehicle's front tires (case photo #57)

Figure 4: Case vehicle's frontal damage from impact and underride of Dodge pickup; Note: direct damage extends from yellow tape to front right bumper corner, hood has been flattened out, and deformity to passenger side windshield wiper (case photo #06)

The city roadway was straight and level (i.e., actual slope was less than 1.0%, negative to the north) at the area of impact (**Figure** 1 above). The pavement was concrete, but worn, and the width of the outside northbound lane was 3.9 meters (12.8 feet). The roadway was bordered by 10.2 centimeter (4 inch) high barrier curbs. The north and southbound roadways were separated by a 4.9 meter (16.1 foot) wide curbed grassy median. The northbound travel lanes were separated by a single white dashed line. In addition, the curb along the west side of the roadway was painted yellow. The estimated coefficient of friction was 0.65. The traffic controls for the northbound roadway were located approximately 75 meters (246 feet) further north from the area of impact and consisted of one horizontally mounted and one vertically mounted on-colors, pre-timed, traffic control signals. In addition, there were NO PARKING ANY TIME signs (Manual on Uniform Traffic Control Devices, R7-1) on the east and west sides of the trafficway. The statutory speed limit was 56 km.p.h. (35 m.p.h.). 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 clear, and the road pavement was dry. Traffic density was moderate

Figure 5: Damage to Dodge's back; Note: damage is restricted to underneath side of bumper and below bumper, between yellow taped areas (case photo #50)

to heavy, and the site of the crash was urban commercial.

The front (**Figure 4** above) of the case vehicle impacted the back of the Dodge (**Figure 5** above), causing the case vehicle's driver and front right passenger supplemental restraints (air bags) to deploy. The case vehicle and the Dodge moved at most only a short distance before coming to rest near the point of impact, heading northward (**Figure 6**).

Figure 6: On-scene view looking west at case vehicle's (left) and Dodge's (right) final rest positions (case photo #58)

Figure 7: On-scene view looking east at final rest positions of case vehicle (right) and Dodge (left); Note: uneven damage pattern (case photo #59)

The damage to the case vehicle was primarily above the bumper (**Figure 7**) resembling an underride impact pattern. The underride type damage resulted in the air bag deploying late during the duration of the impact. This late deployment occurred due to the prolonged change in time (Delta T) relative to the change in speed (magnitude of Delta V–i.e., ramp versus spike). Initially the case vehicle was believed to have traveled a measured distance of 114 centimeters (44.9 inches) under the back bumper and bed of the Dodge pick-up truck before contacting the back part of the transmission's differential housing (**Figure 8**). This was later discounted because there was no corresponding evidence (i.e., differential imprint) on the case vehicle.

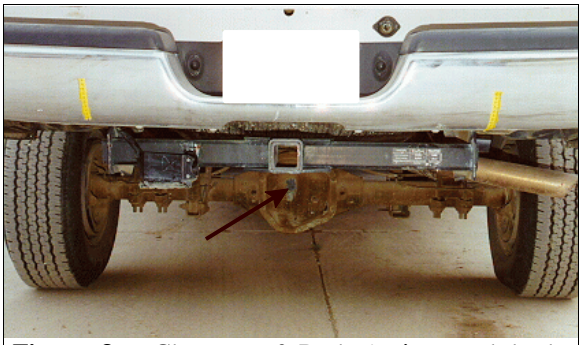


Figure 8: Close-up of Dodge's impacted back bumper and tow hitch (between yellow tape); Note: arrow shows contact to differential which was subsequently discounted (case photo #51)

CASE VEHICLE

The 1997 Hyundai Sonata GL was a front wheel drive, five-passenger, four-door sedan (VIN: KMHCF24TXVU------) equipped with a 3.0L, V-6 engine and a four-speed automatic

transmission. The case vehicle was not equipped with anti-lock brakes. Braking was achieved by a power-assisted, front disc and rear drum system. The case vehicle's wheelbase was 270 centimeters (106.3 inches), and the odometer reading at inspection was 74,390 kilometers (46,224 miles).

