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ON-SITE AIR BAG INVESTIGATION

CASE NUMBER - IN97-047
LOCATION - LOUISIANA
VEHICLE - 1995 FORD WINDSTAR GL
CRASH DATE - November, 1997

Submitted:

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

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

Technical Report Documentation Page

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On-site air bag deployment investigation involving a 1995 Ford Windstar GL, three-door minivan, with manual safety belts and dual front air bags, and a 1987 Chevrolet Celebrity, four-door sedan.

16. *Abstract*

This report covers an on-site investigation of an air bag deployment crash that involved a 1995 Ford Windstar GL, three-door minivan (case vehicle) and a 1987 Chevrolet Celebrity, four-door sedan (other vehicle). This crash is of special interest because the case vehicle's, unrestrained, front right passenger (4-year-old female), who was seated on the lap of another front right passenger, sustained critical brain injuries from the deploying front right air bag, resulting in her death. The case vehicle was traveling south to southeast in a left-hand curve in the inside through lane of the two-lane, southbound roadway. The roadway was part of a five-lane, divided trafficway (i.e., southbound roadway had two through lanes; northbound roadway had two through lanes and one left-hand turn lane on the south leg of the four-leg intersection). The Chevrolet was traveling east in the eastbound lane of an intersecting, two-lane, undivided roadway. The crash occurred in the inside, southbound lane in the intersection of the two roadways. The front of the case vehicle impacted the left side center of the Chevrolet, causing the case vehicle's driver and front right passenger supplemental restraints (air bags) to deploy. The case vehicle's "on-lap" front right passenger (i.e., daughter of the front right passenger) was not using the active, three-point, lap-and-shoulder, safety belt system because the system was in use by the front right passenger (i.e., father). She was seated between her father's legs with the front right seat track located in its rearmost position. According to her medical records, she sustained: a critical nonanatomic brain injury; a critical, diffuse, cerebral edema; a posterior subarachnoid hemorrhage and scalp contusion, bilateral lung contusions; bilateral retinal hemorrhages; abrasions to her chin and anterior neck, and contusions to her neck and right upper chest. The other three case vehicle occupants [i.e., front right passenger (35-year-old male), driver (grandfather; 68-year-old male), and second seat left passenger (grandmother; 66-year-old female)] were all seated and restrained by their available, active, three-point, lap-and-shoulder, safety belt systems. The driver's seat track was located between its middle and rearmost positions, and the tilt steering wheel was located in its middle position. According to their medical records, the front right passenger sustained cervical and thoracic strains and a left knee contusion. The driver sustained minor soft tissue injuries to his face, scalp, right forearm, and right shoulder blade. According to her self-reported injuries, the second seat left passenger sustained a lacerated left eyebrow and contusions to her left knee and both breasts. The Chevrolet's restrained driver was fatally injured in the crash.

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BACKGROUND

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This on-site investigation was brought to NHTSA's attention on November 25, 1997 by a Governor's Highway Safety Representative. This crash involved a 1995 Ford Windstar GL (case vehicle) and a 1987 Chevrolet Celebrity (other vehicle). The crash occurred in November, 1997, at 5:52 p.m., in Louisiana and was investigated by the applicable city police department. This crash is of special interest because the case vehicle's, unrestrained, front right passenger [4-year-old, White (non-Hispanic) female], who was seated on the lap of another front right passenger, sustained critical brain injuries from the deploying front right air bag, resulting in her death. This contractor inspected the scene and vehicles on 4-5 December, 1997. This contractor interviewed the case vehicle's driver on December 5, 1997. This report is based on the Police Crash Report, interviews with the case vehicle's driver 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 south to southeast in a left-hand curve in the inside through lane of the two-lane, southbound roadway and intended to continue traveling southward. The roadway was part of a five-lane, divided trafficway (i.e., southbound roadway had two through lanes; northbound roadway had two through lanes and one left-hand turn lane on the south leg of the four-leg intersection). The Chevrolet was traveling east in the eastbound lane of an intersecting, two-lane, undivided roadway and was attempting to cross the southbound roadway in order to turn left and go north on the northbound roadway. The case vehicle's driver made no avoidance maneuvers prior to the crash. The crash occurred in the inside, southbound lane in the intersection of the two roadways; see **CRASH DIAGRAM** below.

The front of the case vehicle impacted the left side center of the Chevrolet, causing the case vehicle's driver and front right supplemental restraints (air bags) to deploy. The posted speed limit for the case vehicle was 80 km.p.h. (50 m.p.h.). The impact caused the case vehicle to become embedded into the left side of the Chevrolet, causing both vehicle's to remain attached for a short distance. The impact sent both vehicles in a southeasterly direction off the roadway onto the unprotected grassy median that separated the trafficway's two roadways. The case vehicle drove the Chevrolet sideways a short distance before the case vehicle's counterclockwise yaw enabled it to separated from the Chevrolet. Upon separation, the case vehicle corrected itself back clockwise approximately 15 degrees prior to coming to an abrupt stop in the median heading essentially southward. The case vehicle came to rest approximately 19.2 meters (63 feet) southeast of the point of impact. After separating from the case vehicle, the Chevrolet rotated approximately 65 degrees counterclockwise before coming to rest in the median heading northeastward. The Chevrolet came to rest approximately 27.1 meters (89 feet) southeast of the point of impact.

The case vehicle's "on-lap" front right passenger [i.e., daughter of the front right passenger; 91 centimeters and 16 kilograms (36 inches, 35 pounds)] was not using the active, three-point, lap-and-shoulder, safety belt system because the system was in use by the front right passenger (i.e.,

father). In addition, the father indicated that he was holding his daughter between his legs and, thus, the child was facing forward.

