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ON-SITE AIR BAG INVESTIGATION

CASE NUMBER - IN98-013
LOCATION - ILLINOIS
VEHICLE - 1995 JEEP GRAND CHEROKEE LIMITED
CRASH DATE - January, 1998

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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.

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16. <i>Abstract</i> This report covers an on-site investigation of an air bag deployment crash that involved a 1995 Jeep Grand Cherokee (case vehicle) and a 1995 Chevrolet minivan (other vehicle). This crash is of special interest because the case vehicle's unrestrained driver (26-year-old female) sustained a fatal cervical spinal cord injury from her deploying driver air bag. The case vehicle was traveling south in the southbound lane of a two-lane, undivided, city street. The Chevrolet was illegally parked heading south along the east edge of the roadway. While driving southbound the driver failed to notice a truck tractor and semitrailer backing into a loading dock ahead of her on the west side of the street. The case vehicle's driver steered sharply to the left, successfully avoiding the backing noncontact vehicle, but consequently lost control. The crash occurred near the east (left) side of the roadway. The front left corner of the case vehicle impacted the right front door and wheel area of the Chevrolet, causing the case vehicle's driver supplemental restraint (air bag) to deploy. The case vehicle's side slapped the right side of the Chevrolet just before the case vehicle was redirected slightly to its right. The case vehicle traveled south-southeastward, departing the east side of the road, and impacting the corner of a brick building. At the time of the crash the case vehicle's driver was seated upright with her seat track located in its forward-most position, and the tilt steering wheel was in its up-most position. She was not using her available, active, three-point, lap-and-shoulder, safety belt system and sustained, according to her autopsy, a fatal atlanto-occipital dislocation with contusion to her upper cervical spinal cord. In addition, she sustained: diffuse cerebral edema with flattening of the cortical convolutions; a laceration to her ascending pulmonary artery (i.e., pulmonary trunk); bilateral lung contusions involving the anterior surfaces of both upper lobes with bilateral hemothoraces; bilateral rib fractures with multiple fractures both anteriorly and laterally; a fractured sternum; hemopericardium (tamponade); and multiple contusions and abrasions to the chest, face, and extremities. The front right passenger (28-year-old male) was seated upright with his seat track located between its middle and rearmost positions and was not using his available, active, three-point, lap-and-shoulder, safety belt system. He sustained, according to his medical records, moderate injuries which included: a comminuted nasal fracture, a large "V"-shaped laceration to his forehead, a chin laceration, abrasions to his face and right lower leg, and a contusion to his right knee.					
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This on-site investigation was brought to NHTSA's attention on January 28, 1998 by NHTSA's Region IV office. This crash involved a 1995 Jeep Grand Cherokee (case vehicle) and a 1995 Chevrolet minivan (other vehicle). The crash occurred in January, 1998, at 8:00 a.m., in Illinois and was investigated by the applicable city police department. This crash is of special interest because the case vehicle's driver [26-year-old, White (non-Hispanic) female] sustained a fatal cervical spinal cord injury from her deploying driver air bag. This contractor inspected the scene and vehicles on January 30, 1998. This contractor interviewed the front right passenger (through an interpreter) on February 3, 1998. This report is based on the Police Crash Report; interviews with the front right passenger, the medical examiner, and witnesses; scene and vehicle inspections; occupant kinematic principles; occupant medical records; and this contractor's evaluation of the evidence.

SUMMARY

The case vehicle was traveling south in the southbound lane of a two-lane, undivided, city street and intended to continue its travel path southbound. While driving southbound the driver was preoccupied in a conversation with her passenger and failed to notice a truck tractor and semitrailer backing into a loading dock ahead of her on the west side of the street. Upon realization of an impending crash, the case vehicle's driver steered sharply to the left, successfully avoiding the backing noncontact vehicle. The case vehicle's driver may have attempted to steer back to the right just prior to the crash. The crash occurred near the east (left) side of the roadway (see **CRASH DIAGRAM** below).

The front left corner of the case vehicle impacted the right front door and wheel area of the Chevrolet, causing the case vehicle's driver supplemental restraint (air bag) to deploy. The case vehicle's impact to the right front door and wheel areas of the Chevrolet was forceful enough that it knocked (i.e., lifted and rotated) the left half of the Chevrolet's front end [i.e., the Chevrolet weighed at least 1,814 kilograms (4,000 pounds)] over a 10.2 centimeter (4 inch) high curb and onto the sidewalk where it came to rest. The Chevrolet was illegally parked and heading south on the east (left) side of the street. The initial impact occurred 2.1 meters (7 feet) north of the north side of a parking lot driveway that intersected the roadway from the east roadside. The case vehicle's left outside rearview mirror side slapped (i.e., more like a side swipe than a slap) the right side of the parked van just before the case vehicle was redirected slightly to its right. The case vehicle traveled south-southeastward, departing the east side of the road, and continued an additional 13.1 meters (43 feet) prior to impacting the corner of a brick building. The case vehicle rotated slightly counterclockwise before it essentially came to rest against the building.