Inspection of the vehicle's interior revealed adjustable front bucket seats with adjustable head restraints; a non-adjustable back bench seat with separate backs and integral 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 equipped with manually operated, upper anchorage adjusters for the "D"-rings. The driver's upper anchorage adjusters was located between the middle and upmost positions and the front right passenger had her upper anchorage adjuster located in the down-most position. The vehicle was equipped with knee bolsters for both the driver and front right passenger, neither of which were deformed. Automatic restraint was provided by a Supplemental Restraint System (SRS) that consisted of a frontal air bag for the driver and front right passenger seating positions. Both frontal air bags deployed as a result of the case vehicle's frontal impact with the Dodge.

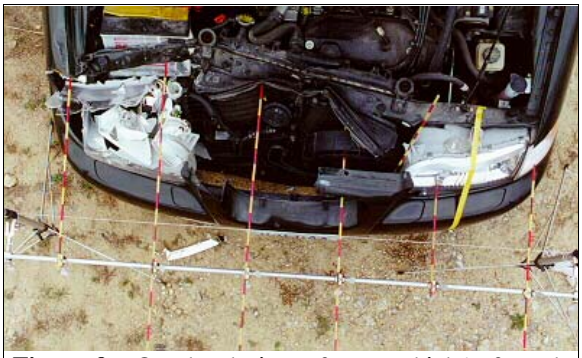


Figure 9: Overhead view of case vehicle's frontal damage with contour gauge present showing uneven damage pattern from underriding back of Dodge (case photo #10)

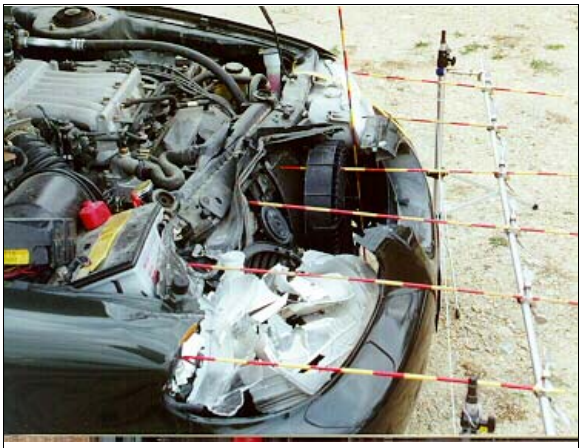


Figure 10: Reference line view from right of case vehicle's uneven frontal damage pattern with contour gauge present (case photo #14)

Figure 11: Case vehicle's frontal damage as a result of underriding Dodge; direct damage begins at front right corner and extends to yellow tape; Note: bent hood has been flattened out and right windshield wiper is bent outward at approximately its lower one-third from contact to windshield's glazing by front right passenger's head (case photo #19)

CASE VEHICLE DAMAGE

The case vehicle's contact with the Dodge involved the vast majority of its front–primarily above the bumper (**Figures 9** and **10**). Direct damage began 51 centimeters (20.1 inches) left of the vehicle's center and extended, a measured distance of 122 centimeters (48.0 inches), along the front bumper to the front right bumper corner (**Figure 11**). Residual maximum crush at bumper level was a measured as 4 centimeters (1.6 inches) at C_6, and the residual maximum crush above the bumper was measured as 33 centimeters (13.0 inches) from C_4 to C_5. The case vehicle's

wheelbase was unaltered from the crash. The case vehicle's front bumper fascia, grille, hood, right fender, and right headlight and turn signal assemblies were directly damaged and crushed rearward. The hood had two indentations from the tow hitch attached to the back of the Dodge (**Figure 8** above and **Figure 12**). The right side of the windshield's glazing was cracked and holed. This contractor believes that as the windshield's glazing flexed outward from contact by the occupant's head, the upper portion of the right windshield wiper was bent outward while the more rigid lower portion of the wiper holed the windshield (**Figure 13**). None of the case vehicle's tires were damaged, deflated, or physically restricted. The right fender and hood sustained induced damage as well. No obvious induced damage or remote buckling was noted to the remainder of the case vehicle's exterior.