The case vehicle's driver made no known pre-crash avoidance maneuvers. As a result and independent of the nonuse by the "on-lap" front right passenger of any safety restraints, the daughter's pre-impact body position did not change just prior to impact. The case vehicle's impact with the Chevrolet enabled the "on-lap" front right passenger to continue forward and upward as the case vehicle decelerated. The child's forward momentum allowed her to move toward and over the front right air bag module. As the air bag began to deployed, it impacted the child on the chin and under the child's neck, but her forward momentum enabled the child to continue forward and contact the windshield (i.e., a spider web with hair in it). As the air bag fully expanded, she was driven upwards where she contacted the windshield header (i.e., scuff with clump of hair) and sun visor. As the case vehicle rotated approximately 20 degrees counterclockwise, the child contacted the right side window glazing (i.e., an oil smear) before ending up back on her father's lap, still facing forward.

The "on-lap" front right occupant was transported by ambulance to the hospital. She sustained critical injuries and was pronounced brain dead approximately 17 hours post-crash. The injuries sustained by the case vehicle's "on-lap" front right passenger included: a critical nonanatomic brain injury; a critical, diffuse, cerebral edema; a posterior subarachnoid hemorrhage and scalp contusion, bilateral lung contusions; bilateral retinal hemorrhages; abrasions to her chin and anterior neck, and contusions to her neck and right upper chest.

The case vehicle was a front wheel drive 1995 Ford Windstar GL, three-door minivan (VIN: 2FMDA5141SB------). The case vehicle was equipped with four-wheel, anti-lock brakes. The Chevrolet is a front wheel drive 1987 Chevrolet Celebrity, four-door sedan (VIN: 1G1AW51R7H6------). The case vehicle and the Chevrolet were both towed due to damage. Based on the vehicle inspections, the CDCs were determined to be: **12-FDEW-1 (10)** for the case vehicle [maximum crush was 9 centimeters (3.5 inches) at C_1] and **10-LPEW-4 (290)** for the Chevrolet [maximum crush was 69 centimeters (27.2 inches) near C_3]. 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: 29.7 km.p.h. (18.5 m.p.h.), -29.2 km.p.h. (-18.1 m.p.h.), and -5.2 km.p.h. (-3.2 m.p.h).

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 three tethers, each 6 centimeters (2.4 inches) wide. The driver's air bag had two vent ports, approximately 1.5 centimeters (0.6 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 59 centimeters (23.2 inches) and a width of approximately 63 centimeters (24.8 inches). There was no contact evidence readily apparent on the driver's air bag; however, to the right of center, there was an area containing cola splatters.

The front right passenger's air bag was located in the middle (i.e., on the front of the top portion) of the right 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 one vent port, approximately 4 centimeters (1.6 inches) in diameter, located at the 10 o'clock position. The deployed front right air bag was rectangular with a height of approximately 55 centimeters (21.7 inches) and a width of approximately 70 centimeters (27.6 inches). The inspection of the air bag revealed only a few blood spots to the front left side.

The inspection of the case vehicle's interior revealed the following evidence of occupant contact. There was a scratch/scuff on the glove compartment door and an unknown white fluid on the right front door's armrest. In addition, there was a scuff to the backside of the front right seat back and an oil smear on the glazing near where the second seat left passenger was sitting. The inspection of the case vehicle's interior also revealed the following noncontact-related evidence. There was broken glass on the floor in front of the front bucket seats from the cola bottle that broke spraying the driver's air bag. In addition, there was a crack in the windshield near the driver's side caused by contact from the rearview mirror, and the rearview mirror was broken and hanging down after being struck by the deploying front right air bag.

Immediately prior to the crash the case vehicle's "on-lap" front right passenger was seated in an upright posture between the front right passenger's legs with her back against his chest, her feet dangling over the front edge of the seat's cushion angled downward, and both hands trying to unwrap a toy. The front right seat track was in its rearmost position, and the seat back was sightly reclined.

The case vehicle's front right passenger [father of "on-lap" passenger; 35-year-old, White (non-Hispanic) male; 183 centimeters and 74 kilograms (72 inches, 163 pounds)] was seated in a slightly reclined posture with his back against the seat back, legs spread with both feet on the floor, and both arms around his daughter (i.e., helping her unwrap a toy). As mentioned earlier his seat track was in its rearmost position.

The front right passenger was restrained by his available, active, three-point, lap-and-shoulder, safety belt system. The case vehicle's front right passenger accompanied his daughter in the ambulance to the hospital. Initially, he complained of only soreness to his knees and back and refused treatment; however, he returned the next day and was treated and released for minor injuries. According to his medical records, he sustained strains to his cervical and thoracic regions and a contusion to his left knee.

The case vehicle's driver [grandfather; 68-year-old, White (non-Hispanic) male; 178 centimeters and 86 kilograms (70 inches, 190 pounds)] was seated upright with his back against the seat back, his left foot on the floor, his right foot on the accelerator, and both hands on the steering wheel. His seat track was located between its middle and rearmost positions, and the tilt steering wheel was located in its middle position.