The 1995 Jeep Grand Cherokee Limited was a four wheel drive, four-door sport utility vehicle (VIN: 1J4GZ78SXSC-----). The case vehicle was equipped with a four-wheel, anti-lock brake system. Based on the vehicle inspection, the CDCs for the case vehicle were determined to be: **12-FLEE-1 (0)**, **10-LPMN-1 (300)**, and **12-FYEW-3 (0)** [maximum crush was 18 centimeters (7.1 inches) for its initial impact and 50 centimeters (19.7 inches) for the impact with the brick wall]. The WinSMASH reconstruction program, barrier algorithm, was used on the case vehicle's highest severity impact with the corner of the brick building. The Total, Longitudinal,

and Lateral Delta Vs are, respectively: 36.7 km.p.h. (22.8 m.p.h.), -36.7 km.p.h. (-22.8 m.p.h.), and 0.0 km.p.h. (0.0 m.p.h). The WinSMASH reconstruction program, damage only algorithm, was used on the case vehicle's air bag deployment (i.e., second highest severity) impact with the Chevrolet. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 10.3 km.p.h. (6.4 m.p.h.), -10.3 km.p.h. (-6.4 m.p.h.), and 0.0 km.p.h. (0.0 m.p.h). The case vehicle was towed due to damage.

The case vehicle's initial contact with the Chevrolet involved the front left corner. Direct damage extended from the front left bumper corner to the right 26 centimeters (10.2 inches). The case vehicle's primary impact with the brick wall involved approximately two-thirds of the case vehicle's front end. The direct damage started at the front left bumper corner and extended to the right 93 centimeters (36.6 inches). The case vehicle's entire front end was damaged as a result of its impact with the wall.

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's fabric. However, there appeared to be mucous on the driver air bag module's cover flap. The driver's air bag was designed without any tethers. The driver's air bag had two vent ports, approximately 3 centimeters (1.2 inches) in diameter, located at the 11:30 and 12:30 o'clock positions. The deployed driver's air bag was elliptical with a height of approximately 58 centimeters (22.8 inches) and a width of approximately 62 centimeters (24.4 inches). There was a large amount of blood on the driver's air bag, primarily on the right half.

An inspection of the case vehicle's interior revealed blood on the armrests of both front doors and blood on the right front door's handle. Further, there was blood on the driver's head restraint and the center console. The bottom of the left instrument panel showed evidence of contacts: slightly off center and to the right of the steering column, under the left side of the glove compartment's door, on and just below the right quadrant of the glove compartment's door, and to the right of the glove compartment. The center mounted rearview mirror was distorted, and there were two distinct spider web type impacts to the right windshield—one toward the right "A"-pillar and one toward the rearview mirror. The latter impact to the windshield glazing contained a small hole (i.e., a slit) with skin and hair in it. Finally, there was an area of blood and hair on front right sun visor and header.

The 1995 Chevrolet was a rear wheel drive, 4x2, incomplete chassis minivan, equipped with an Astro conversion package (VIN: 1GBDM19WXS-----). The CDCs for the Chevrolet were determined to be: **05-RFEW-2 (160)** and **04-RPMN-1 (120)** [maximum crush was 18 centimeters (7.1 inches) for its initial impact with the case vehicle]. The Chevrolet was towed due to damage.

Immediately prior to the crash the case vehicle's driver [163 centimeters and 59 kilograms (64 inches, 130 pounds)] was seated upright with her back against the seat back, her left foot on the floor, her right foot between the accelerator and the brake, and both hands on the steering wheel. Her seat track was located in its forward-most position, the seat back was upright, and the

tilt steering wheel was in its up-most position. The post-crash, measured distance from the driver's seat back to the steering wheel hub was 46 centimeters (18.1 inches).

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

The case vehicle's driver steered to the left, attempting to avoid the noncontact vehicle. As a result of this attempted avoidance maneuver and the nonuse of her available safety belts, she most likely moved to her right just prior to impacting the Chevrolet. The case vehicle's impact with the Chevrolet enabled the case vehicle's driver to continue forward as the case vehicle decelerated. The driver's interaction with the deploying air bag caused her fatal cervical injuries and knocked her back into her seat back where she subsequently rebounded slightly forward. As the driver's head and upper torso were being knocked backwards, the right foot of the case vehicle's driver may have reacted by pressing forward against the accelerator pedal. The case vehicle's impact with the corner of the brick building accelerated the driver's forward momentum into the steering wheel and column, causing the driver's severe chest injuries. The driver's forward momentum and subsequent impact with the steering wheel was so severe that it caused the steering column shear capsules to completely separate from the mounting brackets and caused the driver's right knee to deform the rigid knee bolster. However, there was no deformation to the steering wheel rim itself. The driver rebounded backwards off the steering wheel assembly and, at final rest, the lower torso of the case vehicle's driver was seated forward in her seat with her upper torso leaning back and turned slightly to her left leaning against her seat back and the interior surface of the driver's door. She was unconscious and unable to exit the case vehicle.

The driver was transported by ambulance to the hospital. She sustained fatal injuries and was pronounced dead upon arrival at the hospital, unknown minutes post-crash. Based on her autopsy, the case vehicle's driver sustained: an atlanto-occipital dislocation with contusion to her upper cervical spinal cord; diffuse cerebral edema with flattening of cortical convolutions; a laceration to the ascending pulmonary artery (i.e., pulmonary trunk); bilateral lung contusions involving the anterior surfaces of both upper lobes with bilateral hemothoraces; bilateral rib fractures with multiple fractures both anteriorly and laterally; a fractured sternum; hemopericardium (tamponade); and multiple contusions and abrasions to the chest, face, and extremities. The driver's cervical and brain injuries were caused by contact with the deploying driver air bag. The chest injuries resulted from loading the steering wheel/column and occurred during the case vehicle's impact with the corner of the brick building.