Figure 12: Close-up of creases in case vehicle's hood from direct contact with Dodge's tow hitch (case photo #08)

Figure 13: Close-up of case vehicle's lower right windshield showing cracked and holed glazing from contact by front right passenger's head and lower portion of right windshield wiper, respectively (case photo #28)

Figure 14: Vertical view of case vehicle's front right passenger seating area showing contacted (tape) windshield, right "A"-pillar, front right air bag module's cover flap and top of air bag (case photo #26)

Inspection of the case vehicle's interior revealed a spider web-type impact to the right windshield's glazing from contact by the front right passenger's head (**Figure 13** and **Figure 14**). Furthermore, there was contact to near the left side of the front right sun visor, most likely from the front right passenger's left hand and a smear toward the top of the right "A"-pillar, most likely from the front right passenger's right hand. Likewise, there was a smear on the right front window's glazing also most likely from the front right passenger's right hand. In addition, there

was blood on the front right passenger's seat and a makeup transfer on the back side of the front right passenger's head rest from contact by the back right passenger.

Based on the vehicle inspection the CDC for the case vehicle was determined to be: **12-FDMW-2 (0).** The WinSMASH reconstruction program, missing vehicle algorithm, was used on the case vehicle's highest severity impact because the crush profile for the Dodge could not be determined. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 21.5 km.p.h. (13.4 m.p.h.), -21.5 km.p.h. (-13.4 m.p.h.), and 0.0 km.p.h. (0.0 m.p.h.). Although this crash has an underride type crush pattern, these results appear to be reasonable. The case vehicle was towed due to damage.

Figure 15: Vertical view of case vehicle's driver seating area and deployed air bag; Note: small area (tape) of contact evidence (case photo #25)

Figure 16: Case vehicle's deployed driver air bag showing skin transfer (yellow tape) on air bag's fabric (case photo #36)

AUTOMATIC RESTRAINT SYSTEM

The case vehicle was equipped with a Supplemental Restraint System (SRS) that contained frontal air bags at the driver and front right passenger positions. Both frontal air bags deployed as a result of the frontal impact with the Dodge. The case vehicle's driver air bag was located in the steering wheel hub. The module cover consisted of asymmetrical "H"-configuration cover flaps made of thick vinyl with overall dimensions of 17 centimeters (6.7 inches) at the horizontal seam and 7.5 centimeters (3.0 inches) vertically for the upper flap and 5.5 centimeters (2.2 inches) vertically for the lower flap. An inspection of the air bag module's cover flaps and the air bag fabric 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 approximately 13 centimeters (5.1 inches) wide, sewn internally and extending from the 1-5 and 7-11 o'clock positions. The driver's air bag had two vent ports, approximately 3 centimeters (1.2 inches) in diameter, located at the 10:30 and 1:30 o'clock positions. The deployed driver's air bag was round with a diameter 66 centimeters (26.0 inches). An inspection of the driver's air bag fabric revealed what appeared to be a skin transfer on the upper left quadrant of the air bag's fabric (**Figure 15**). The skin transfer was located

23 centimeters (9.1 inches) down from the top of the air bag and 14-15 centimeters (5.5-5.9 inches) left of center (**Figure 16** above).

The front right passenger's air bag was located in the middle of the instrument panel. There was a single, essentially rectangular, modular cover flap. The cover flap was made of a thick vinyl over a thick cardboard type frame. The flap's dimensions were 34 centimeters (13.4 inches) at the lower horizontal seam and 21 centimeters (8.3 inches) along both vertical seams. The profile of the case vehicle's instrument panel was flush with the leading edge of the cover flap. An inspection of the front right air bag module's cover flap and the air bag fabric revealed that the cover flap opened at the designated tear points and there was no evidence of damage during the deployment to the air bag's fabric. The inspection did reveal what appeared to be contact scuffs (possibly skin) to the two front corners of the front right air bag module's cover flap (**Figure 14** above). The front right passenger's air bag was designed with two tethers, each approximately 48 centimeters (18.9 inches) in width. The top tether was located 6 centimeters (2.4 inches) down from the top horizontal seam and the bottom tether was located 30 centimeters (11.8 inches) below the top tether. The front right air bag was not designed with pre-cut vent ports. The deployed front right air bag was rectangular with a height of approximately 58 centimeters (22.8 inches) and a width of approximately 49 centimeters (19.3 inches).

