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 REDESIGNED AIR BAG INVESTIGATION

CASE NUMBER - IN98-032
LOCATION - ILLINOIS
VEHICLE - 1998 DODGE CARAVAN
CRASH DATE - December, 1998

Submitted:

February 12, 2003

Contract Number: DTNH22-94-D-17058

Prepared for:

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The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points be coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety systems.

Technical Report Documentation Page

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15. *Supplementary Notes*
On-site air bag deployment investigation involving a 1998 Dodge Caravan, three-door minivan, with manual safety belts, driver air bag, redesigned front right air bag, and a 1997 GMC Suburban, four-door wagon

16. *Abstract*
This report covers an on-site investigation of an air bag deployment crash that involved a 1998 Dodge Caravan (case vehicle) and a 1997 GMC Suburban (other vehicle). This crash is of special interest because the case vehicle's unrestrained driver (39-year-old female) sustained critical chest injuries as a result of loading her steering wheel as well as minor injuries from impacting her deploying driver air bag, resulting in her death. The case vehicle was traveling north in the northbound lane of a two-lane, divided, city street [i.e., both the north and southbound roadways had only one travel lane, and the lanes were separated by two double-solid-yellow center lines, spaced approximately 1.3 meters (4.3 feet) apart at the point of impact]. The Suburban was traveling south in the southbound roadway of the same two-lane, divided, city street. The crash occurred in the southbound roadway of the trafficway. The front of the case vehicle impacted the front of the Suburban, causing the case vehicle's driver (i.e., first generation) and front right passenger (i.e., redesigned–next generation) supplemental restraints (air bags) to deploy. The Suburban was pushed rearward by the head-on impact. The case vehicle rotated slightly counterclockwise as a result of the impact and then continued north-northwestward where it came to rest on the west sidewalk. The case vehicle's driver was "sitting upright" with her seat track located between its middle and rearmost positions, and the vehicle was not equipped with a tilt steering wheel. She was not using her available, active, three-point, lap-and-shoulder, safety belt system and sustained, according to her autopsy, critical chest injuries which included: multiple bilateral rib fractures, a major laceration to her left pulmonary vein, a heart contusion, and a fractured sternum. In addition, she sustained multiple lacerations to her liver and spleen and contusions to her chest, abdomen, right upper arm, right thigh, and both lower legs. The patient's total blood loss was approximately 45% by volume. This occupant's critical chest injuries were caused primarily when she loaded the case vehicle's steering wheel after loading through her deployed driver air bag as a result of the crash forces, but her air bag contributed to the seriousness of her injuries.

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This on-site investigation was brought to NHTSA's attention on December 16, 1998, by a staff member of an NHTSA regional office. This crash involved a 1998 Dodge Caravan (case vehicle) and a 1997 GMC Suburban (other vehicle). The crash occurred in December, 1998, at 1:59 p.m., in Illinois, and was investigated by the applicable city police department. This crash is of special interest because the case vehicle's unrestrained driver [39-year-old, White (unknown if Hispanic) female] sustained critical chest injuries as a result of loading her steering wheel as well as minor injuries from impacting her deploying driver air bag, resulting in her death. This case initially began as an **ADULT AIR BAG-RELATED FATALITY INVESTIGATION**; however, this case became a **REDESIGNED AIR BAG INVESTIGATION** after it was determined that the steering wheel was the injury mechanism that caused the lesions that resulted in the driver's death. This contractor inspected the scene and the case vehicle on 21 December and the Suburban on December 22, 1998. The Suburban's driver was interviewed on December 21, 1998. This report is based on the Police Crash Report, an interview with the Suburban's driver, conversations with the investigating police officer, scene and vehicle inspections, occupant kinematic principles, the autopsy performed on the case vehicle's driver, and this contractor's evaluation of the evidence.

SUMMARY

The case vehicle was traveling north in the northbound lane of a two-lane, divided, city street and intended to continue its northerly travel path [i.e., both the north and southbound roadways had only one travel lane, and the lanes were separated by two double-solid-yellow center lines, spaced approximately 1.3 meters (4.3 feet) apart at the point of impact]. The Suburban was traveling south in the southbound roadway of the same two-lane, divided, city street and intended to continue its southerly travel path. The case vehicle's driver made no avoidance maneuvers prior to the crash. The Suburban's driver braked attempting to avoid the crash. The crash occurred in the southbound roadway of the trafficway; see **CRASH DIAGRAM** below.

The front of the case vehicle impacted the front of the Suburban, causing the case vehicle's driver (i.e., first generation) and front right passenger (i.e., redesigned–next generation) supplemental restraints (air bags) to deploy. The Suburban was pushed rearward by the head-on impact. The case vehicle rotated slightly counterclockwise as a result of the impact and then continued north-northwestward off the west side of the southbound roadway. The case vehicle came to rest with all tires, except the right rear, on the west sidewalk. The Suburban was pushed backwards in the southbound lane and rotated slightly clockwise before coming to rest in the southbound lane with its left rear tire straddling the median's double- solid-yellow lines.