The case vehicle's front right passenger [28-year-old, White (non-Hispanic) male; 170 centimeters and 70 kilograms (67 inches and 155 pounds)] was seated upright with his back against the seat back, both feet on the floor, and both hands in his lap. His seat track was located between its middle and rearmost positions, and the seat back was upright. The case vehicle's front right passenger was not using his available, active, three-point, lap-and-shoulder, safety belt system. This vehicle was not equipped with a front right passenger supplemental restraint (air bag) system. The front right passenger was transported by ambulance to the hospital. He sustained moderate

injuries and was hospitalized for one day post-crash. The injuries sustained by the case vehicle's front right passenger included: comminuted nasal fractures, a large "V"-shaped laceration to his forehead, a chin laceration, abrasions to his face and right lower leg, and a contusion to his right knee.

CRASH CIRCUMSTANCES

The case vehicle was traveling south in the southbound lane of a two-lane, undivided, city street in an industrial park and intended to continue its travel path southbound (**Figure 1**). While driving southbound the driver was preoccupied in a conversation with her passenger and failed to notice a truck tractor and semitrailer backing into a loading dock ahead of her on the west side of the street. Upon realization of an impending crash, the case vehicle's driver steered sharply to the left, attempting to avoid the backing noncontact vehicle. The case vehicle's driver may have attempted to steer back to the right just prior to the crash. The crash occurred near the east (left) side of the roadway (see **CRASH DIAGRAM** below).



Figure 1: Case vehicle's southward approach path; Note: case vehicle struck Chevrolet which was illegally parked along east (left) side of roadway and then struck and came to rest near corner of red brick building in background (case photo #01)

The city roadway was straight and level at the area of impact. The pavement was bituminous, and the width of the unmarked roadway was 10.6 meters (33.5 feet). The roadway was bordered by 10.2 centimeter (4 inches) high mountable curbs. There were no pavement markings. The estimated coefficient of friction was 0.85 when dry. This coefficient of friction was higher than normal but occurred as a result of the heavy truck traffic and fluctuating temperatures which resulted in the middle portion of the roadway having a generous amount of cracks and potholes. The only traffic controls were regulatory NO PARKING signs (Manual on Uniform Traffic Control Devices, R7-2) on the east and west sides of the roadway in the immediate area of the crash. The statutory speed limit was 48 km.p.h. (30 m.p.h.); however, 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. According to the Police Crash Report the roadway was icy, but based on the on-scene insurance photos, the roadway looked primarily dry with the ice and snow along the curb areas and sidewalks only. Traffic density was light, and the site of the crash was urban industrial. In addition, there were numerous loading dock driveways and parking lot entrances lining both sides of this city street in the industrial park.



Figure 2: Case vehicle's frontal damage viewed from left of front with contour gauge present; Note: yellow tape on hood near left front wheel indicates direct damage from impact with parked van; yellow tape toward center of hood indicates direct damage from impact with corner of brick building; and angled left rear wheel (case photo #15)

The front left corner of the case vehicle (**Figure 2** above and **Figures 3** and **4**) impacted the right front door and wheel area of the Chevrolet, rearward of the right “A”-pillar (**Figure 5**). The case vehicle swiped forward into and momentarily snagged the Chevrolet's right front wheel assembly. This initial impact triggered the case vehicle's driver supplemental restraint (air bag) to deploy. The Chevrolet was illegally parked and heading south on the east (left) side of the street. The initial impact occurred 2.1 meters (7 feet) north of the north side of a parking lot driveway that intersected the roadway from the east roadside.



Figure 3: Close-up of case vehicle's front showing deformation from both frontal impacts; Note: yellow tape toward right indicates width of direct damage from impact with parked van, yellow tape near center of vehicle indicates direct damage width from impact with corner of brick building, and slit in windshield near center is from head contact by front right passenger (case photo #12)

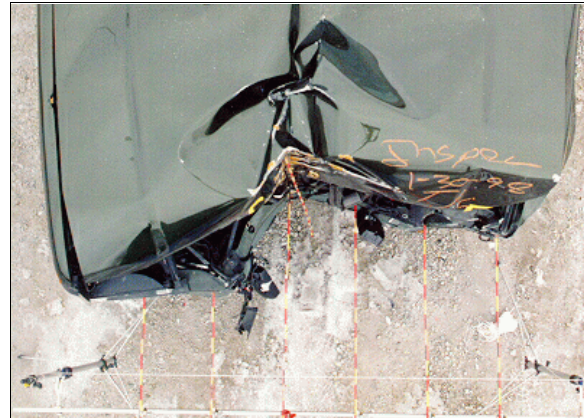


Figure 4: Overhead view of case vehicle's front damage, with contour gauge present, from both frontal impacts; Note: overlapping damage at front left corner (case photo #14)



Figure 5: Close-up of damage to Chevrolet's right front door, fender, and wheel from impact by case vehicle's front left (case photo #62)

The case vehicle's left outside rearview mirror (**Figure 6** below) side slapped (i.e., more like a side swipe than a slap) the right side of the parked van (**Figure 7** below) just before the case vehicle was redirected slightly to its right after knocking the Chevrolet out of its path. The case vehicle traveled south-southeastward, departing the east side of the road, and continued an additional 13.1 meters (43 feet) prior to impacting the corner of a brick building (**Figure 1** above and **Figure 8** below). The case vehicle rotated slightly counterclockwise before it essentially came to rest against the building. The case vehicle's impact to the right front door and wheel areas of the Chevrolet was forceful enough that it knocked (i.e., lifted and rotated) the left half of the Chevrolet's front end [i.e., the Chevrolet weighted at least 1,814 kilograms (4,000 pounds)] over a 10.2 centimeter (4 inch) high curb and onto the sidewalk where it came to rest (**Figure 9** below).



