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ON-SITE AIR BAG INVESTIGATION

CASE NUMBER - IN97-042
LOCATION - MISSISSIPPI
VEHICLE - 1995 FORD CONTOUR 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 Contour GL, four-door sedan, with manual safety belts and dual front air bags, and a 1995 Ford Ranger, two-door, pickup truck

16. *Abstract*

This report covers an on-site investigation of an air bag deployment crash that involved a 1995 Ford Contour GL (case vehicle) and a 1995 Ford Ranger XLT pickup truck (other vehicle). This crash is of special interest because the case vehicle's, unrestrained, front right passenger (5-year-old female) sustained fatal cervical injuries from contacting her deploying front right air bag module's cover flap. The case vehicle was traveling primarily north in the northbound lane of a two-lane, undivided county road in the middle segment of an "S"-curve. The Ford pickup, which was traveling northward ahead of the case vehicle in the northbound lane of the same winding roadway, came to a complete stop in the roadway. The crash occurred in the northbound lane of the roadway. The front of the case vehicle impacted the back of Ford pickup, causing the case vehicle's driver and front right supplemental restraints (air bags) to deploy. The case vehicle's front right passenger was seated with her seat track located between its middle and forward-most positions. She was not wearing her available, active, three-point, lap-and-shoulder, safety belt system and sustained, according to her autopsy, fatal injuries which included: a transection of her proximal spinal cord with associated atlanto-occipital dislocation and a fracture of C_1; a large subdural hemorrhage; diffuse, bilateral subarachnoid hemorrhages; moderate cerebral edema; a lacerated larynx; bilateral lung contusions; a large, gaping, laceration of her anterior neck with surrounding abrasions superior and inferior to the laceration, a contusion (cephalhematoma) to her scalp, and multiple abrasions and contusions scattered about her face, shoulders, right upper chest, and right mid-superior back. This occupant's primary cervical and neck injuries were caused directly by her contact with the front right passenger air bag module's cover flap. The case vehicle's driver (35-year-old female) was seated with her seat track located in its middle position. The case vehicle was not equipped with a tilt steering wheel. She was not wearing her available, active, three-point, lap and shoulder belt and sustained only a minor thumb laceration. The case vehicle's back left passenger (8-year-old male) was seated but his seat track and seat back were not adjustable. He was not wearing his available, active, three-point, lap and shoulder belt and did not sustain any injuries as a result of this crash.

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BACKGROUND

IN97-042

This on-site investigation was brought to NHTSA's attention on November 17, 1997 by one of the NHTSA's Regional offices. This crash involved a 1995 Ford Contour (case vehicle) and a 1995 Ford Ranger pickup truck (other vehicle). The crash occurred in November, 1997, at 7:00 p.m., in Mississippi and was investigated by the applicable county sheriff department. This crash is of special interest because the case vehicle's, unrestrained, front right passenger [5-year-old, Black (non-Hispanic) female] sustained fatal cervical injuries from contacting her deploying front right air bag module's cover flap. This contractor inspected the scene and vehicles on 19-20 November, 1997. This contractor interviewed the driver for the case vehicle on November 20, 1997. This summary is based on the Police Crash Report; interviews with the case vehicle's driver, the County Medical Examiner, and the investigating police officer; scene and vehicle inspections; occupant kinematic principles, the front right occupant's autopsy report; and this contractor's evaluation of the evidence.

SUMMARY

The case vehicle was traveling primarily north in the northbound lane of a two-lane, undivided county road in the middle segment of an "S"-curve. The case vehicle intended to continue traveling northward. The Ford pickup, which was traveling northward ahead of the case vehicle in the northbound lane of the same two-lane, undivided, winding roadway, came to a complete stop in the roadway because he saw the case vehicle's high beam headlights flash (i.e., "on-and-off"). The pickup's driver thought that either the case vehicle had hit a deer, or that the case vehicle's driver was trying to get his attention for some other reason. The case vehicle's driver braked at the very last second, attempting to avoid the crash. The crash occurred in the northbound lane of the roadway; see **CRASH DIAGRAM** below.