The 1998 Dodge Caravan was a front wheel drive, three-door minivan (VIN: 2B4FP25B9WR------). Based on the vehicle inspection, the CDC for the case vehicle was determined to be: **12-FDEW-2 (10)**. The WinSMASH reconstruction program, damage only algorithm, was used on the case vehicle's highest severity impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 37.0 km.p.h. (23.0 m.p.h.), -36.4 km.p.h. (-22.6 m.p.h.), and -6.4 km.p.h. (-4.0 m.p.h.). The case vehicle was towed due to disabling damage.

The case vehicle's initial contact with the Suburban involved its front left half; however, as the case vehicle pushed the Suburban backwards while continuing in its north-northwesterly direction, the remaining width of the front bumper was directly damaged. Direct damage began at the front left bumper corner and extended, a measured distance of 152 centimeters (59.8 inches), along the front bumper to the front right bumper corner. Residual maximum crush was measured as 32 centimeters (12.6 inches) at C_1. The case vehicle's wheelbase was unaltered from the crash. The case vehicle's front bumper, bumper fascia, grille, hood, 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 from the crash. The right headlight and turn signal assemblies sustained induced damage as well as both the right and left fenders.

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 or the cover flaps. The driver's air bag was designed with two tethers, each approximately 6 centimeter (2.4 inches) in width. The driver's air bag had no vent ports. The deployed driver's air bag was elliptical with a height of approximately 54 centimeters (21.3 inches) and a width of approximately 65 centimeters (25.6 inches). An inspection of the driver's air bag fabric revealed a lipstick smear at the lower midline of the circular center stitching, several black scratches adjacent to the center stitching at the top left quadrant of the bag's fabric, and clear body fluid stains to the middle of the bottom left quadrant of the air bag.

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 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 front right passenger's air bag was designed without any tethers. The front right air bag had no vent ports. The deployed front right air bag was rectangular with a height of approximately 72 centimeters (28.3 inches) and a width of 46 centimeters (18.1 inches). An inspection of the front right passenger's air bag fabric revealed no contact evidence readily apparent on the air bag's fabric.

Inspection of the case vehicle's interior revealed possible knee contacts to the driver's knee bolster on both sides of the steering column and scratches on the interior surface of the driver's door at the window sill and on the armrest. In addition, the upper portion of the steering wheel rim was bent toward the left instrument panel, 3 centimeters (1.2 inches), as a result of the driver loading the air bag, momentarily blocking the air bag's forward expansion, and causing the air bag to expand against and bend the steering wheel rim.

The 1997 GMC Suburban 1500 SLT was a rear wheel drive, 4x2, four-door utility station wagon (VIN: 1GKEC16R9VJ------). The Suburban was equipped with driver and front right passenger supplemental restraints (air bags) which deployed as a result of its frontal impact. Based on the vehicle inspection, the CDC for the Suburban was determined to be: **12-FDEW-3 (350)** [maximum crush was 57 centimeters (22.4 inches)]. The WinSMASH reconstruction program, damage only algorithm, was used on the Suburban's highest severity impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 27.0 km.p.h. (16.8 m.p.h.), -26.6 km.p.h.

(-16.5 m.p.h.), and +4.7 km.p.h. (+2.9 m.p.h.). The Suburban was towed due to disabling damage.

The Suburban's initial contact with the case vehicle involved its front left half; however, as the Suburban was pushed backwards by the case vehicle as the case vehicle continued in its north-northwesterly direction, the remaining width of the Suburban's front bumper was directly damaged. Direct damage began at the front left bumper corner and extended, a measured distance of 132 centimeters (52.0 inches), along the front bumper toward the front right bumper corner. Residual maximum crush was measured as 57 centimeters (22.4 inches) at C_1. The wheelbase on the case vehicle's left side was shortened 12 centimeters (4.7 inches) while the right side was unaltered from the crash. The case vehicle's front bumper, bumper fascia, grille, hood, radiator, 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 top of the tire was rotated inward from the crash. The right headlight and turn signal assemblies sustained induced damage as well as the left fender.

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 or the cover flaps. The driver's air bag was designed with two tethers, each approximately 9 centimeter (3.5 inches) in width. The driver's air bag had two vent ports, approximately 2 centimeters (0.8 inches) in diameter, located at the 11 and 1 o'clock positions. The deployed driver's air bag was elliptical with a height of approximately 64 centimeters (25.2 inches) and a width of approximately 54 centimeters (21.3 inches). An inspection of the driver's air bag fabric revealed black scratch marks near the air bag's lower seam on the left lower quadrant, toward the center of the air bag, and near the center of the right lower quadrant.

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 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 front right passenger's air bag was designed without any tethers. The front right air bag had two vent ports, approximately 6 centimeters (2.4 inches) in diameter, located at the 10 and 2 o'clock positions. The deployed front right air bag was rectangular with a height of approximately 45 centimeters (17.7 inches) and a width of approximately 54 centimeters (21.3 inches). An inspection of the front right passenger's air bag fabric revealed no contact evidence readily apparent on the front right air bag's.