The case vehicle's driver was restrained by his available, active, three-point, lap-and-shoulder, safety belt system. An inspection of the driver's belt restraint system showed evidence of loading on the "D"-ring, and there was sprayed cola drink on the webbing. The case vehicle's driver was transported to the hospital by a good Samaritan. He sustained minor injuries and was treated and released. The injuries sustained by the case vehicle's driver included: an abrasion to his forehead and right forearm from his air bag; a contusion to his head of unspecified location, possibly from contacting the air bag; a superficial laceration to the top, right back of his head from flying glass (i.e., the cola bottle); and a contusion over his right shoulder blade, most likely from contacting his seat back.

Immediately prior to the crash, the case vehicle's second seat left passenger [grandmother; 66-year-old, White (non-Hispanic) female] was seated in an upright posture with her back against the seat back, both feet on the floor, and both hands on her lap. The second seat left passenger [157 centimeters and 93 kilograms (62 inches, 205 pounds)] was restrained by her available, active, three-point, lap-and-shoulder, safety belt system. An inspection of the left rear passenger's belt restraint system revealed what appeared to be blood drops on the webbing. The second seat left passenger was transported by ambulance from the scene to the hospital. She sustained minor injuries and was treated and released. Her self-reported injuries included: a deep laceration to her left eyebrow, a contusion to her left knee, and contusions to both breasts from her safety belt.

The driver of the Chevrolet [15-year-old (unknown race or ethnic origin) female; unknown height and weight] was restrained by her available, active, three-point, lap-and-shoulder, safety belt system. She sustained unknown brain and internal injuries and died six days post-crash.

CRASH CIRCUMSTANCES

Figure 1: Case vehicle's southbound travel path in inside lane of left-hand curve; Note: roadway's +8% superelevation and the 8% positive grade on the west leg (arrow) as Chevrolet attempted to cross the roadway from right-to-left, heading eastward (case photo #01)

Figure 2: Case vehicle's southbound travel path in inside lane of left-hand curve just prior to impact; Note: police marked tire and impact positions (case photo #02)

The case vehicle was traveling south to southeast in a left-hand curve in the inside through lane of the two-lane, southbound roadway and intended to continue traveling southward. The roadway was part of a five-lane, divided trafficway (i.e., southbound roadway had two through lanes; northbound roadway had two through lanes and one left-hand turn lane on the south leg of the four-leg intersection). The two southbound lanes were divided by a dashed white line and

bordered by a solid yellow edge line on the east side and a solid white edge line on west side (**Figure 1** above). The west side of the southbound road had a 3.5 meter (11.6 feet) paved shoulder and the east side had a 1.3 meter (4.3 feet) paved shoulder, prior to the 8.3 meter (27.2 feet) wide unprotected grassy median (**Figure 2** above). The southbound roadway for the case vehicle at the point of impact was level (i.e., actual slope was 0.1%, negative to the south). The roadway was bituminous, and the ambient conditions were dry, cloudy, and dark, but there were street lamps for illumination at the time of the crash. There was no precipitation at the time of the crash. The posted speed limit for the case vehicle was 80 km.p.h. (50 m.p.h.). The Chevrolet was traveling east in the eastbound lane of an intersecting, two-lane, undivided roadway and was attempting to cross the southbound roadway in order to turn left and go north on the northbound roadway. The Chevrolet's approach to the southbound roadway involved crossing a frontage road and then driving up a incline (i.e., 8.5% slope, positive to the east; **Figure 1** above) of approximately 14.0 meters (46 feet) prior to reaching the crest of the southbound roadway's superelevation, which was located on the west shoulder of the southbound roadway. The west leg of the intersection was controlled by a regulatory YIELD sign (**Figure 3**). Presumably the driver of the Chevrolet yielded prior to accelerating over the crest and driving down the southbound roadways's superelevation (i.e., 8.1% slope, negative to the east), attempting to cross the roadway. It should be noted that this contractor attempted this same crossing maneuver and found it awkward due to the upward slope and line-of-sight. The case vehicle's driver made no avoidance maneuvers prior to the crash. It is unknown if the Chevrolet's driver saw the case vehicle or attempted any evasive action prior to the crash. The crash occurred in the inside, southbound lane in the intersection of the two roadways; see **CRASH DIAGRAM** below.

Figure 3: Chevrolet's eastward travel path across frontage road and up 8% positive grade of west leg of four-leg intersection; Note: case vehicle was traveling southward (i.e., left-to-right) in photo (case photo #07)

Figure 4: Case vehicle's frontal damage viewed from left of front with contour gauge present (case photo #15)

Figure 5: Case vehicle's frontal damage viewed from right of front with contour gauge present (case photo #21)

Figure 6: Chevrolet's left side damage (case photo #56)

Figure 7: Overhead view of crush to Chevrolet's left side showing extensive intrusion into driver's space (case photo #57)

The front of the case vehicle (**Figures 4** and **5** above) impacted the left side center of the Chevrolet (**Figures 6** and **7**), causing the case vehicle's driver and front right supplemental restraints (air bags) to deploy. The impact caused the case vehicle to become embedded into the left side of the Chevrolet, causing both vehicle's to remain attached for a short distance. The impact sent both vehicles in a southeasterly direction off the roadway onto the unprotected grassy median that separated the trafficway's two roadways. The case vehicle drove the Chevrolet sideways a short distance before the case vehicle's counterclockwise yaw enabled it to separated from the Chevrolet. Upon separation, the case vehicle corrected itself back clockwise approximately 15 degrees prior to coming to an abrupt stop in the median heading essentially southward. The case vehicle came to rest approximately 19.2 meters (63 feet) southeast of the point of impact. After separating from the case vehicle, the Chevrolet rotated approximately 65 degrees counterclockwise before coming to rest in the median heading northeastward. The Chevrolet came to rest approximately 27.1 meters (89 feet) southeast of the point of impact.