Figure 6: Close-up of case vehicle's damaged left outside rearview mirror from side slap impact with right side of Chevrolet (case photo #19)



Figure 7: Damage to Chevrolet's right front and narrow area of side slap damage (case photo #63)



Figure 8: Red brick building which case vehicle hit and came to rest near (case photo #06)



Figure 9: On-scene view of case vehicle at final rest against corner of brick building; Note: struck parked van in background and angled right rear wheel (case photo #09)

CASE VEHICLE

The 1995 Jeep Grand Cherokee Limited was a four wheel drive, five-passenger, four-door, sport utility vehicle (VIN: 1J4GZ78SXSC-----) equipped with power-assisted rack-and-pinion steering, a 4.0 liter, MPI, I-6 engine, and a four-speed automatic transmission. Braking was achieved by a hydraulic, power-assisted, front disc and rear drum, four-wheel, anti-lock system. The case vehicle's wheelbase was 269 centimeters (105.9 inches), and the odometer reading at inspection was 51,596 kilometers (32,060 miles).

Inspection of the vehicle's interior revealed electronic window and door locks; adjustable front bucket seats with adjustable head restraints; a 60/40, non-adjustable, split bench back seat with folding backs and adjustable head restraints for the



Figure 10: Case vehicle's front seating area showing damage from driver's contact to steering column and knee bolster; Note: damage to front right instrument panel (case photo #29)

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 height adjusters for the “D”-rings. The vehicle was equipped with a knee bolster for the driver. The case vehicle’s driver knee bolster was scuffed and deformed (**Figure 10** above). Automatic restraint was provided by a Supplemental Restraint System (SRS) that consisted of a frontal air bag for the driver’s seating position. The front seat air bag (i.e., driver only) deployed as a result of the case vehicle’s front left corner impact with the Chevrolet.



Figure 11: Case vehicle’s center console and floor areas showing blood evidence on console and contacts under right side of steering column and below right instrument panel; Note: distortion to center instrument panel and toe pan intrusions (case photo #38)

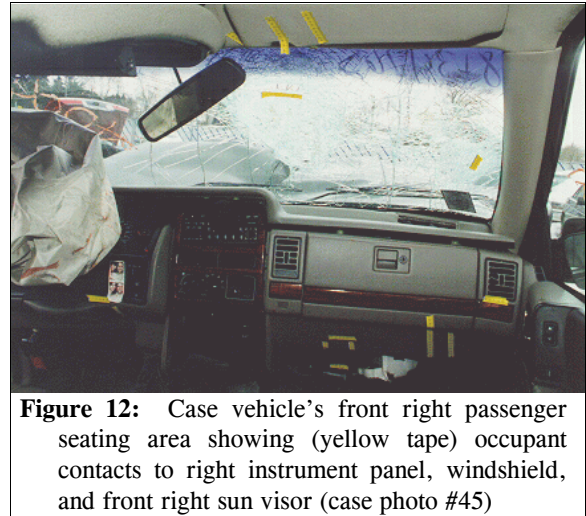


Figure 12: Case vehicle’s front right passenger seating area showing (yellow tape) occupant contacts to right instrument panel, windshield, and front right sun visor (case photo #45)

An inspection of the case vehicle’s interior revealed blood smears on the armrests of both front doors and blood on the right front door’s handle. Further, there was a blood smear on the driver’s head restraint and an area of puddled blood on the floor-mounted, center console (**Figure 11**). The bottom of the instrument panel showed evidence of contacts slightly off center and to the right of the steering column (**Figure 10** above and **Figure 11**) from the case vehicle’s driver. Further there were contacts under the left side of the glove compartment’s door, on and just below the right quadrant of the glove compartment’s door, and to the right of the glove compartment (**Figure 12**) from contact by the front right passenger. The center mounted rearview mirror was distorted, and there were two distinct spider web type impacts to the right windshield—one toward the right “A”-pillar and one toward the rearview mirror (**Figure 13**), from contact by the front right passenger’s head and right arm. The latter impact to the windshield glazing contained a small hole (i.e., a slit—**Figure 14** below) with skin and hair in it, and there was an area of blood and hair on front right sun visor and header