The front of the case vehicle impacted the back of Ford pickup, causing the case vehicle's driver and front right passenger supplemental restraints (air bags) to deploy. The case vehicle and the Ford pickup moved forward slightly post-crash with each vehicle coming to rest heading in a north-northeasterly direction in the northbound lane of the roadway.

The 1996 Ford Contour was a front wheel drive, four-door sedan, (VIN: 1FALP6532SK------). The case vehicle was equipped with anti-lock brakes. Based on the vehicle inspection, the CDC for the case vehicle was determined to be: **12-FDMW-1 (0)**. 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: 12.3 km.p.h. (7.6 m.p.h.), -12.3 km.p.h. (-7.6 m.p.h.), and 0.0 km.p.h. (0.0 m.p.h.). The case vehicle was initially abandoned at the scene, but later it was towed but not due to damage.

The case vehicle's contact with the Ford pickup involved the top surface of the front bumper and the hood. Direct damage began 61 centimeters (24.0 inches) leftward of the vehicle's center and extended to the right along the top of the front bumper. Maximum crush was measured as 8 centimeters (3.2 inches) between C_2 and C_3. The case vehicle's wheelbase was not shortened on either the left side or right sides. The case vehicle's hood was directly damaged and crushed

rearward. In addition, there was scraping to the top of the front bumper. None of the tires were physically restricted or deflated.

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 fabric revealed that the cover flaps opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover flaps. The driver's air bag was designed with four tethers, each 6 centimeters (2.4 inches) in width. The driver's air bag had two vent ports, approximately 2 centimeters (0.8 inches) in diameter, located at the 11 and 1 o'clock positions. The deployed driver's air bag was round with a diameter of 55 centimeters (21.7 inches). An inspection of the driver's air bag revealed a blood smear with a skin transfer located at approximately the 1:30-2 o'clock position in the upper right quadrant and blood smears at approximately the 9:30-10 o'clock position in the left upper quadrant of the driver's air bag.

The front right passenger's air bag was located in the top of the instrument panel. An inspection of the front right air bag module's cover flap and air bag fabric revealed that the cover flap opened at the designated tear points and there was definitive evidence of direct contact to the cover flap [i.e., and skin and blood transfers along with significant deformation–8 centimeters (3.1 inches)]. Furthermore, the cover flap was bowed downward from its direct contact with the front right passenger's neck and lower face. The front right air bag's fabric did not show any damage from the deployment. The front right passenger's air bag was designed with two tethers, each 7.5 centimeters (3.0 inches) in width. The front right air bag had one vent port, approximately 7 centimeters (2.8 inches) in diameter, located at the 10 o'clock position. The deployed front right air bag was rectangular with a height of approximately 50 centimeters (19.7 inches) and a width of approximately 73 centimeters (28.7 inches). An inspection of the front right air bag revealed contact evidence on the left side of the air bag's front, top, and bottom surfaces. On the top left surface there was an area of blood with dark skin. On the front surface near the vent port there was an area of oily and bloody smears, and finally, on the bottom left surface there was an area of blood and unknown body fluids.

The inspection of the case vehicle's interior revealed that there was damage in the shape of a large spider web to the front right of the windshield's glazing. Hair and skin deposited by the case vehicle's front right passenger was present within that damage pattern. Furthermore, there was a scuff and some hair present on the front right sun visor and header, most likely from the front right passenger. In addition, the roof above the steering wheel had an area of scuffing with blood present, and there was a knob missing from the center instrument panel. Finally, there was a slightly oblique vertically oriented area of scuffing on the glove compartment door most likely from the front right passenger's right knee.

The 1995 Ford Ranger is a rear wheel drive, two-door, regular cab pickup truck (VIN: 1FTCR10A5SU------). Based on the vehicle inspection, the CDC for Ford pickup was determined to be: **06-BDLN-1 (180)** [maximum crush was less than 0.5 centimeter (0.2 inches)]. The Ford pickup was driven from the scene.

Immediately prior to the crash the case vehicle's front right passenger [94 centimeters and 18 kilograms (37 inches, 40 pounds)] was seated upright with her back against the seat back, both feet sticking out from the seat cushion, and both hands on her lap. Her seat track was located between its middle and forward-most positions.