Inspection of the case vehicle's interior revealed scratches on the steering wheel rim just to the left of top-center. Furthermore, cloth transfers were found on the left lower instrument panel, and a slight depression was detected to the right side of the driver's sun visor.

All that is known of the posture of the case vehicle's driver [168 centimeters and 59 kilograms (66 inches, 130 pounds)] is that, immediately prior to the crash, she was "sitting upright", and her head could be seen by the Suburban's driver who was attempting to make eye contact. The Suburban's driver was not successful since he indicated that he never saw the eyes

of the case vehicle's driver. It is unknown if the back of the case vehicle's driver was against her seat back. According to the investigating police officer, the case vehicle's driver, who was conscious post-crash, indicated that she must have fallen asleep. According to her autopsy, her blood alcohol concentration was 103 mg/dl (i.e., .103). Thus, she may have been slumped forward just prior to impact. Also unknown are her feet and hand positions; although, presumably, her left foot was on the floor, her right foot on the accelerator (i.e., given that the case vehicle drove a heavier vehicle backwards as a result of the crash), and her hands on the steering wheel. At the time of the vehicle inspection, the driver's seat track was located between its middle and rearmost positions, the seat back was sightly reclined, and the vehicle was not equipped with a tilt steering wheel.

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, and the inspection of the driver's seat belt webbing, "D"-ring, and latch plate showed no evidence of loading.

The case vehicle's driver made no known avoidance maneuvers prior to the crash. As a result and independent of the nonuse of her available safety belts, her pre-impact body position did not change just prior to impact. Given the driver's posture, it is likely that the driver was close to the steering wheel just prior to the impact. The case vehicle's frontal impact with the Suburban enabled the case vehicle's driver to continue forward and slightly upward toward the **10** degree Direction of Principal Force loading her deploying air bag as the case vehicle decelerated. In addition, because of her close proximity to the air bag module at the time of the air bag's deployment, the resistance caused by the driver to the air bag's expansion most likely caused the air bag to expand towards the left instrument panel and deform the upper portion of the steering wheel rim. When the case vehicle reached maximum engagement, the driver rebounded backwards toward the right side of her seat back. She most likely rebounded face-first into the air bag and moved slightly to the right as the case vehicle was redirected counterclockwise. The exact posture of the case vehicle's driver at final rest is unknown, but she was most likely sitting in her seat near her pre-crash posture.

The driver was transported by ambulance to the hospital. She was initially able to converse with the investigating police officers. In reality, she sustained critical injuries, exsanguinated, and was pronounced dead at the hospital, one hour and forty-three minutes post-crash. According to her autopsy, the case vehicle's driver sustained critical chest injuries which included: multiple bilateral rib fractures, a major laceration to her left pulmonary vein, a heart contusion, and a fractured sternum. In addition, she sustained multiple lacerations to her liver and spleen and contusions to her chest, abdomen, right upper arm, right thigh, and both lower legs. The patient's total blood loss was approximately 45% by volume. This occupant's critical chest injuries were caused primarily when she loaded the case vehicle's steering wheel after loading through her deployed driver air bag as a result of the crash forces, but her air bag contributed to the seriousness of her injuries.

The Suburban's driver [42-year-old, White (non-Hispanic) male; 178 centimeters and 75 kilograms (70 inches, 165 pounds)] was seated in an upright posture with his back against the seat

back, his left foot on the floor, and his right foot on the brake. In addition, the exact position of his hands is unknown (i.e., the driver was unsure if they were on the steering wheel). His seat track was located between its middle and rearmost positions, the seat back was upright, and the tilt steering wheel was located between its middle and down-most positions.

The Suburban's driver was restrained by his available, active, three-point, lap-and-shoulder, safety belt system. Furthermore, there was evidence of shoulder belt abrasions to the driver's left shoulder, and the inspection of the driver's seat belt webbing, "D"-ring, and latch plate showed slight stretching on the belt's webbing and the "D"-ring had faint scratches. The latch plate showed no indication of loading.

When the Suburban's driver noticed the case vehicle crossing the median (i.e., the double center lines), he applied his brakes and slowed from approximately 48 km.p.h. (30 m.p.h.) to an estimated 24 km.p.h. (15 m.p.h.) at impact. As a result of his pre-crash braking and the use of his available safety belts, the driver's body moved only slightly forward just prior to impact. The Suburban's impact with the case vehicle enabled the Suburban's driver to moved forward and slightly to the left toward the **350** degree Direction of Principal Force as the Suburban decelerated.

The Suburban's driver exited his vehicle under his own power, refused medical treatment at the scene, and was not transported to a medical facility. Later, he was taken by private vehicle to a hospital emergency room where he was treated and released. According to the Suburban's driver, his self-reported injuries included abrasions to his left shoulder and left hand, a contusion to his left wrist, and a strained {i.e., "wrenched"} lower back.