Figure 17: Close-up of small skin transfer to top portion of case vehicle's front right passenger air bag; Note: contacted corners of cover flap at top of photo (case photo #43)

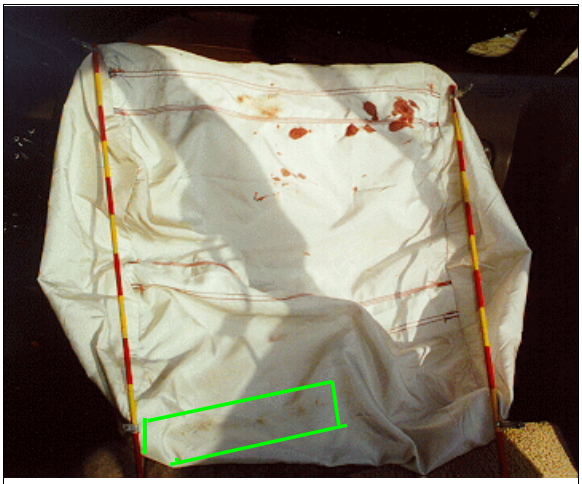


Figure 18: Case vehicle's front right passenger air bag showing blood spots and skin (highlighted) at bottom left portion (case photo #41)

An inspection of the front right passenger's air bag fabric revealed contact evidence readily apparent on the top (**Figure 17**) and front surfaces. On the top surface there was an 8 centimeter (3.1 inch) curvilinear skin transfer. On the front surface there were numerous areas of blood at and between the two tether seams in the middle of the bag (**Figure 18**). Furthermore, there was an obliquely oriented skin transfer [3 centimeters (1.2 inches) high and 29 centimeters (11.4 inches) in width] along the lower leftward portion of the air bag's front surface (**Figure 19** below) that may well have come from contact with the front right passenger's left hand and/or forearm as it was deflected away by the deploying air bag.

Immediately prior to the crash the case vehicle's front right passenger [170 centimeters and 66 kilograms (67 inches, 145 pounds)] was seated in an upright posture with her torso turned slightly to the left and her left shoulder near the seat back, both of her feet were on the floor, and both of her arms were extended forward **attempting** to brace herself against the front right instrument panel. Her seat track was located in its rearmost position, and the seat back was sightly reclined.

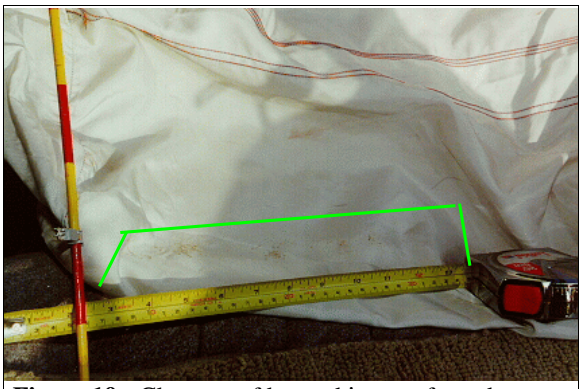


Figure 19: Close-up of large skin transfer to bottom (highlighted) of case vehicle's front right passenger air bag (case photo #42)

The case vehicle's front right passenger was not using her available, active, three-point, lap-and-shoulder, safety belt system. Furthermore, there is no evidence that indicates the presence of belt pattern bruising and/or abrasions to the front right passenger's body. In addition, the inspection of the front right passenger's seat belt webbing, "D"-ring, and latch plate showed no evidence of loading.