The case vehicle's front right passenger was not wearing her available, active, three-point, lap and shoulder belt. According to her autopsy, there was no evidence of belt pattern bruising and/or abrasions to the front right passenger's body. Furthermore, the inspection of the front right passenger's seatbelt webbing, "D"-ring, and latch plate showed no blood smears or evidence of loading.

At the last second the case vehicle's driver braked, attempting to avoid the crash. As a result of this attempted avoidance maneuver and the nonuse of her available safety belts, the front right passenger leaned and moved forward just prior to impact. The case vehicle's underriding type of impact with the back of Ford pickup enabled the case vehicle's front right passenger to continue forward and slightly upward toward the case vehicle's 0 degree Direction of Principal Force as the case vehicle decelerated. The underride type damage resulted in the air bag deploying late during the sequence of the impact. This delayed deployment occurred due to the prolonged change in time (Delta T) relative to the change in speed (magnitude of Delta V–i.e., ramp versus spike). As a result, the front right passenger was positioned on top of the front right air bag module's cover flap immediately prior to deployment. When the front right passenger air bag module's cover flap opened, the cover flap struck the 5-year-old passenger's chin and anterior neck, causing her head to hyper extend backwards. As the air bag deployed, it lifted her upwards into the windshield's glazing (i.e., the windshield had a "spider web" pattern with hair in it). In addition, the front right passenger struck the forward edge of the sun visor and front right header, depositing strands of hair. This sequence of head contacts initiating with the cover flap strike, were responsible for this occupants fatal injuries. After striking the sun visor and header, the passenger may have contacted the roof above the right instrument panel and front right floor area before rebounding backwards against the seat back and falling into her seat where she came to rest on the seat cushion, on her left side, with her head towards the driver. This occupant's final rest position is based on the blood evidence on the seat cushion and air bag fabric.

The front right occupant was transported in the Ford pickup to the hospital. She sustained fatal injuries and was pronounced dead 1 hour and 20 minutes post-crash. Based on her autopsy, the injuries sustained by the case vehicle's front right passenger included: a transection of her proximal spinal cord with associated atlanto-occipital dislocation and a fracture of C_1; a large subdural hemorrhage; diffuse, bilateral subarachnoid hemorrhages; moderate cerebral edema; a lacerated larynx; bilateral lung contusions; a large, gaping, laceration of her anterior neck with surrounding abrasions superior and inferior to the laceration across the whole anterior neck, a contusion (cephalhematoma) to her scalp, and multiple abrasions and contusions scattered about her face, shoulders, right upper chest, and right mid-superior back. This occupant's primary cervical and neck injuries were caused directly by her contact with the front right passenger air bag module's cover flap. Her brain injuries were caused by the case vehicle's front right sun visor and header as a result of being redirected by the deploying front right air bag.

Immediately prior to the crash the case vehicle's driver [35-year-old, Black (non-Hispanic) female; 160 centimeters and 57 kilograms (63 inches, 125 pounds)] was seated in an upright posture with her back against the seat back, her left foot on the floor, her right foot on the brake, and both hands on the steering wheel. Her seat track was located in its middle position. The case vehicle was not equipped with a tilt steering wheel. The case vehicle's driver was not wearing her available, active, three-point, lap and shoulder belt.

Immediately prior to the crash the case vehicle's back left passenger [8-year-old, Black (non-Hispanic) male; 122 centimeters and 29 kilograms (48 inches, 65 pounds)] was seated in an upright posture with his back against the seat back, both feet sticking out from the seat cushion, and both hands reportedly on his lap. His seat track and seat back were not adjustable. The case vehicle's back left passenger not was wearing his available, active, three-point, lap and shoulder belt.

The case vehicle's driver and back left passenger were transported by the driver of the Ford pickup to the hospital. The case vehicle's driver sustained minor injuries and was treated and released. According to her interview, the only injury she sustained was a right thumb laceration, while the case vehicle's back left passenger did not sustain any injuries as a result of this crash.

CRASH CIRCUMSTANCES

The case vehicle was traveling primarily north in the northbound lane of a two-lane, undivided county road in the middle segment of an "S"-curve (**Figures 1** and **2**). The case vehicle intended to continue traveling northward. The Ford pickup, which was traveling northward ahead of the case vehicle in the northbound lane of the same two-lane, undivided, winding roadway, came to a complete stop in the roadway because he saw the case vehicle's high beam headlights flash (i.e., "on-and-off"). The pickup's driver thought that either the case vehicle had hit a deer, or that the case vehicle's driver was trying to get his attention for some other reason. The case vehicle's driver braked at the very last second, attempting to avoid the crash. The crash occurred in the northbound lane of the roadway; see **CRASH DIAGRAM** below.