CASE VEHICLE

The 1995 Ford Windstar GL was a front wheel drive, seven-passenger, three-door minivan (VIN: 2FMDA5141SB------) equipped with a 3.8L, EPFI-OHV, V-6 engine, power-assisted steering, and a four-speed automatic transmission. Braking was achieved by a power assisted, four-wheel, anti-lock brakes. The case vehicle's wheel base was 307 centimeters (120.7 inches), and the odometer reading at inspection is unknown because of the case vehicle was equipped with an electronic odometer.

Figure 8: Contacts to case vehicle's front right windshield (i.e., spider web with hair) and header/sun visor; in addition, there were blood spots on upper left side of front right air bag (case photo #29)

The interior of the case vehicle was equipped with adjustable, box-mounted, front bucket seats with adjustable head restraints; three-point, lap-and-shoulder, safety belt systems in the six outboard seating positions; and a manual, two-point, lap belt in the back center seat position.

Only the front belt systems were equipped with manually operated height adjusters for the "D"-rings. The driver's height adjustor was in the middle position, and the front right passenger's adjustor was towards the upmost position. The vehicle had electronic door-locks and windows openers as well as electronic seat adjusters for the front seating positions. The vehicle was equipped with knee bolsters for the driver and front right passenger. The second row seats were also box-mounted, bucket seats with folding backs and adjustable head restraints. The back seat was an adjustable bench type seat with no head restraints. Automatic restraint was provided by a Supplemental Restraint System (SRS) that consisted of frontal air bags for the driver and front right passenger positions.

Figure 9: Case vehicle's right sun visor (in raised position) and front right header showing occupant contact evidence on header (case photo #32a)

Figure 10: Close-up of case vehicle's front right header showing evidence (i.e., hair, scuff) of contact (case photo #32b)

Figure 11: Case vehicle's front right seating area showing scuffs to glove box door and a black scuff to top of dash (case photo #31)

Figure 12: Case vehicle's front right seating area and interior view of right front door showing deployed front right air bag and oil smear (i.e., yellow tape) to right front door's glazing from contact by "on-lap" front right passenger (case photo #33)

An examination of the case vehicle's interior revealed the following evidence of occupant contact. There was a contact (i.e., a spider web with hair in it; **Figure 8** above) to the windshield and a contact to the windshield (front) header (i.e., scuff with clump of hair) and sun visor (**Figures 9** and **10**). There was a scratch/scuff on the glove compartment door (**Figure 11**) and an unknown white fluid on the right front door's armrest. The right front door's glazing revealed contact evidence (i.e., oil/grease smear with unknown fluid; **Figure 12** and **Figure 13** below). In addition, there was a scuff to the backside of the front right seat back and an oil smear on the

glazing near where the second seat left passenger was sitting (**Figures 14**, **15**, and **16**). The inspection of the case vehicle's interior also revealed the following noncontact-related evidence. There was broken glass on the floor in front of the front bucket seats from the cola bottle that broke spraying the driver's air bag. In addition, there was a crack in the windshield near the driver's side caused by contact from the rearview mirror, and the rearview mirror was broken and hanging down after being struck in the lower right corner and forced it into the windshield by the deploying front right air bag. The energy absorbing steering column showed no evidence of compression. The left rear glazing popped off the case vehicle while being towed from the scene.

Figure 13: Close-up interior view of case vehicle's right front door glazing showing oil smears and fluid on glazing (case photo #34)

Figure 14: Case vehicle's second seating area; Note: contact to glazing by second seat left passenger (case photo #46)

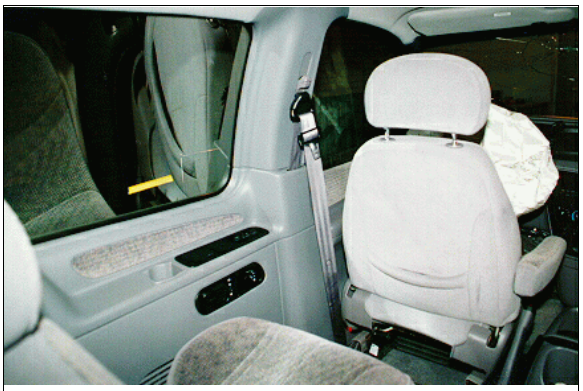


Figure 15: Seating area of case vehicle's second seat left passenger showing contact to side glazing; Note: driver's safety belt, box-mounted seat, and deployed air bag (case photo #49)

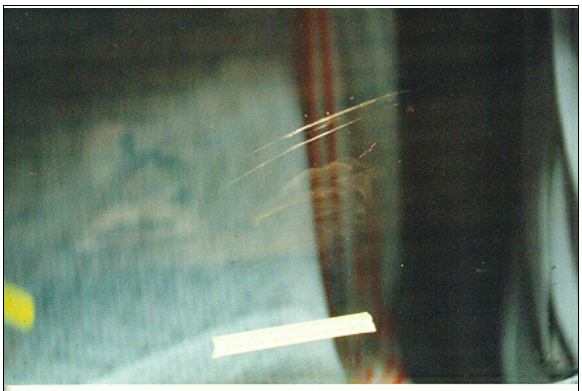


Figure 16: Close-up of make-up and oil smear on interior of left glazing for case vehicle's second seating area (case photo #51)