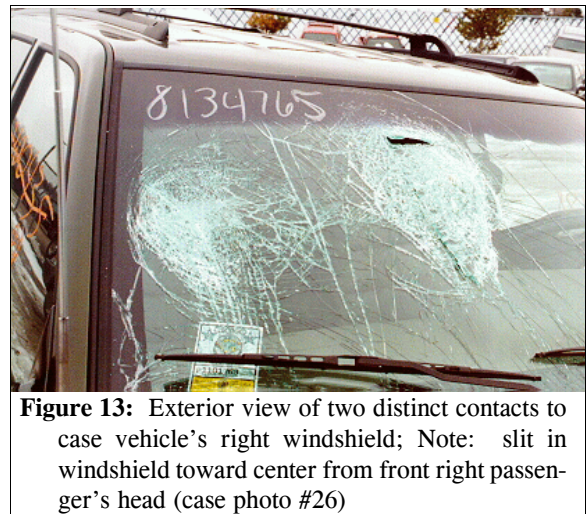


Figure 13: Exterior view of two distinct contacts to case vehicle’s right windshield; Note: slit in windshield toward center from front right passenger’s head (case photo #26)

(**Figure 15**) from contact by the front right passenger. In addition, there were several unknown black scuffs to the roof near the windshield header and the driver's sun visor. Finally, the overhead console located in the center of the case vehicle's roof fell down with only the electrical wires holding it to the roof. The toe pan in driver and front right passenger foot wells showed different amounts of intrusion with the most significant being 17 centimeters (6.7 inches) to the front right passenger's toe pan (**Figure 11** above). The intrusion to the case vehicle's left and center instrument panel measured 4 centimeters (1.6 inches).

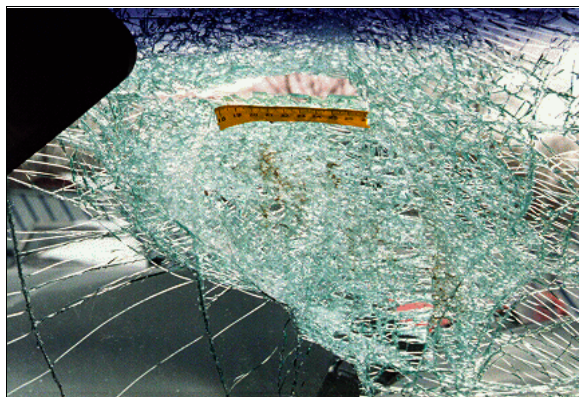


Figure 14: Close-up of interior surface of case vehicle's windshield, just to the right of center, showing front right passenger's head contact; Note: approximate 13 cm (5 in) opening above yellow tape (case photo #48)

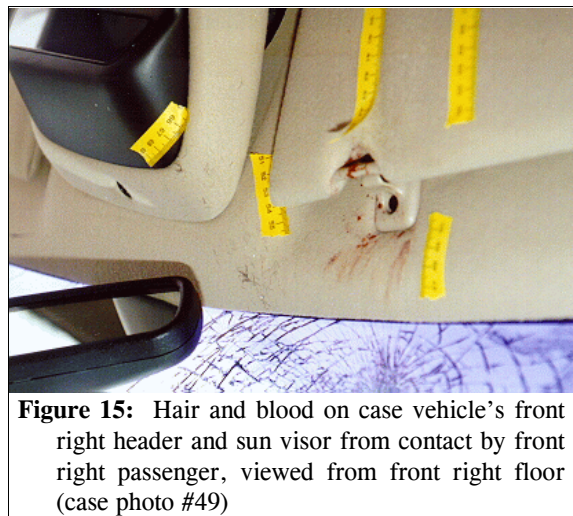


Figure 15: Hair and blood on case vehicle's front right header and sun visor from contact by front right passenger, viewed from front right floor (case photo #49)

CASE VEHICLE DAMAGE

The case vehicle's initial contact with the Chevrolet involved the front left corner. Direct damage extended from the left bumper corner to the right (**Figures 2** and **3** above) 26 centimeters (10.2 inches). The residual crush extended down the left side (i.e., C₁) and was measured at 18 centimeters (7.1 inches). The case vehicle's primary impact with the brick wall involved approximately two-thirds of the case vehicle's front end. The direct damage started near the front left bumper corner and extended to the right (**Figures 2** through **4** above) 93 centimeters (36.6 inches). The case vehicle's entire front end was damaged as a result of its impact with the wall. Maximum crush was 50 centimeters (19.7 inches) near C₄ (**Figure 4** above).

The front bumper fascia, grille, and radiator were crushed rearward. Both front fenders were pulled inwards because of the case vehicle's centered hit with the corner of the brick wall. As mentioned, the windshield had two spider web cracks from the front right passenger striking it when the vehicle hit the wall. The left front tire was physically restricted from the vehicle's front end impact to the brick wall. The wheelbase was altered 12 centimeters (4.7 inches) on the left side from both the vehicle impacts with the parked van and wall. At some point during the crash the case vehicle's right rear shock absorber broke away and the rear axle/drive train was broken. As a result, the left and right rear wheels were toed inwards at their top (**Figures 1** and **9** above).

Based on the vehicle inspection, the CDCs for the case vehicle were determined to be: **12-FLEE-1 (360)**, **10-LPMN-1 (300)**, and **12-FYEW-3 (360)**. The WinSMASH reconstruction program, barrier algorithm, was used on the case vehicle's highest severity impact with the corner of the brick building. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 36.7 km.p.h. (22.8 m.p.h.), -36.7 km.p.h. (-22.8 m.p.h.), and 0.0 km.p.h. (0.0 m.p.h.). The WinSMASH reconstruction program, damage only algorithm, was used on the case vehicle's air bag deployment (i.e., second highest severity) impact with the Chevrolet. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 10.3 km.p.h. (6.4 m.p.h.), -10.3 km.p.h. (-6.4 m.p.h.), and 0.0 km.p.h. (0.0 m.p.h.). The case vehicle was towed due to damage.