Figure 1: Case vehicle's northwest travel path in "S" curve approaching short straight section of roadway (case photo #02)

Figure 2: Short straight roadway segment in middle of "S" just prior to impact location between case vehicle's front and back of Ford pickup (case photo #04)

The county roadway in the area of the crash was an "S"-curve. The roadway curved to the right (**Figure 1** and **Figure 3** below) for northbound traffic [i.e., Radius = 100 meters (328.1 feet)] prior to straightening out for

approximately 21 meters (68.9 feet), including the point of impact, and then began to curve back to the left (**Figure 2** above). The country roadway was straight in the immediate vicinity of the crash. The roadway had a 2.2% pre-crash grade negative to the north (i.e., a downgrade the case vehicle's direction of travel), but the roadway leveled out (i.e., actual slope was 0.9%, negative to the north) at the area of impact. The pavement was bituminous but traveled, and the width of the travel lanes for both vehicles was 5.2 meters (17.1 feet). The shoulders were not improved, and there was a 2.0 meter (6.6 foot) wide area of trimmed grass adjacent to the roadway on the east side and a 2.6 meter (8.5 foot) wide area of trimmed grass adjacent to the roadway on the west side. The trimmed grass was followed by dense forest (**Figure 3**). There were no roadway markings or visible controls in the surrounding area other then an occasional Advisory sign that read: "WATCH FOR LOGGING TRUCKS ENTERING ROAD". The estimated coefficient of friction was 0.65. The statutory speed limit was 89 km.p.h. (55 m.p.h.). No regulatory speed limit sign was posted near the crash site. At the time of the crash the light condition was dusk, the atmospheric condition was dusty, and the road pavement was dry. Because there was a dense tree cover along this county road and no overhead illumination at the area of impact, the roadway gets prematurely dark. The "dusty" atmospheric condition, which was indicated on the Police Crash Report, can be explained by the fact that the roadway is heavily used by logging trucks, making the atmospheric environment over the roadway "dusty" when it's being driven. Traffic density was light, and the site of the crash was rural undeveloped, with scattered houses and mobile homes in the area.

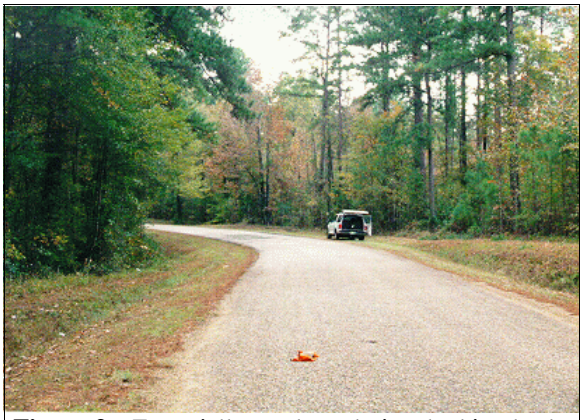

Figure 3: Essentially southward view looking back at northward travel path of case vehicle and Ford pickup after exiting "S" curve (case photo #06)

The front (**Figure 4**) of the case vehicle impacted the back of Ford pickup (**Figure 5** below), causing the case vehicle's driver and front right passenger supplemental restraints (air bags) to deploy. The case vehicle and the Ford pickup moved forward slightly post-crash with each vehicle coming to rest heading in a north-northeasterly direction in the northbound lane of the roadway.

Figure 4: Case vehicle's frontal deformation from impact with Ford pickup; Note: impact to right windshield's glazing from front right passenger and imprint of pickup's back center on hood of case vehicle (case photo #08)

CASE VEHICLE

The 1996 Ford Contour GL was a front wheel drive, five-passenger, four-door sedan, (VIN: 1FALP6532SK------) equipped with a 2.0L, I-4 engine and a four-speed automatic transmission. Braking was achieved by a power-

assisted, front disc and rear drum, four-wheel, anti-lock system. The case vehicle's wheelbase was 271 centimeters (106.5 inches), and the odometer reading at inspection was 119,378 kilometers (74,178 miles).