CASE VEHICLE DAMAGE

The case vehicle's frontal impact with the Chevrolet caused direct damage across the entire front, and the case vehicle's penetrating impact into the left side of the Chevrolet resulted in direct damage extending up to, but not involving, the left "A"-pillar (**Figure 4** above). The field L and direct damage extended across the entire front bumper a distance of 154 centimeters (60.6 inches). The residual crush across the case vehicle's front bumper was minor compared to the extensive crush to the Chevrolet (discussed below) and ranged from 0 centimeters (0.0 inches) at C_6 to 9 centimeters (3.5 inches) at C_1. The front bumper fascia, grille, hood, both fenders, and the

radiator were crushed rearward. Both front headlight assemblies were knocked out. As mentioned above, the windshield had two spider web cracks, one from rear view mirror and the other from the front right "on-lap" passenger. Neither of the front tires were physically restricted from the front end damage. The wheelbase was unaltered from the crash. The case vehicle was towed due to damage.

Based on the vehicle inspection, the CDC was determined to be: **12-FDEW-1 (10)** for the case vehicle [maximum crush was 9 centimeters (3.5 inches) at C_1]. 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: 29.7 km.p.h. (18.5 m.p.h.), -29.2 km.p.h. (-18.1 m.p.h.), and -5.2 km.p.h. (-3.2 m.p.h).

AUTOMATIC RESTRAINT SYSTEM

As previously mentioned, the case vehicle was equipped with a SRS that consisted of frontal air bags at the driver and front right passenger seating positions. The SRS deployed as a result of the case vehicle's frontal impact with the left side of the Chevrolet. 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 21 centimeters (8.3 inches) at the upper and lower horizontal seams and 11 centimeters (4.3 inches) vertically for the upper flap and 5 centimeters (2.0 inches) vertically for the lower flap. An inspection of the air bag module's cover flaps and air bag revealed that the cover flaps opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover flaps. The driver's air bag was designed with three tethers, each 6 centimeters (2.4 inches) wide, sewn to the center interiorly. The driver's air bag had two vent ports, approximately 1.5 centimeters (0.6 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 59 centimeters (23.2 inches) and a width of approximately 63 centimeters (24.8 inches). There was no contact evidence readily apparent on the driver's air bag; however, to the right of center, there was a large amount of cola splatter to the majority of the front right half surface (**Figure 17**). All the splatter came from a broken cola bottle that was thrown forward against the dash during the case vehicle's impact.

Figure 17: Case vehicle's deployed driver air bag showing no visible contact evidence, but there was sprayed cola on right half (case photo #37)

The front right passenger's air bag was located in the middle (i.e., on the front of the top portion) of the right 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 32.5 centimeters (12.8 inches) at the lower horizontal seam and 12.5 centimeters (4.9 inches) along both vertical seams. The profile of the case vehicle's instrument panel/dash resulted in a 21 centimeter (8.3 inch)

setback of the leading edge of the cover flap relative to the protruding right instrument panel. This distance gave the appearance of a ledge or shelve in front of the air bag module's 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 one vent port, approximately 4 centimeters (1.6 inches) in diameter, located at the 10 o'clock position. The deployed front right air bag was rectangular with a height of approximately 55 centimeters (21.7 inches) and a width of approximately 70 centimeters (27.6 inches). The inspection of the air bag revealed three small blood spots to the front portion of the air bag towards left side (**Figures 18** and **19**). All three spots were from 3 to 7 centimeters (1.2 - 2.8 inches) inward of the front left edge of the front right passenger air bag and 18 to 23 centimeters (7.1 - 9.1 inches) down from the top edge of the air bag.

Figure 18: Case vehicle's deployed front right passenger air bag showing blood spots near green dot on left middle portion (case photo #41)

Figure 19: Close-up of blood spots on front surface of case vehicle's deployed front right air bag near left middle portion (case photo #42)

CASE VEHICLE "ON-LAP" FRONT RIGHT PASSENGER KINEMATICS

The case vehicle's impact with the Chevrolet deployed the front right passenger air bag. Immediately prior to the crash the case vehicle's "on-lap" front right passenger [4-year-old, White (non-Hispanic) female; 91 centimeters and 16 kilograms (36 inches, 35 pounds)] was seated in an upright posture between the front right passenger's legs with her back against his chest, her feet dangling over the front edge of the seat's cushion angled downward, and both hands trying to unwrap a toy. The front right seat track was in its rearmost position, and the seat back was sightly reclined.

The case vehicle's "on-lap" front right passenger (i.e., daughter of the front right passenger) was not using the active, three-point, lap-and-shoulder, safety belt system because the system was in use by the front right passenger (i.e., father). In addition, the father indicated that he was holding his daughter between his legs and, thus, the child was facing forward.

The case vehicle's driver made no known pre-crash avoidance maneuvers. As a result and independent of the nonuse by the "on-lap" front right passenger of any safety restraints, the daughter's pre-impact body position did not change just prior to impact. The case vehicle's impact

with the Chevrolet enabled the "on-lap" front right passenger to continue forward and upward as the case vehicle decelerated. The child's forward momentum allowed her to move toward and over the front right air bag module. As the air bag began to deploy, it impacted the child on the chin and under the child's neck, but her forward momentum enabled the child to continue forward and contact the windshield (i.e., a spider web with hair in it; **Figure 8** above). As the air bag fully expanded, she was driven upwards where she contacted the windshield header (i.e., scuff with clump of hair; **Figures 9** and **10** above) and sun visor. As the case vehicle rotated approximately 20 degrees counterclockwise, the child contacted the right side window glazing (i.e., an oil smear; **Figures 12** and **13** above) before ending up back on her father's lap, still facing forward. The case vehicle's subsequent clockwise rotation following its separation from the Chevrolet caused her to shift back to the left while on the lap of the seated front right passenger. The "on-lap" passenger was removed from the case vehicle through the right front door and placed on the roadside prior to the arrival of emergency medical personnel.