The case vehicle's driver braked, attempting to avoid the crash. As a result of this attempted avoidance maneuver and the nonuse of her available safety belts, the front right passenger moved forward and slightly upward just prior to impact as the case vehicle pitched slightly downward from the heavy braking. The case vehicle's impact and subsequent underride with the Dodge enabled the case vehicle's front right passenger to continue forward and upward toward the **0** degree Direction of Principal Force as the case vehicle decelerated. As previously mentioned, the delayed deployment of the case vehicle's air bag system allowed the front right passenger to move further forward towards the front right instrument panel and air bag module. As a result of this forward motion, this contractor believes that the front right passenger responded by simultaneously putting her hands forward toward the instrument panel. As a result, either the edges of the deploying air bag module's cover flap or more likely the fabric of the deploying air bag deflected her hands away from the instrument panel. This contractor believes that her left hand was deflected upwards toward the top of the right windshield, near the left side of the passenger's sun visor, while her right hand may have been deflected upwards into the right "A"-pillar. It should be noted that although this contractor strongly suspects that this occupant's hand and/or forearms interacted with the vehicle's air bag module and/or interior structures, the ***available*** medical records do not discuss whether or not there were any injuries to her hands and/or forearms. As the air bag was deploying, the air bag's fabric contacted the still forward-moving front right passenger in her face and chin lifting her head forward and upwards into the windshield. Based on the available evidence it is most likely that the front right passenger's head and/or face pushed the top portion of the air bag's fabric backwards into the windshield as she traveled into it. This contractor believes this assertion because of three factors. First, there were tiny puncture holes in the top of the air bag's fabric that were most likely caused by the windshield's glazing. Second, there was no evidence of hair or skin on the windshield's glazing, and third, the ***available*** medical records make no mention, either positively or negatively, of any injuries to the occupant's

forehead and/or scalp. As the front right passenger's torso was sliding forward into the air bag and windshield, her knees most likely contacted the lower instrument panel causing her lower extremities to move downward onto the floorboard as the front right passenger's head and torso rebounded rearward. At final rest the front right passenger's legs and lower torso were crumpled on the floor with her upper torso leaning back against the seat cushion. In addition, her torso was slightly turned to the left and her head arched back over the seat cushion.

The ***available*** medical records indicated that the front right passenger sustained critical brain injuries, but some uncertainty exists as to whether those injuries resulted from the deploying air bag or from the impact with the windshield. It does not appear that the front right passenger was lifted upwards into the front header and/or sun visor area because of the lack of physical contact evidence in those areas and the occupant's known final rest position (discussed above). This contractor believes that the heavy pre-crash braking combined with the front right passenger's lack of restraint use enabled her to move forward headfirst into the deploying air bag causing her brain to absorb the full force of the deploying air bag. The air bag redirected her upward into the relatively "soft" windshield glazing prior to her rebound backwards.

CASE VEHICLE FRONT RIGHT PASSENGER INJURIES

The front right occupant was transported by ambulance to a local hospital. She sustained critical brain injuries and was transferred, hospitalized, and subsequently pronounced dead four days post-crash. According to her medical records, the injuries sustained by the case vehicle's front right passenger included: a critical nonanatomic brain injury, a diffuse axonal injury, bilateral intra-cerebral hemorrhages, small bilateral cerebral contusions, diffuse subarachnoid hemorrhages, a left pneumothorax, and abrasions to her right cheek and chin. This occupant's critical brain injuries were most likely caused by her contact with the case vehicle's front right passenger air bag.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Nonanatomic brain injury with unconsciousness, GCS=3, decerebrate posturing, nonresponsive to painful stimuli; possible hypoxic[1] brain injury	160824.5 critical	Air bag, front right passenger's	Certain	Hospitalization records