Figure 5: Minor damage to Ford pickup's back bumper; Note: yellow tape indicates direct damage to case vehicle's hood and scrapes to top of front bumper's fascia (case photo #63)

Inspection of the vehicle's interior revealed adjustable front bucket seats with adjustable head restraints; a non-adjustable back bench seat with adjustable head restraints for the back outboard seating positions; continuous loop, three-point, lap-and-shoulder, safety belt systems at the front and back outboard positions; and a two-point, lap belt system at the back center position. The front seat belt systems were equipped with manually operated height adjusters for the "D"-rings and both were set in the full-up position. There was a center console between the two front bucket seats that was used as an arm rest or small storage area. The vehicle was equipped with rigid, padded knee bolsters for both the driver and front right passenger, neither of which showed any visible evidence of contact or deformation. Automatic restraint was provided by a Supplemental Restraint System (SRS) that consisted of a frontal air bag for the driver and front right passenger seating positions. Both frontal air bags deployed as a result of the case vehicle's frontal impact with the Ford pickup.

CASE VEHICLE DAMAGE

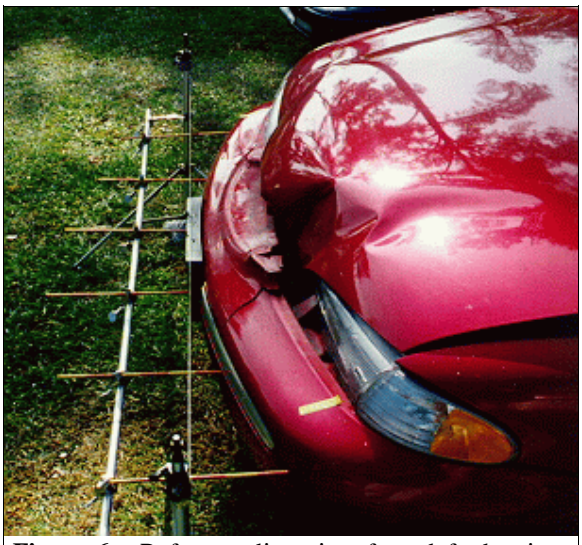

Figure 6: Reference line view from left showing underride damage to top of case vehicle's bumper (case photo #13)

The case vehicle's contact with the Ford pickup's back bumper involved the top surface of the front bumper (**Figure 6** and **Figure 7** below) and the hood (**Figures 8** and **9** below), indicating it underrode the back bumper of the pickup. Direct damage began 61 centimeters (24.0 inches) leftward of the vehicle's center and extended to the right, a measured distance of 122 centimeters (48.0 inches), along the top of the front bumper, ending just prior to the front right bumper corner. There was no evidence of direct contact to the front face of the bumper's fascia. Crush was measured both along the front bumper and across the entire grille area; however, the differences were not sufficient for averaging. Maximum crush was measured as 8 centimeters (3.2 inches) between C_2 and C_3. The case vehicle's wheelbase was not shortened on either the left or right sides. The case vehicle's hood, grille, and radiator with supports were directly damaged and crushed rearward. The deformation that initiated the deployment of the air bags was above the bumper and into the grille area and involved

direct contact to the radiator supports to which the air bag sensors are attached (**Figure 7**). Based on previous SCI cases, when contacted, the sensor supports tend to deploy the air bags in low Delta V crashes. In addition, there was scraping to the top of the front bumper. Both front fenders sustained minor induced damage from the frontal impact which also deformed both headlight brackets leaving the headlights undamaged. None of the case vehicle's tires were physically restricted or deflated from the front end damage.