AUTOMATIC RESTRAINTS

As previously mentioned, the case vehicle was equipped with a SRS that consisted of a front air bag at the driver's (only) seat position. The SRS deployed as a result of the case vehicle's front left corner impact with the right front side of the Chevrolet. The case vehicle's driver air bag was located in the steering wheel hub. The module cover consisted of a near symmetrical "H"-configuration cover flaps made of thick vinyl with overall dimensions of 17.5 centimeters (6.9 inches) and 18 centimeters (7.1 inches) at the top and bottom horizontal seams, respectively and 7 centimeters (2.8 inches) vertically for both the upper flap and for the lower flaps. 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's fabric. However, there appeared to be mucous or saliva on the driver air bag module's top cover flap (**Figure 16**) but no evidence of direct contact from the driver or other passenger. The driver's air bag was designed without any tethers. The driver's air bag had two vent ports, approximately 3 centimeters (1.2 inches) in diameter, located at the 11:30 and 12:30 o'clock positions. The deployed driver's air bag was elliptical with a height of approximately 58 centimeters (22.8 inches) and a width of approximately 62 centimeters (24.4 inches). There was a large amount of blood smear and splatter, primarily on the right half, on the driver's air bag (**Figure 17**). Presumably, most of the splatter came from the front right passenger when he was thrown towards the left side after contacting the windshield.



Figure 16: Case vehicle driver air bag module's top cover flap, viewed from front center, showing unknown body fluid splatter on cover flap and air bag's two vent ports (case photo #34)



Figure 17: Case vehicle's driver air bag showing blood smears on upper right quadrant; Note: steering wheel rotated clockwise (to right) approximately 45 degrees (case photo #37)

The case vehicle's impact with the parked the Chevrolet deployed the driver's air bag. Immediately prior to the crash the case vehicle's driver [26-year-old, White (non-Hispanic) female; 163 centimeters and 59 kilograms (64 inches, 130 pounds)] was seated upright with her back against the seat back, her left foot on the floor, her right foot between the accelerator and the brake, and both hands on the steering wheel. Based on the vehicle inspection, her seat track was located in its forward-most position (**Figure 18**), the seat back was upright, and the tilt steering wheel was in its up-most position. The measured distance from the driver's seat back to the steering wheel hub was 46 centimeters (18.1 inches).



Figure 18: Case vehicle's interior showing deployed driver air bag, close proximity of driver's seat to steering column, and upward movement of steering column (case photo #51)

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

The case vehicle's driver steered to the left, attempting to avoid the noncontact vehicle. As a result of this attempted avoidance maneuver and the nonuse of her available safety belts, she most likely moved to her right just prior to impacting the Chevrolet. The case vehicle's impact with the Chevrolet enabled the case vehicle's driver to continue forward as the case vehicle decelerated. The driver's interaction with the deploying air bag caused her fatal cervical injuries. There was evidence of blood but no visible skin transfers found on the driver's air bag (**Figure 17** above). The driver was knocked backwards by the deploying air bag into her seat back, where she subsequently rebounded slightly forward. As the driver's head and upper torso was being knocked backwards, the right foot of the case vehicle's driver may have reacted by pressing forward against the accelerator pedal. In any case, the case vehicle continued in a south-southeasterly direction and into the corner of a brick building. The case vehicle's impact with the corner of the brick building accelerated the driver's forward momentum into the steering wheel and column with the non-pressurized driver air bag, causing the driver's severe chest injuries. The driver's forward momentum and subsequent impact with the steering wheel was so severe that it caused the steering column shear capsules to completely separate from the mounting brackets

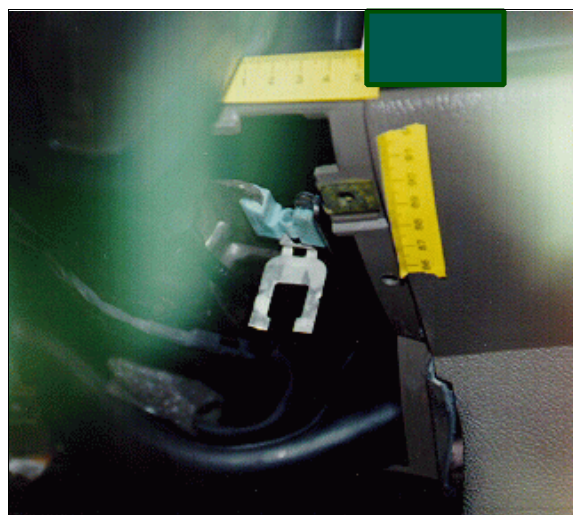


Figure 19: Close-up of separated shear capsule on case vehicle's steering column (case photo #32)

(Figure 19 above) but did not cause deformation to the steering wheel rim. In addition, the forward momentum caused the driver's right knee to deform the rigid knee bolster (Figure 10 above). Upon removing the screws holding the driver's knee bolster, the entire steering column dropped downward. The impact with the corner of the wall resulted in the case vehicle rotating counterclockwise approximately 5 degrees to final rest. The driver rebounded backwards off the steering wheel assembly and, at final rest, the lower torso of the case vehicle's driver was seated forward on the front of the seat cushion with her upper torso leaning back and turned slightly to her left leaning against her seat back and the interior surface of the driver's door. She was unconscious and unable to exit the case vehicle.