CRASH CIRCUMSTANCES

Figure 1: Case vehicle's northbound travel path; arrow indicates approximate point of impact in southbound lane (case photo #02)

The case vehicle was traveling north in the northbound lane of a two-lane, divided (**Figure 1**), city street and intended to continue its northerly travel path [i.e., both the north and southbound roadways had only one travel lane, and the lanes were separated by two double-solid-yellow center lines, spaced approximately 1.3 meters (4.3 feet) apart at the point of impact]. The Suburban was traveling south in the southbound roadway of the same two-lane, divided, city street and intended to continue its southerly travel path. The case vehicle's driver made no avoidance maneuvers prior to the crash. The Suburban's driver braked attempting to avoid the crash. The crash occurred in the southbound roadway of the trafficway; see **CRASH DIAGRAM** below.

The city roadway was straight and level (i.e., actual slope was 1.0%, positive to the north) at the area of impact. The pavement was concrete, and new, and the width of the travel lanes was 4.3 meters (14.1 feet) for both the northbound and southbound lanes. The concrete, unprotected median was 1.3 meters (4.3 feet) wide. The roadway was bordered by barrier curbs. Pavement

markings consisted of two pair of double solid yellow center lines that border the median that separated the north and southbound roadways. In addition, no edge lines were present. The estimated coefficient of friction was 0.85. There were no visible traffic controls located in the immediate area of the crash. 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 light, and the site of the crash was urban commercial.

The front of the case vehicle (**Figure 2**) impacted the front of the Suburban (**Figure 3**), causing the case vehicle's driver (i.e., first generation) and front right passenger (i.e., redesigned–next generation) supplemental restraints (air bags) to deploy. The Suburban was pushed rearward by the head-on impact. The case vehicle rotated slightly counterclockwise as a result of the impact and then continued north-northwestward off the west side of the southbound roadway. The case vehicle came to rest with all tires, except the right rear, on the west sidewalk. The Suburban was pushed backwards in the southbound lane and rotated slightly clockwise before coming to rest in the southbound lane with its left rear tire straddling the median's double- solid-yellow lines.

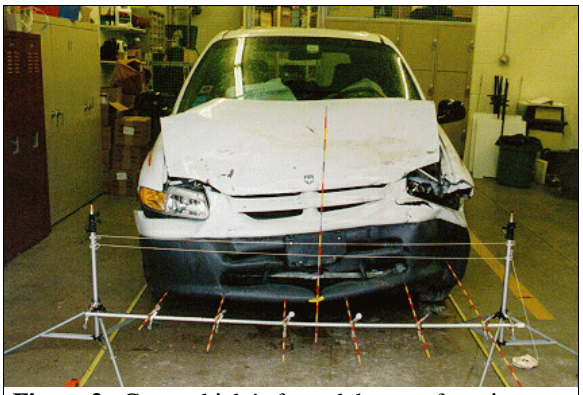


Figure 2: Case vehicle's frontal damage from impact with GMC Suburban; Note: contour gauge present at bumper level (case photo #09)

Figure 3: GMC Suburban's frontal damage from impact with case vehicle (case photo #51)

CASE VEHICLE

The 1998 Dodge Caravan was a front wheel drive, seven-passenger, three-door minivan (VIN: 2B4FP25B9WR------) equipped with a 2.4L, I-4 engine and a three-speed automatic transmission. Braking was achieved by a power-assisted, front disc and rear drum system. The case vehicle's wheelbase was 288 centimeters (113.3 inches), and the odometer reading at inspection was 49,925 kilometers (29,158 miles).

Inspection of the vehicle's interior revealed adjustable front bucket seats with adjustable head restraints; non-adjustable bench seats for the second and back seating areas neither of which had head restraints for the outboard seating positions; continuous loop, three-point, lap-and-shoulder, safety belt systems at the front, second, and back outboard positions; and a two-point, lap belt system at the back center position. The front and second seating area belt systems were equipped

with manually operated height adjusters for the "D"-rings. For the front and second center seat the height adjusters were located in their down-most positions. The height adjuster for the second seat left position was located in its middle position. The vehicle was equipped with knee bolsters for both the driver and front right passenger and there were scratches noted on the driver's knee bolster, both left and right of the steering column. Automatic restraint was provided by a Supplemental Restraint System (SRS) that consisted of a frontal air bag for the driver (1st generation) and front right passenger (redesigned) seating positions. Both frontal air bags deployed as a result of the case vehicle's frontal impact with the Suburban.

CASE VEHICLE DAMAGE

The case vehicle's initial contact with the Suburban involved its front left half (**Figure 4**); however, as the case vehicle pushed the Suburban backwards while continuing in its north-northwesterly direction, the remaining width of the front bumper was directly damaged (**Figure 5**). Direct damage began at the front left bumper corner and extended, a measured distance of 152 centimeters (59.8 inches), along the front bumper to the front right bumper corner. Residual maximum crush was measured as 32 centimeters (12.6 inches) at C_1. The case vehicle's wheelbase was unaltered from the crash. The case vehicle's front bumper, bumper fascia, grille, hood, 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 from the crash. The right headlight and turn signal assemblies sustained induced damage as well as both the right and left fenders.