[1] The following terms are defined in DORLAND'S ILLUSTRATED MEDICAL DICTIONARY as follows:
anoxic (a-nok/sik): pertaining to or characterized by anoxia.
anoxia (a-nok/se-a): a total lack of oxygen; often used interchangeably with ***hypoxia*** to mean a reduced supply of oxygen to the tissues.
hypoxemia (hi"pok-se/e-a): deficient oxygenation of the blood; hypoxia.
hypoxia (hi-pok/se-a): reduction of oxygen supply to tissue below physiological levels despite adequate perfusion of the tissue by blood. Compare with ***anoxia***.
hypoxia-ischemia (hi-pok/se-a-is-ke/me-a): the changes occurring in tissues when the blood supply is cut off, particularly in a fetus or infant with asphyxia.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
2	Diffuse axonal injury (i.e., hemorrhages consistent with shear injuries)	140628.5 critical	Air bag, front right passenger's	Certain	Hospitalization records
3 4	Hemorrhages, intracerebral, in bilateral frontal and temporal regions with edema[2] surrounding hemorrhages; edema effaces sulci bilaterally with small mass effect on right and mild midline shift of structures to left	140638.4 140638.4 severe	Air bag, front right passenger's	Certain	Hospitalization records
5	Contusions, small {tiny}, bilateral inferior frontal and temporal lobes and left upper parietal lobe	140622.3 serious	Air bag, front right passenger's	Probable	Hospitalization records
6	Hemorrhage, subarachnoid, scattered most notably in superior sulcal regions [Aspect = Unknown]	140684.3 serious	Air bag, front right passenger's	Probable	Hospitalization records
7	Injury, thoracic cavity, with small left apical pneumothorax	442202.3 serious	Air bag, front right passenger's	Probable	Hospitalization records
8 9	Abrasion right cheek Abrasion chin	290202.1 290202.1 minor	Air bag, front right passenger's	Certain	Emergency room records

CASE VEHICLE DRIVER KINEMATICS

The case vehicle's driver [25-year-old, White (non-Hispanic) female; 170 centimeters and 73 kilograms (67 inches, 160 pounds)] was seated in an upright posture with her back against the seat back, both feet on the brake, and both hands on the steering wheel. Her seat track was located between its middle and rearmost position, the seat back was upright, and the tilt steering wheel was located in its upmost position.

The case vehicle's driver was restrained by her available, active, three-point, lap-and-shoulder, safety belt system. Although there was no evidence of belt pattern bruising and/or abrasions to the driver's body, the inspection of the driver's seat belt webbing, "D"-ring, and latch plate showed trace evidence of usage during this crash.

[2] According to her medical records, she had high intracranial pressures despite aggressive medical management. Because her intracranial pressures were unable to be controlled, she subsequently died.

The case vehicle's driver braked, attempting to avoid the crash. As a result of this attempted avoidance maneuver and the nonuse of her available safety belts, the driver moved forward and slightly upward just prior to impact as the case vehicle pitched slightly downward from the heavy braking. The driver's braking maneuver caused her seat belt retractor to locked up. The case vehicle's impact and subsequent underride with the Dodge enabled the case vehicle's driver to continue forward and upward toward the **0** degree Direction of Principal Force as the case vehicle decelerated. As a result of this forward motion, this contractor believes that the driver loaded her safety belts, limiting her forward movement. The delayed deployment of the case vehicle's air bag system had little effect on the driver because of her seat belt usage. As the air bag was deploying, the air bag's fabric contacted the still forward-moving driver in her face, neck, and chest knocking her backwards into her seat back. At final rest she remained near her original seating position.

CASE VEHICLE DRIVER INJURIES

The driver was not transported by ambulance to the hospital. According to her interview, she sustained a minor contusion to her chest, but she did not seek medical treatment.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Contusion chest, not further specified	490402.1 minor	Air bag, driver's	Probable	Interviewee (same person)

CASE VEHICLE BACK LEFT PASSENGER KINEMATICS

The case vehicle's back left passenger [23-year-old, White (non-Hispanic) female; 170 centimeters and 91 kilograms (67 inches, 200 pounds)] was seated in an upright posture, but she was leaning forward away from her seat back, with her feet on the floor, and both arms on the driver's seat back. Her seat track and seat back were not adjustable.

The case vehicle's back left passenger was not using her available, active, three-point, lap-and-shoulder, safety belt system. Furthermore, the inspection of the back left passenger's seat belt webbing and latch plate showed no evidence of usage during this crash.