CASE VEHICLE "ON-LAP" FRONT RIGHT PASSENGER INJURIES

The "on-lap" front right occupant was transported by ambulance to the hospital. She sustained critical injuries and was pronounced brain dead approximately 17 hours post-crash. The injuries sustained by the case vehicle's "on-lap" front right passenger included: a critical nonanatomic brain injury; a critical, diffuse, cerebral edema; a posterior subarachnoid hemorrhage and scalp contusion, bilateral lung contusions; bilateral retinal hemorrhages; abrasions to her chin and anterior neck, and contusions to her neck and right upper chest. This passenger's close proximity to the front right passenger air bag module combined with the nonuse of any safety belts resulted in this passenger's critical brain injuries.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Nonanatomic brain injury with GCS = 3, no response to painful stimuli, flaccid, no respirations or movements, pupils fixed & dilated, no corneal reflex, no brain wave activity	160824.5 critical	Air bag, front right passenger's	Certain	Hospitalization records
2	Edema, severe, diffuse, cerebral with "slit-like" ventricles [Aspect = Unknown]	140674.5 critical	Air bag, front right passenger's	Certain	Hospitalization records
3	Hemorrhage, subarachnoid in posterior skull, not further specified [Aspect = Unknown]	140684.3 serious	Front right windshield header	Possible	Emergency room records
4	Contusions, bilateral lungs, lobes not specified	441410.4 severe	Air bag, front right passenger's	Certain	Hospitalization records

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
5 6	Hemorrhages, retinal, bilateral	240499.1 240499.1 minor	Air bag, front right passenger's	Certain	Emergency room records
7	Contusion {hematoma} @ crown of head and upper posterior scalp	190402.1 minor	Front right windshield header	Probable	Emergency room records
8	Abrasion chin	290202.1 minor	Air bag, front right passenger's	Certain	Hospitalization records
9	Abrasions across anterior neck down to clavicles	390202.1 minor	Air bag, front right passenger's	Certain	Hospitalization records
10	Contusion {bruising} anterior neck	390402.1 minor	Air bag, front right passenger's	Certain	Emergency room records
11	Contusion {bruising}, slight, right upper chest	490402.1 minor	Air bag, front right passenger's	Certain	Hospitalization records

CASE VEHICLE FRONT RIGHT PASSENGER KINEMATICS

The case vehicle's front right passenger [father of "on-lap" passenger; 35-year-old, White (non-Hispanic) male; 183 centimeters and 74 kilograms (72 inches, 163 pounds)] was seated in a slightly reclined posture with his back against the seat back, legs spread with both feet on the floor, and both arms around his daughter (i.e., helping her unwrap a toy). As mentioned earlier, his seat track was in its rearmost position. The front right passenger was restrained by his available, active, three-point, lap-and-shoulder, safety belt system. An inspection of the front right safety belt system revealed loading evidence on the adjustable "D"-ring (i.e., heat abrasion) and to the belt webbing [i.e., rippling to webbing near latch plate (**Figure 20**) along with possible cloth transfer and blood smears at two separate places].

Figure 20: Close-up of case vehicle's front right safety belt showing heat abrasion on webbing from "D"-ring (case photo #44)

The case vehicle's driver made no known pre-crash avoidance maneuvers. As a result and independent of the use by the front right passenger

of any safety restraints, the father's pre-impact body position did not change just prior to impact. The case vehicle's impact with the Chevrolet enabled the front right passenger to continue forward and upward as the case vehicle decelerated. The passenger's belt restraint locked-up during the vehicle's deceleration restricting the passenger's forward excursion. The seated passenger's restraint usage prevented the "on-lap" passenger from being extensively compressed between the deployed front right air bag and himself (i.e., most likely there was some compression). The front right passenger loaded the locked restraint and moved toward the right against the restraint as the case vehicle rotated approximately 20 degrees counterclockwise after impact. Upon separating from the Chevrolet, the case vehicle corrected itself back clockwise approximately 15 degrees. The case vehicle's subsequent clockwise rotation following its separation from the Chevrolet caused him to shift slightly back to the left. As the case vehicle came to an abrupt stop, he shifted back to the left. At final rest the seated front right passenger remained in his seat with his 4-year-old daughter laying on his lap.

CASE VEHICLE FRONT RIGHT PASSENGER INJURIES

The case vehicle's front right passenger accompanied his daughter in the ambulance to the hospital. Initially, he complained of only soreness to his knees and back and refused treatment; however, he returned the next day and was treated and released for minor injuries. According to his medical records, he sustained strains to his cervical and thoracic regions and a contusion to his left knee.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Strain, cervical, myofascial	640278.1 minor	Other noncontact injury source: flexion-extension	Probable	Emergency room records
2	Strain, thoracic, myofascial	640478.1 minor	Other noncontact injury source: flexion-extension	Probable	Emergency room records
3	Contusion left knee	890402.1 minor	Glove compartment door	Probable	Emergency room records

CASE VEHICLE DRIVER KINEMATICS

The case vehicle's impact with the Chevrolet deployed the driver air bag. The case vehicle's driver [grandfather; 68-year-old, White (non-Hispanic) male; 178 centimeters and 86 kilograms (70 inches, 190 pounds)] was seated upright with his back against the seat back, his left foot on the floor, his right foot on the accelerator, and both hands on the steering wheel. His seat track was located between its middle and rearmost positions, and the tilt steering wheel was located in its middle position. The case vehicle's driver was restrained by his available, active, three-point, lap-and-shoulder, safety belt system. An inspection of the driver's belt restraint system showed

evidence of loading on the "D"-ring, and there was sprayed cola drink on the webbing (**Figure 21**).