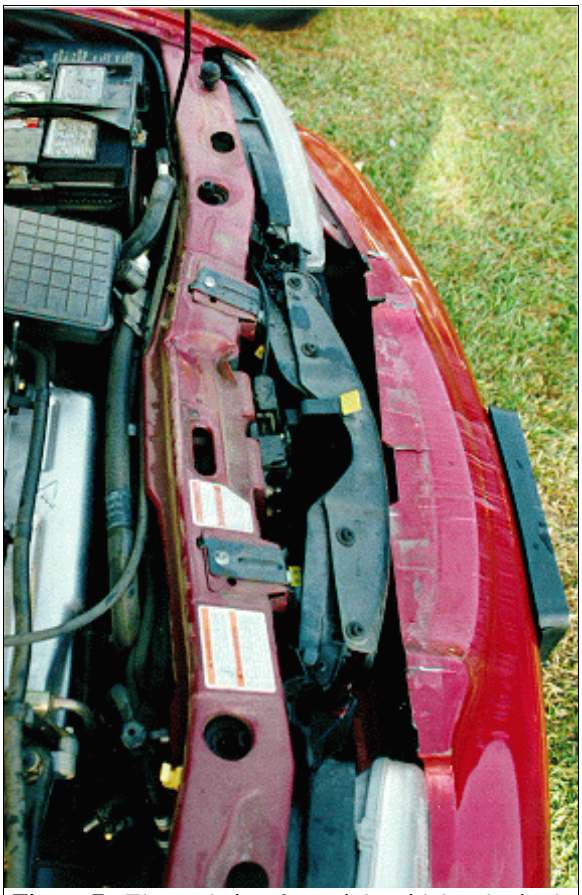

Figure 7: Elevated view from right with hood raised showing scrape on top of case vehicle's front bumper fascia; Note: air bag sensors not visible (case photo #19)

Figure 8: Case vehicle's frontal damage with contour gauge present; Note: contact to windshield's glazing on passenger side and damage on top of bumper from underride (case photo #24)

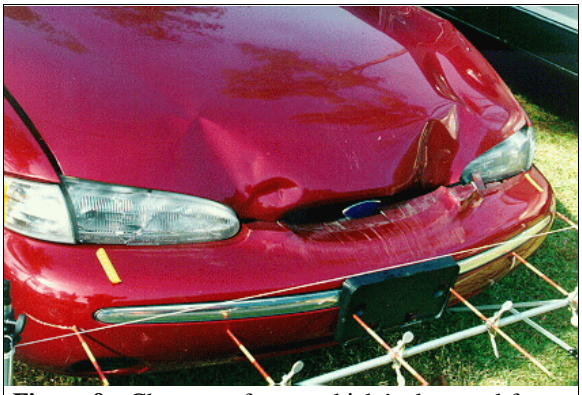

Figure 9: Close-up of case vehicle's damaged front showing (yellow tape) direct damage width from Ford's back bumper which overrode case vehicle's front bumper; Note: hood contact from back center of Ford (case photo #22)

The inspection of the case vehicle's interior revealed that there was damage in the shape of a large spider web to the front right of the windshield's glazing (**Figure 10** below). Hair and skin deposited by the case vehicle's front right passenger was present within that damage pattern. Furthermore, there was a scuff and some hair present on the front right sun visor and header, most likely from the front right passenger's head (**Figure 11** below). In addition, the roof above the steering wheel had an area of scuffing with blood present (**Figure 12** below). It is unknown, however, if the blood was from the driver or front right passenger. The energy absorbing steering column showed no evidence of compression. The air flow knob located in the center instrument panel was knocked off its stem (**Figure 12** below). There was what appeared to be a spray of body fluids to the interior of the front right door's glazing. Finally, there was a slightly oblique

vertically oriented area of scuffing on the glove compartment door, directly in front of the front right passenger, most likely from the front right passenger's right knee.

Figure 10: Close-up of case vehicle's right windshield glazing damaged from impact by front right passenger (case photo #16)

Figure 11: Vertical view of case vehicle's front right passenger seating area showing contacts to right windshield's glazing, right sun visor and header, and possibly to right roof areas (case photo #47)

Figure 12: Vertical view of case vehicle's driver seating area showing contact evidence on air bag's fabric, center instrument panel (highlighted), and possibly to roof (case photo #31)

Based on the vehicle inspection, the CDC for the case vehicle was determined to be: **12-FDMW-1 (0)**. 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: 12.3 km.p.h. (7.6 m.p.h.), -12.3 km.p.h. (-7.6 m.p.h.), and 0.0 km.p.h. (0.0 m.p.h.). The case vehicle was initially abandoned at the scene, but later it was towed but not due to damage.