The case vehicle's driver braked, attempting to avoid the crash. As a result of this attempted avoidance maneuver and the nonuse of her available safety belts, the back left passenger moved forward and slightly upward just prior to impact as the case vehicle pitched slightly downward from the heavy braking. As a result of this forward motion, this contractor believes that the back left passenger responded by simultaneously putting her hands forward toward the driver's seat back. The case vehicle's impact and subsequent underride with the Dodge enabled the case vehicle's back left passenger to continue forward and upward toward the **0** degree Direction of Principal Force as the case vehicle decelerated. As a result, she contacted the driver's seat back. At final rest she remained in the back seat but her exact position is unknown.

According to the interview with the case vehicle's driver, the back left passenger sustained minor injuries and was treated later by a private physician. The back left passenger sustained a right shoulder strain.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Sprain right shoulder, not further specified	751020.1 minor	Seat back, driver's	Probable	Interviewee (driver)

CASE VEHICLE BACK RIGHT PASSENGER KINEMATICS

The case vehicle's back right passenger [28-year-old, White (non-Hispanic) female; 165 centimeters and 64 kilograms (65 inches, 140 pounds)] was seated in an upright posture, but she was leaning forward away from her seat back, with her left leg folded under her, her right foot on the floor, and both arms on the front right passenger's seat back. Her seat track and seat back were not adjustable.

The case vehicle's back right was not using her available, active, three-point, lap-and-shoulder, safety belt system. Furthermore, the inspection of the back right passenger's seat belt webbing and latch plate showed no evidence of usage during this crash.

The case vehicle's driver braked, attempting to avoid the crash. As a result of this attempted avoidance maneuver and the nonuse of her available safety belts, the back right passenger moved forward and slightly upward just prior to impact as the case vehicle pitched slightly downward from the heavy braking. As a result of this forward motion, this contractor believes that the back right passenger responded by simultaneously putting her hands forward toward the front right passenger's seat back. The case vehicle's impact and subsequent underride with the Dodge enabled the case vehicle's back right passenger to continue forward and upward toward the **0** degree Direction of Principal Force as the case vehicle decelerated. As a result, her face impacted the back side of the front right seating position's head rest, depositing a makeup smear (**Figure 20**), and her torso hit the seat back. At final rest she remained in the back seat but her exact position is unknown.

Figure 20: Case vehicle's back seating area; Note: a makeup transfer was found on the back side of the front right head restraint (case photo #47)