Figure 4: Case vehicle's frontal damage viewed from left of front showing maximum crush at C_1 (case photo #11)

Figure 5: Case vehicle's frontal damage viewed from right of front (case photo #23)

Inspection of the case vehicle's interior revealed possible knee contacts to the driver's knee bolster on both sides of the steering column (**Figure 6**) and scratches on the interior surface of the driver's door at the window sill and on the armrest. In addition, the upper portion of the steering wheel rim was bent toward the left instrument panel, 3 centimeters (1.2 inches), as a result of the driver loading the air bag, momentarily blocking the air bag's forward expansion, and causing the air bag to expand

Figure 6: Case vehicle's driver seating area showing contact evidence on driver's knee bolster, left of steering column (case photo #31)

against and bend the steering wheel rim (**Figure 7**).

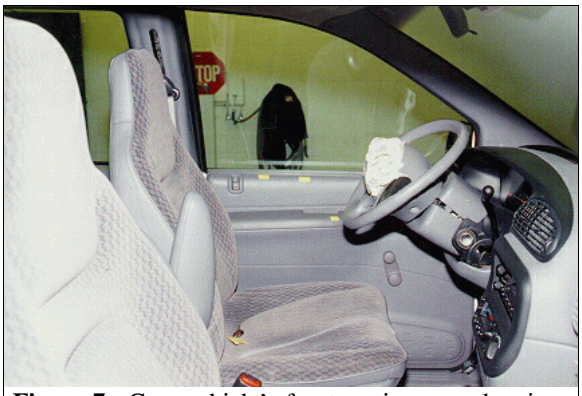


Figure 7: Case vehicle's front seating area showing scratches on interior surface of driver's door and deformed steering wheel rim (case photo #35a)

Based on the vehicle inspection, the CDC for the case vehicle was determined to be: **12-FDEW-2 (10)**. The WinSMASH reconstruction program, damage only algorithm, was used on the case vehicle's highest severity impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 37.0 km.p.h. (23.0 m.p.h.), -36.4 km.p.h. (-22.6 m.p.h.), and -6.4 km.p.h. (-4.0 m.p.h.). The case vehicle was towed due to disabling damage.

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. The driver's air bag was a 1st generation air bag while the front right passenger air bag was redesigned. Both air bags deployed as a result of the frontal impact with the Suburban. 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 18 centimeters (7.1 inches) at the horizontal seam and 10 centimeters (3.9 inches) vertically for the upper flap and 2 centimeters (0.8 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 approximately 6 centimeter (2.4 inches) in width. The driver's air bag had no vent ports. The deployed driver's air bag was elliptical with a height of approximately 54 centimeters (21.3 inches) and a width of approximately 65 centimeters (25.6 inches). An inspection of the driver's air bag fabric revealed a lipstick smear at the lower midline of the circular center stitching, several black scratches adjacent to the center stitching at the top left quadrant of the bag's fabric, and clear body fluid stains to the middle of the bottom left quadrant of the air bag (**Figure 8** and **Figure 9** below).

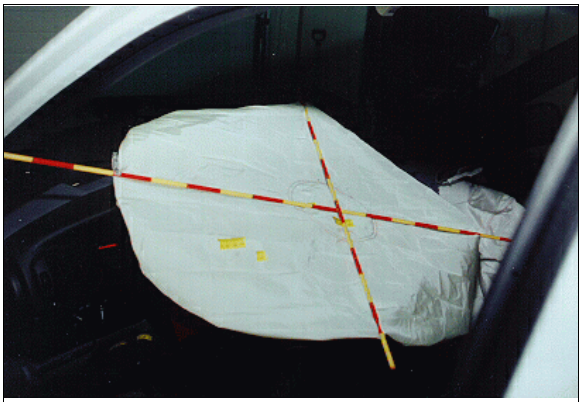


Figure 8: Case vehicle's deployed driver air bag; Note: yellow tape marks contact evidence (case photo #40)

The front right passenger's air bag was located in the middle of the instrument panel. There were two, symmetrical, "H"-configuration modular cover flaps made of thick vinyl over a sheet metal frame/liner which acted as the hinge point for the deploying flaps. The flap's dimensions were: 30 centimeters (11.8 inches) at the top and bottom horizontal seams and 6 centimeters (2.4

inches) vertically for both the upper and lower flaps. 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 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 front right passenger's air bag was designed without any tethers. The front right air bag had no vent ports. The deployed front right air bag was rectangular with a height of approximately 72 centimeters (28.3 inches) and a width of 46 centimeters (18.1 inches). An inspection of the front right passenger's air bag fabric revealed no contact evidence readily apparent on the air bag's fabric (**Figure 10**).