Figure 21: Case vehicle's driver safety belt showing heat abrasion to "D"-ring (case photo #50)

The case vehicle's driver made no known pre-crash avoidance maneuvers. As a result and independent of the driver's use of his safety restraints, his pre-impact body position did not change just prior to impact. The case vehicle's impact with the Chevrolet enabled the driver to continue forward and upward as the case vehicle decelerated. The case vehicle's driver contacted the deploying air bag, but the driver's safety belt locked-up during the deceleration restricting the driver's forward movement. The driver moved toward the right off of the deployed air bag as the vehicle rotated approximately 20 degrees counterclockwise after impact. The counterclockwise yaw carried the case vehicle onto the grassy median. Upon separating from the Chevrolet, the case vehicle corrected itself back clockwise approximately 15 degrees prior to coming to an abrupt stop at final rest. The case vehicle's subsequent clockwise rotation following its separation from the Chevrolet caused him to shift slightly back to the left. At final rest the driver remained in his seat.

CASE VEHICLE DRIVER INJURIES

The case vehicle's driver was transported to the hospital by a good Samaritan. He sustained minor injuries and was treated and released. The injuries sustained by the case vehicle's driver included: an abrasion to his forehead and right forearm from his air bag; a contusion to his head of unspecified location, possibly from contacting the air bag; a superficial laceration to the top, right back of his head from flying glass (i.e., the cola bottle); and a contusion over his right shoulder blade, most likely from contacting his seat back.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Abrasion forehead, not further specified	290202.1 minor	Air bag, driver's	Probable	Emergency room records
2	Contusion head, not further specified	190402.1 minor	Air bag, driver's	Possible	Emergency room records
3	Laceration, superficial, to scalp at top, right back	190602.1 minor	Other noncontact injury source: flying glass	Probable	Emergency room records
4	Contusion over inferior right shoulder blade	790402.1 minor	Seat, back support	Possible	Emergency room records
5	Abrasion right forearm, not further specified	790202.1 minor	Air bag, driver's	Probable	Emergency room records

Immediately prior to the crash, the case vehicle's second seat left passenger [grandmother; 66-year-old, White (non-Hispanic) female; 157 centimeters and 93 kilograms (62 inches, 205 pounds)] was seated in an upright posture with her back against the seat back, both feet on the floor, and both hands on her lap. The second seat left passenger was restrained by her available, active, three-point, lap-and-shoulder, safety belt system. An inspection of the left rear passenger's belt restraint system revealed what appeared to be blood drops on the webbing.

The case vehicle's driver made no known pre-crash avoidance maneuvers. As a result and independent of the use by the second seat left passenger of any safety restraints, the grandmother's pre-impact body position did not change just prior to impact. The case vehicle's impact with the Chevrolet enabled the second seat left passenger to continue forward and upward as the case vehicle decelerated. The passenger's safety belt locked-up during the vehicle's deceleration restricting the passenger's forward movement but preventing her from contacting the backside of the driver's seat back with her legs. The second seat left passenger moved from the locked restraint toward to the right as the vehicle rotated approximately 20 degrees counterclockwise after impact. She may have contacted the backside of the front right seat back at this time. The case vehicle's subsequent clockwise rotation following its separation from the Chevrolet caused her to shift back to the left contacting the side glazing leaving a make-up smear (**Figures 15** and **16** above).

CASE VEHICLE SECOND SEAT LEFT PASSENGER INJURIES

The second seat left passenger was transported by ambulance from the scene to the hospital. She sustained minor injuries and was treated and released. Her self-reported injuries included: a deep laceration to her left eyebrow, a contusion to her left knee, and contusions to both breasts from her safety belt.