CASE VEHICLE DRIVER INJURIES

The driver was transported by ambulance to the hospital. She sustained fatal injuries and was pronounced dead upon arrival at the hospital, unknown minutes post-crash. Based on her autopsy, the case vehicle's driver sustained: an atlanto-occipital dislocation with contusion to her upper cervical spinal cord, diffuse cerebral edema with flattening of cortical convolutions, a laceration to the ascending pulmonary artery (i.e., pulmonary trunk), bilateral lung contusions involving the anterior surfaces of both upper lobes with bilateral hemothoraces, bilateral rib fractures with multiple fractures both anteriorly and laterally, a fractured sternum, hemopericardium (tamponade), and multiple contusions and abrasions to the chest, face, and extremities. The driver's cervical and brain injuries were caused by contact with the deploying driver air bag while the chest injuries resulted from loading the steering wheel/column and occurred during the case vehicle's impact with the corner of the brick building.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Contusion upper cervical spinal cord in C ₁ -C ₃ region with atlanto-occipital dislocation	640236.6 ¹ untreatable	Air bag, driver's	Probable	Autopsy
2	Edema, cerebral, diffuse with flattening of cortical convolutions and notching of left temporal uncus ²	140660.3 serious	Air bag, driver's	Certain	Autopsy

¹ The choice of injury code is difficult because the NASS CDS Injury Coding manual presumes that one knows whether there was a complete or an incomplete cord syndrome. Because the only available medical record is an autopsy, the syndrome issue is not discernable (i.e., you cannot determine the difference in a dead person). In the absence of protocol, this contractor chooses to assume the syndrome was complete.

² The following term is defined in DORLAND'S ILLUSTRATED MEDICAL DICTIONARY as follows:
uncus (ung'kas): 1. any hook-shaped structure. 2. the medially curved anterior end of the parahippocampal gyrus; called also *u. gyri fornicati*, *u. gyri hippocampi*, and *u. gyri parahippocampalis*.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
3	Laceration, 0.5 cm (0.2 in), of ascending pulmonary artery, 2 cm (0.8 in) above pulmonic valve leaflets and proximal to the bifurcation of the pulmonary trunk	421099.3 serious	Steering wheel hub/spokes	Certain	Autopsy
4	Contusions, superficial, over anterior surfaces of bilateral upper lobes of lungs with bilateral hemothoraces: 100 ml right pleural cavity, 150 ml left pleural cavity	441410.4 severe	Steering wheel hub/spokes	Certain	Autopsy
5	Fractures bilateral ribs: Right-1 st , 2 nd , and 4 th anteriorly and 1 st through 3 rd laterally Left-4 th and 5 th anteriorly and 2 nd through 6 th and 10 th laterally	450240.4 severe	Steering wheel hub/spokes and rim	Certain	Autopsy
6	Fracture sternum between 4 th and 5 th ribs with displacement {dislocation}	450804.2m oderate	Steering wheel hub/spokes	Certain	Autopsy
7	Hemopericardium (tamponade) 100 ml without heart (myocardium) injury	441604.3 serious	Steering wheel hub/spokes	Certain	Autopsy
8	Contusion {bruise} bridge of nose with swelling and subcutaneous emphysema right lower eyelid	290402.1m inor	Air bag, driver's	Certain	Autopsy
9	Abrasion, superficial, left chin	290202.1m inor	Air bag, driver's	Certain	Autopsy
10	Abrasion, oval, 10.1 x 4.6 cm (4.0 x 1.8 in) between breasts with subcutaneous emphysema upper chest	490202.1m inor	Air bag, driver's	Possible	Autopsy
11	Abrasion, circular, beneath right clavicle {collar bone}	790202.1m inor	Air bag, driver's	Probable	Autopsy
12	Contusion {bruise} right medial {inner} forearm	790402.1m inor	Air bag, driver's	Probable	Autopsy
13 14	Abrasions, circular, right lateral {outer} upper arm and posterior {back} right elbow	790202.1 790202.1m inor	Center instrument panel and below	Possible	Autopsy

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
15 16	Abrasion, superficial, surrounded by contusion right anterior {shin} lower leg	890202.1 890402.1m inor	Left instrument panel and below	Certain	Autopsy
17 18	Abrasion, superficial, surrounded by contusion over left proximal {top} knee	890202.1 890402.1m inor	Knee bolster, driver's	Probable	Autopsy
19	Abrasion, linear, over left anterior {shin} lower leg	890202.1m inor	Left instrument panel and below	Probable	Autopsy
20	Contusion {bruise} over left lateral {outer} ankle	890402.1m inor	Left instrument panel and below	Probable	Autopsy

CASE VEHICLE FRONT RIGHT PASSENGER KINEMATICS

The case vehicle's front right passenger [28-year-old, White (non-Hispanic) male; 170 centimeters and 70 kilograms (67 inches and 155 pounds)] was seated upright with his back against the seat back, both feet on the floor, and both hands in his lap. His seat track was located between its middle and rearmost positions, and the seat back was upright (**Figure 18** above).

The case vehicle's front right passenger was not using his available, active, three-point, lap-and-shoulder, safety belt system. This vehicle was not equipped with a front right passenger supplemental restraint (air bag) system. In addition, there was no evidence of belt pattern bruising and/or abrasions to the front right passenger's body, and the inspection of the front right seat belt webbing, "D"-ring, and latch plate showed no evidence of loading.