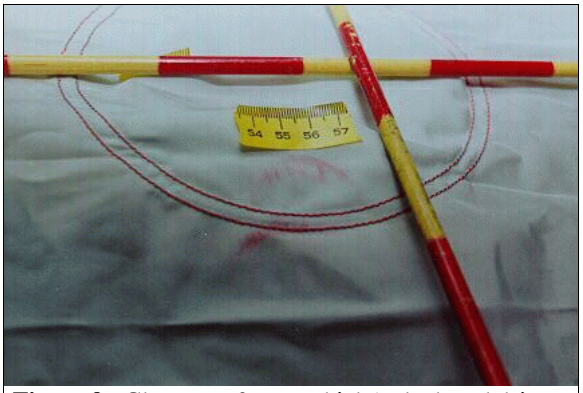


Figure 9: Close-up of case vehicle's deployed driver air bag showing lipstick imprint (case photo #42)

Figure 10: Case vehicle's deployed front right passenger air bag showing no occupant contact evidence (case photo #45)

CASE VEHICLE DRIVER KINEMATICS

All that is known of the posture of the case vehicle's driver [168 centimeters and 59 kilograms (66 inches, 130 pounds)] is that, immediately prior to the crash, she was "sitting upright", and her head could be seen by the Suburban's driver who was attempting to make eye contact. The Suburban's driver was not successful since he indicated that he never saw the eyes of the case vehicle's driver. It is unknown if the back of the case vehicle's driver was against her seat back. According to the investigating police officer, the case vehicle's driver, who was conscious post-crash, indicated that she must have fallen asleep. According to her autopsy, her blood alcohol concentration was 103 mg/dl (i.e., .103). Thus, she may have been slumped forward just prior to impact. Also unknown are her feet and hand positions; although, presumably, her left foot was on the floor, her right foot on the accelerator (i.e., given that the case vehicle drove a heavier vehicle backwards as a result of the crash), and her hands on the steering wheel. At the time of the vehicle inspection, the driver's seat track was located between its middle and rearmost positions, the seat back was sightly reclined, and the vehicle was not equipped with a tilt steering wheel.

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, and the inspection of the driver's seat belt webbing, "D"-ring, and latch plate showed no evidence of loading.

The case vehicle's driver made no known avoidance maneuvers prior to the crash. As a result and independent of the nonuse of her available safety belts, her pre-impact body position did not change just prior to impact. Given the driver's posture, it is likely that the driver was close to the steering wheel just prior to the impact. The case vehicle's frontal impact with the Suburban enabled the case vehicle's driver to continue forward and slightly upward toward the **10** degree Direction of Principal Force loading her deploying air bag as the case vehicle decelerated. In addition, because of her close proximity to the air bag module at the time of the air bag's deployment, the resistance caused by the driver to the air bag's expansion most likely caused the air bag to expand towards the left instrument panel and deform the upper portion of the steering wheel rim (**Figure 7** above). When the case vehicle reached maximum engagement, the driver rebounded backwards toward the right side of her seat back. She most likely rebounded face-first into the air bag and moved slightly to the right as the case vehicle was redirected counterclockwise. The exact posture of the case vehicle's driver at final rest is unknown, but she was most likely sitting in her seat near her pre-crash posture.

CASE VEHICLE DRIVER INJURIES

The driver was transported by ambulance to the hospital. She was initially able to converse with the investigating police officers. In reality, she sustained critical injuries, exsanguinated, and was pronounced dead at the hospital, one hour and forty-three minutes post-crash. According to her autopsy, the case vehicle's driver sustained critical chest injuries which included: multiple bilateral rib fractures, a major laceration to her left pulmonary vein, a heart contusion, and a fractured sternum. In addition, she sustained multiple lacerations to her liver and spleen and contusions to her chest, abdomen, right upper arm, right thigh, and both lower legs. The patient's total blood loss was approximately 45% by volume. This occupant's critical chest injuries were caused primarily when she loaded the case vehicle's steering wheel after loading through her deployed driver air bag as a result of the crash forces, but her air bag contributed to the seriousness of her injuries.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Fractured ribs: Right–3rd through 5th laterally, 6th anteriorly; Left: 3rd through 5th laterally with 1 liter of hemothorax	450245.5 critical	Steering wheel hub and/or spokes and rim	Certain	Autopsy
2	Laceration, major[1], left pulmonary vein	421206.4 severe	Steering wheel hub and/or spokes and rim	Certain	Autopsy

[1] This laceration may have been caused by one of the broken ribs. In any case, there was 1 liter of left hemothorax and 1 liter of hemoperitoneum. The former is certainly related to this laceration while the later (hemoperitoneum) was most likely contributed to by the multiple lacerations of this patient's liver and spleen. This patient's total blood loss was approximately 45% by volume.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
3	Contusion, 3 x 1 cm (1.2 x 0.4 in) left ventricle, anterior surface	441006.4 severe	Steering wheel hub and/or spokes and rim	Possible	Autopsy
4	Fracture mid-sternum, not further specified	450804.2 moderate	Steering wheel hub and/or spokes	Certain	Autopsy
5	Lacerations, multiple, liver, not further specified	541820.2 moderate	Steering wheel rim	Certain	Autopsy
6	Lacerations, multiple, spleen, not further specified	544220.2 moderate	Steering wheel rim	Certain	Autopsy
7	Contusion, oval-shaped, right breast	490402.1 minor	Air bag, driver's	Probable	Autopsy
8	Contusions lower abdomen, oval-shaped, right and left lower quadrants	590402.1 minor	Steering wheel rim	Probable	Autopsy
9	Contusion, oval-shaped, right upper arm, not further specified	790402.1 minor	Air bag, driver's	Probable	Autopsy
10	Contusion anterior right thigh, not further specified	890402.1 minor	Steering wheel rim	Probable	Autopsy
11	Contusions, multiple, right lower shin, not further specified and contusion, oval-shaped, anterior left shin	890402.1 minor	Left instrument panel and below	Certain	Autopsy

OTHER VEHICLE

The 1997 GMC Suburban 1500 SLT was a rear wheel drive, 4x2, four-door utility station wagon (VIN: 1GKEC16R9VJ------). The Suburban was equipped with driver and front right passenger supplemental restraints (air bags) which deployed as a result of its frontal impact.