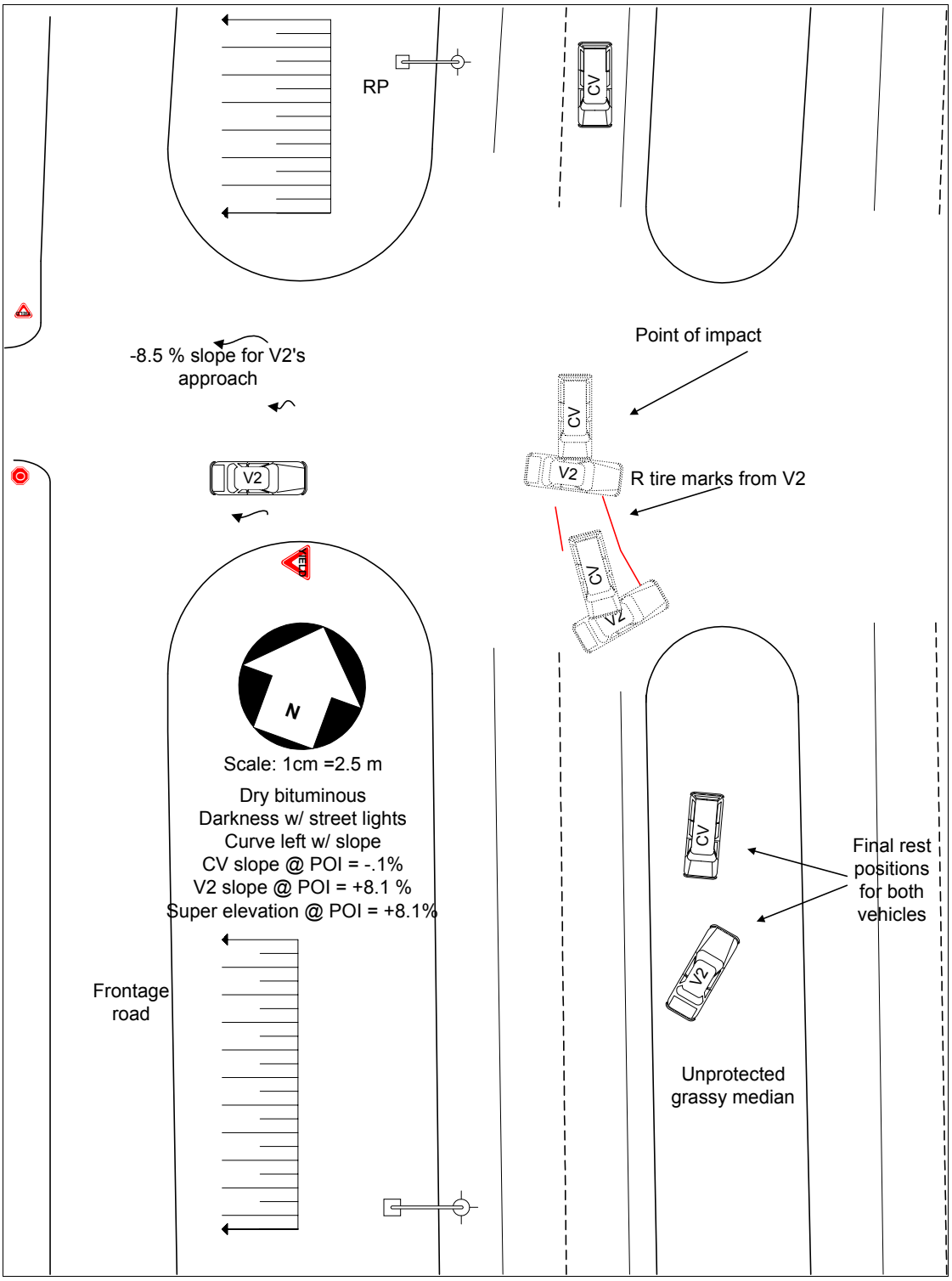
Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1 2	Contusion left breast Contusion right breast	490402.1 490402.1 minor	Torso portion of safety belt	Probable	Interviewee (driver)
3	Laceration, 6.4 cm (2.5 in), deep to bone, left eyebrow	290602.1 minor	Side window sill	Probable	Interviewee (driver)
4	Contusion left knee	890402.1 minor	Left side interior surface, excluding hardware or armrests	Probable	Interviewee (driver)

The 1987 Chevrolet Celebrity is a front wheel drive, six-passenger, four-door sedan (VIN: 1G1AW51R7H6------) equipped with a 2.5L, EFI, L-4 engine and a three-speed automatic transmission. Braking was achieved using a dual hydraulic, self adjusting, front disk and rear drum system. The Chevrolet was not equipped with anti-lock brakes. The Chevrolet's wheel base was 266 centimeters (104.9 inches), and the odometer reading at inspection was 243,296 kilometers (151,177 miles).

The front outboard seats were equipped with manual, three-point, lap-and-shoulder, safety belt systems. The front center seat and all three back seats were equipped with only a manual, two-point, lap belt. The interior was equipped with a front bench seat, with separate back cushions, and the back was equipped with a fixed bench seat.

The crush to the Chevrolet‘s left side was concentrated primarily to the passenger compartment (i.e., between left “A” and “C” pillars) causing massive intrusion (**Figures 6** and **7** above). The left impact was severe enough to bow the vehicle. All three left side pillars on the Chevrolet were cut by emergency crews and the roof was subsequently peeled over to the right side in order to extricate the restrained driver. Direct damage started 18 centimeters (7.1 inches) behind the left front axle and extended rearward 213 centimeters (83.9 inches) to the left “C”-pillar. The maximum crush was measured at 69 centimeters (27.2 inches) next to C_3. The total field L was measured at 252 centimeters (99.2 inches). The Chevrolet was towed due to damage. Based on the vehicle inspection, the CDC for the Chevrolet was determined to be: **10-LPEW-4 (290)**. The WinSMASH reconstruction program, damage only algorithm, was used on the Chevrolet's highest severity impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 46.4 km.p.h. (28.8 m.p.h.), -15.9 km.p.h. (-9.9 m.p.h.), and +43.6 km.p.h. (+27.1 m.p.h.).

The unlicenced driver of the Chevrolet [15-year-old (unknown race or ethnic origin) female; unknown height and weight] was restrained by her available, active, three-point, lap-and-shoulder, safety belt system. She sustained unknown brain and internal injuries and died six days post-crash.


RP
CV
-8.5 % slope for V2's approach
Point of impact
CV
V2
R tire marks from V2
V2
CV
V2
N
Scale: 1cm =2.5 m
Dry bituminous
Darkness w/ street lights
Curve left w/ slope
CV slope @ POI = -.1%
V2 slope @ POI = +8.1 %
Super elevation @ POI = +8.1%
CV
Final rest positions for both vehicles
V2
Frontage road
Unprotected grassy median