The case vehicle's driver steered to the left, attempting to avoid the noncontact vehicle. As a result of this attempted avoidance maneuver and the nonuse of his available safety belts, the front right passenger most likely moved to his right just prior to impacting the Chevrolet. The case vehicle's impact with the Chevrolet enabled the case vehicle's front right passenger to continue forward as the case vehicle decelerated. According to the interview with the front right passenger, he kept himself from hitting the right instrument panel by putting up his right hand. As the case vehicle continued south-southeastward off the Chevrolet, the front right passenger most likely rebound slightly backwards. The case vehicle's subsequent impact with the corner of the brick building enabled the front right passenger's whole body to be accelerate forward with his face and upper extremities slamming into the windshield and his lower torso, pelvis, and legs going into and below the right instrument panel (**Figure 12** above). The front right passenger's face struck and cracked the windshield just to the right of midline while his right elbow, forearm and/or hand struck the windshield (**Figures 13** and **14** above) toward the right "A"-pillar (i.e., most likely because there are no reported right upper extremity injuries). The front right passenger's facial injuries resulted from the windshield strike and the windshield was holed (i.e., a small, horizontal, slit-like hole) as a result. In addition, the front right passenger's knees and lower legs

contact the right instrument panel below and to the right of the glove compartment. The front right passenger rebounded first, upwards into the right header and sun visor, and second, to the left toward the center console as the case vehicle rotated approximately 5 degrees counterclockwise. At final rest the front right passenger was laying with his upper torso partially on the driver and his lower torso still partially in the front right foot well. The blood splatter on the center console (**Figure 11** above) and most likely on the right half of the driver's air bag resulted from the "near moderate"³ forehead laceration the front right passenger sustained from his windshield contact. According to his interview, the front right passenger was unable to exit the case vehicle.

CASE VEHICLE FRONT RIGHT PASSENGER INJURIES

The front right passenger was transported by ambulance to the hospital. He sustained moderate injuries and was hospitalized for one day post-crash. According to his medical records, the injuries sustained by the case vehicle's front right passenger included: comminuted nasal fractures, a large "V"-shaped laceration to his forehead, a chin laceration, abrasions to his face and right lower leg, and a contusion to his right knee.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Fracture, comminuted, nasal bones	251004.2m oderate	Windshield, right side	Probable	Hospitalization records
2	Laceration, "V"-shaped, 10 cm (3.9 in), to forehead	290602.1m inor	Windshield, right side	Certain	Hospitalization records
3	Abrasions face, not further specified	290202.1m inor	Windshield, right side	Probable	Emergency room records
4	Laceration chin, not further specified	290600.1m inor	Windshield, right side	Probable	Emergency room records
5	Abrasions right lower leg	890202.1m inor	Right instrument panel and below	Probable	Emergency room records
6	Contusion right knee area, not further specified	890402.1m inor	Right instrument panel and below	Probable	Emergency room records

OTHER VEHICLE

The 1995 Chevrolet was a rear wheel drive, 4x2, seven-passenger, incomplete chassis minivan, equipped with an Astro conversion package (VIN: 1GBDM19WXS-----), a 4.3 liter, V-6 CPI engine, and a four-speed automatic transmission with overdrive. Braking was achieved using a power-assisted, dual hydraulic, self adjusting, front disk and rear drum, four-wheel, anti-

³ If the laceration had been greater than 10 centimeters (3.9 inches) and involved the subcutaneous tissue, then it would have been a moderate (i.e., AIS=2) injury.

lock system. The case vehicle's wheelbase was 282 centimeters (111.0 inches), and the odometer reading is unknown. The vehicle was equipped with an air bag for the driver's seat position only and manual, three-point, lap-and-shoulder, safety belt systems for the front, second, and back outboard seating positions. The back center seat had a manual, two-point, lap belt only. The interior was equipped with a bucket seat for the driver and a box-mounted bucket seat for the front right passenger. There were two box-mounted bucket seats for the second seating area of the Chevrolet, and a non-adjustable three occupant bench for the back seat.

The Chevrolet's right front side impact from the case vehicle broke the front axle, broke the right front wheel rim, and aired out the tire. Direct damage started 26 centimeters (10.2 inches) forward of the right rear axle on the sliding door and extended forward 314 centimeters (123.6 inches). Half of this measured direct damage was from the case vehicle's left outside rearview mirror slapping and then scraping down the Chevrolet's right side (**Figure 20**). The maximum crush was measured at 10 centimeters (3.9 inches) near the right front wheel well (**Figure 5** above). The total field L and direct L was measured at 314 centimeters (123.6 inches). Based on the vehicle inspection, the CDCs for the Chevrolet were determined to be: **05-RFEW-2 (160)** and **04-RPMN-1 (120)** [maximum crush was 18 centimeters (7.1 inches) for its initial impact with the case vehicle]. The WinSMASH reconstruction program, damage only algorithm, was used on the Chevrolet's highest severity impact with the case vehicle. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 10.0 km.p.h. (6.2 m.p.h.), +9.4 km.p.h. (+5.8 m.p.h.), and -3.4 km.p.h. (-1.3 m.p.h). The Chevrolet was initially left at the scene, but subsequent, it was towed due to damage.