OTHER VEHICLE DAMAGE

The Suburban's initial contact with the case vehicle involved its front left half; however, as the Suburban was pushed backwards by the case vehicle as the case vehicle continued in its north-northwesterly direction, the remaining width of the Suburban's front bumper was directly damaged (**Figure 3** above and **Figure 11** below). Direct damage began at the front left bumper corner and extended, a measured distance of 132 centimeters (52.0 inches), along the front bumper toward the front right bumper corner. Residual maximum crush was measured as 57 centimeters (22.4 inches) at C_1. The wheelbase on the case vehicle's left side was shortened 12 centimeters (4.7 inches) while the right side was unaltered from the crash. The case vehicle's front bumper, bumper fascia, grille, hood, radiator, 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 top of the tire was rotated inward from the crash (**Figure 11**). The right headlight and turn signal assemblies sustained induced damage as well as the left fender.

Inspection of the Suburban's interior revealed scratches on the steering wheel rim just to the left of top-center. Furthermore, cloth transfers were found on the left lower instrument panel, and a slight depression was detected to the right side of the driver's sun visor **(Figure 12**).

Based on the vehicle inspection, the CDC for the Suburban was determined to be: **12-FDEW-3 (350)** [maximum crush was 57 centimeters (22.4 inches)]. The WinSMASH reconstruction program, damage only algorithm, was used on the Suburban's highest severity impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 27.0 km.p.h. (16.8 m.p.h.), -26.6 km.p.h. (-16.5 m.p.h.), and +4.7 km.p.h. (+2.9 m.p.h.). The Suburban was towed due to disabling damage.

Figure 11: GMC Suburban's frontal crush viewed along left side plane (case photo #53)

Figure 12: GMC Suburban's deployed driver and front right passenger air bags (case photo #67)

AUTOMATIC RESTRAINT SYSTEM

The Suburban'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 approximately 9 centimeter (3.5 inches) in width. The driver's air bag had two vent ports, approximately 2 centimeters (0.8 inches) in diameter, located at the 11 and 1 o'clock positions. The deployed driver's air bag was elliptical with a height of approximately 64 centimeters (25.2 inches) and a width of approximately 54 centimeters (21.3 inches). An inspection of the driver's air bag fabric revealed black scratch marks near the air bag's lower seam

Figure 13: GMC Suburban's deployed driver air bag; Note: yellow tape marks contact evidence (case photo #74)

on the left lower quadrant, toward the center of the air bag, and near the center of the right lower quadrant (**Figures 12** and **13** above).

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 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 front right passenger's air bag was designed without any tethers. The front right air bag had two vent ports, approximately 6 centimeters (2.4 inches) in diameter, located at the 10 and 2 o'clock positions. The deployed front right air bag was rectangular with a height of approximately 45 centimeters (17.7 inches) and a width of approximately 54 centimeters (21.3 inches). An inspection of the front right passenger's air bag fabric revealed no contact evidence readily apparent on the front right air bag's.

OTHER VEHICLE DRIVER KINEMATICS

The Suburban's driver [42-year-old, White (non-Hispanic) male; 178 centimeters and 75 kilograms (70 inches, 165 pounds)] was seated in an upright posture with his back against the seat back, his left foot on the floor, and his right foot on the brake. In addition, the exact position of his hands is unknown (i.e., the driver was unsure if they were on the steering wheel). His seat track was located between its middle and rearmost positions, the seat back was upright, and the tilt steering wheel was located between its middle and down-most positions.