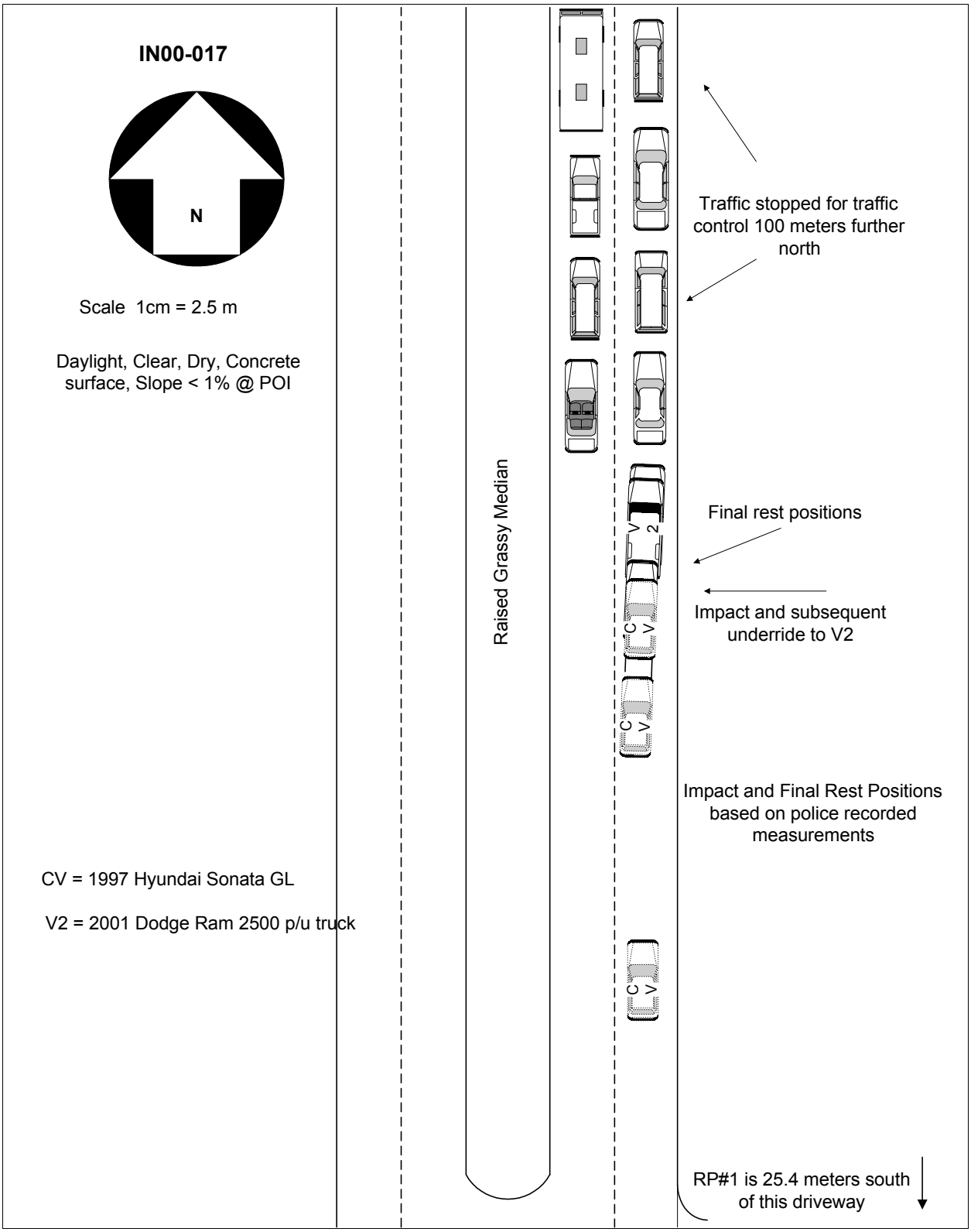
The back right passenger was not transported by ambulance to the hospital. She sustained a minor injury and was treated later by a private physician. The back right passenger sustained a lower back strain.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Strain lumbar (lower back) spine	640678.1 minor	Seat back, front right passenger's	Probable	Interviewee (driver)

OTHER VEHICLE

The 2001 Dodge Ram 2500 was a four wheel drive, 4x4, three-passenger, two-door, standard bed, conventional cab pickup (VIN: 3B7KF26Z71M------) equipped with a 5.9L, V-8 engine and a four-speed automatic transmission with overdrive. Braking was achieved by a power-assisted, front and rear disc, four-wheel, anti-lock system. The case vehicle's wheelbase was 342 centimeters (134.7 inches), and the odometer reading at inspection is unknown because the interior of the Dodge was not inspected.

Based on the vehicle inspection the CDC for the Dodge was determined to be: **06-BYLW-1 (180)**. The WinSMASH reconstruction program, missing vehicle algorithm, was used on the Dodge's highest severity impact because the crush profile for the Dodge could not be determined. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 14.1 km.p.h. (8.8 m.p.h.), +14.1 km.p.h. (+8.8 m.p.h.), and 0.0 km.p.h. (0.0 m.p.h.). The Dodge was driven from the scene.


IN00-017
N
Scale 1cm = 2.5 m
Daylight, Clear, Dry, Concrete surface, Slope < 1% @ POI
Raised Grassy Median
Traffic stopped for traffic control 100 meters further north
Final rest positions
Impact and subsequent underride to V2
Impact and Final Rest Positions based on police recorded measurements
CV = 1997 Hyundai Sonata GL
V2 = 2001 Dodge Ram 2500 p/u truck
RP#1 is 25.4 meters south of this driveway
C V
V 2