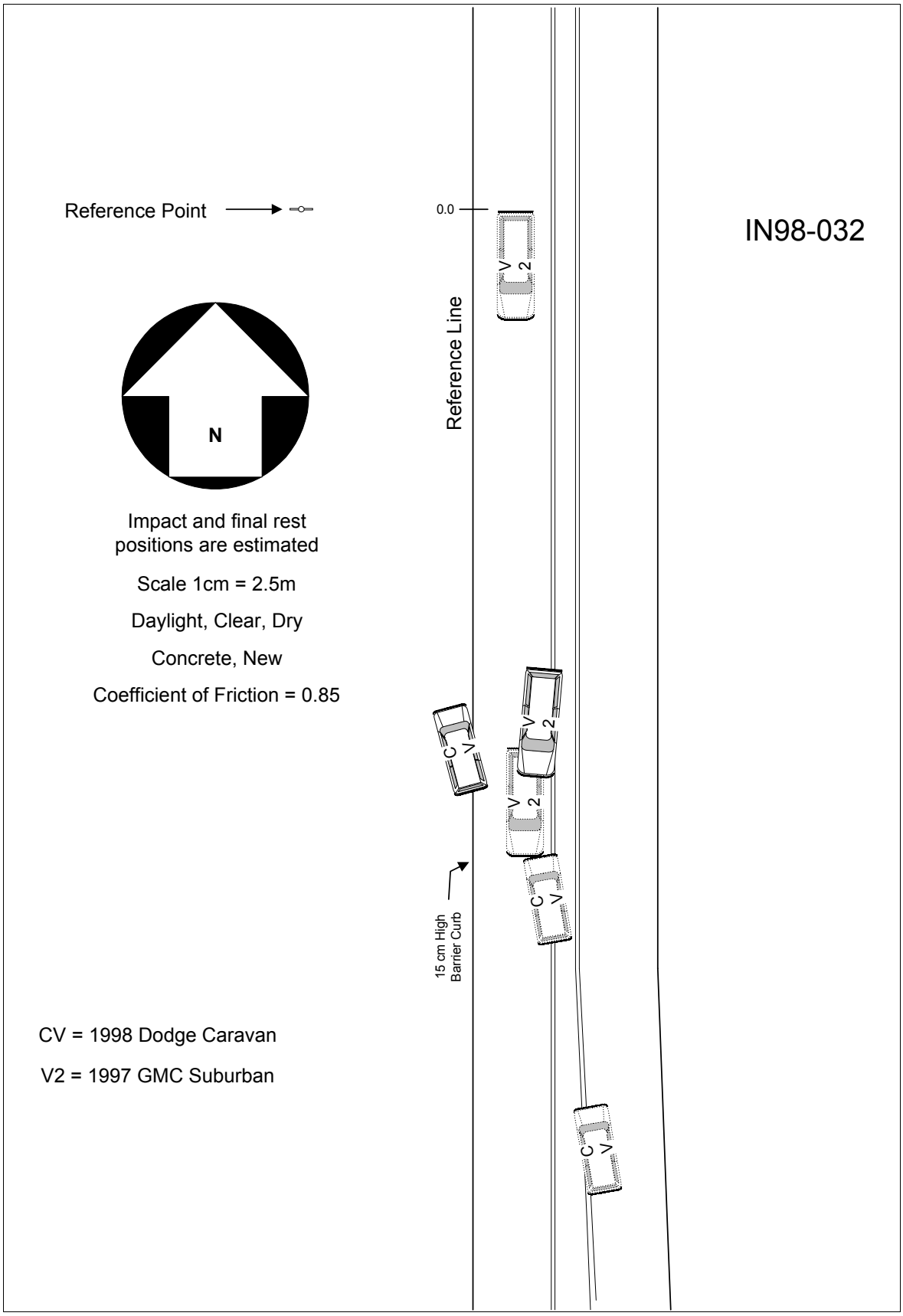
The Suburban's driver was restrained by his available, active, three-point, lap-and-shoulder, safety belt system. Furthermore, there was evidence of shoulder belt abrasions to the driver's left shoulder, and the inspection of the driver's seat belt webbing, "D"-ring, and latch plate showed slight stretching on the belt's webbing and the "D"-ring had faint scratches. The latch plate showed no indication of loading.

When the Suburban's driver noticed the case vehicle crossing the median (i.e., the double center lines), he applied his brakes and slowed from approximately 48 km.p.h. (30 m.p.h.) to an estimated 24 km.p.h. (15 m.p.h.) at impact. As a result of his pre-crash braking and the use of his available safety belts, the driver's body moved only slightly forward just prior to impact. The Suburban's impact with the case vehicle enabled the Suburban's driver to moved forward and slightly to the left toward the **350** degree Direction of Principal Force as the Suburban decelerated.

OTHER VEHICLE DRIVER INJURIES

The Suburban's driver exited his vehicle under his own power, refused medical treatment at the scene, and was not transported to a medical facility. Later, he was taken by private vehicle to a hospital emergency room where he was treated and released. According to the Suburban's driver, his self-reported injuries included abrasions to his left shoulder and left hand, a contusion to his left wrist, and a strained {i.e., "wrenched"} lower back.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Abrasion left shoulder, not further specified	790202.1 minor	Torso portion of safety belt system	Probable	Interviewee (same person)
2	Abrasion left hand, not further specified	790202.1minor	Air bag, driver's	Certain	Interviewee (same person)
3	Contusion with swelling left wrist	790402.1 minor	Air bag, driver's	Probable	Interviewee (same person)
4	Strain {wrenched} lower back	640678.1 minor	Lap portion of safety belt system	Probable	Interviewee (same person)


Reference Point
0.0
IN98-032
Reference Line
N
Impact and final rest positions are estimated
Scale 1cm = 2.5m
Daylight, Clear, Dry
Concrete, New
Coefficient of Friction = 0.85
15 cm High Barrier Curb
CV = 1998 Dodge Caravan
V2 = 1997 GMC Suburban