The case vehicle was equipped with a Supplemental Restraint System (SRS) that contained frontal air bags at the driver and front right passenger positions. Both air bags deployed as a result of the frontal impact with the Ford pickup. The case vehicle's driver air bag was located in the steering wheel hub. The module cover consisted of two asymmetrical, curvilinear (i.e., concave), cover flaps, in an "H"-configuration, made of thick vinyl with overall dimensions of: 26 centimeters (10.2 inches) and 20 centimeters (7.9 inches) at the top and middle horizontal seams, respectively, for the top cover flap and 19 centimeters (7.5 inches) and 21 centimeters (8.3 inches) at the middle and bottom horizontal seams, respectively, for the lower cover flap. The top cover flap measured 7 centimeters (2.8 inches) vertically between the top and middle horizontal seams; however, the curvilinear distance along the top cover flap's surface was 11 centimeters (4.3 inches). The bottom cover flap measured 8 centimeters (3.1 inches) vertically between the middle and bottom horizontal seams. An inspection of the air bag module's cover flaps and air bag fabric revealed that the cover flaps opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover flaps. The driver's air bag was designed with four tethers, each 6 centimeters (2.4 inches) in width, sewn to the center, double-stitched, circular area. The driver's air bag had two vent ports, approximately 2 centimeters (0.8 inches) in diameter, located at the 11 and 1 o'clock positions. The deployed driver's air bag was round with a diameter of 55 centimeters (21.7 inches). An inspection of the driver's air bag revealed a blood smear with a skin transfer located at approximately the 1:30-2 o'clock position in the upper right quadrant and blood smears at approximately the 9:30-10 o'clock position in the left upper quadrant of the driver's air bag (**Figure 12** above). The smears most likely came from the driver's right thumb laceration.

The front right passenger's air bag was located in the top of the instrument panel (**Figure 13**). There was a single, asymmetrical, modular cover flap. The cover flap was made of a thick vinyl over a sheet metal frame. The flap's dimensions were: 37 centimeters (14.6 inches) at the forward horizontal seam, 49 centimeters (19.3 inches) at the rear (i.e., toward the windshield) horizontal seam, 35 centimeters (13.8 inches) along the angled left vertical seam, and 18 centimeters (7.1 inches) along the right vertical seam. However, the cover flap was creased with the majority of each side's vertical distance below the crease [i.e., 22 centimeters (8.7 inches) of the angled left vertical seam and 15 centimeters (5.9 inches) of the right vertical seam]. The profile of the case vehicle's instrument panel resulted in a 14 centimeter (5.5 inch) setback of the leading edge of the cover flap relative to the protruding right instrument panel. An inspection of the front right air bag module's cover flap and air bag fabric revealed that the cover flap opened at the designated tear points and there was definitive evidence of direct contact to the cover flap. Inspection of the cover flap revealed significant deformation with a skin transfer and blood to the

Figure 13: Case vehicle's front right seating area showing deformed front right air bag module's cover flap and blood/skin on top surface of air bag's fabric (case photo #55)

leading edge indicating direct contact with the front right passenger's neck and lower face (**Figure 14**). The skin and blood transfer was 8 centimeters (3.1 inches) wide and was approximately 15 centimeters (5.9 inches) in from the left edge and 14 centimeters (5.5 inches) in from the right edge. The evidence started at the leading edge of the cover flap extended back 6 centimeters (2.4 inches).

Figure 14: Close-up of blood/skin evidence on case vehicle's deformed front right air bag module's cover flap from contact with front right passenger's neck and chin (case photo #44)

The front right air bag's fabric did not show any damage from the deployment. The front right passenger's air bag was designed with two tethers, each 7.5 centimeters (3.0 inches) in width. Both tethers were sewn to the interior face of the air bag at a point that was 23 centimeters (9.1 inches) below the top edge. The front right air bag had one vent port, approximately 7 centimeters (2.8 inches) in diameter, located at the 10 o'clock position. The deployed front right air bag was rectangular with a height of approximately 50 centimeters (19.7 inches) and a width of approximately 73 centimeters (28.7 inches). An inspection of the front right air bag revealed a large transfer of skin to the top and upper front left portions of the air bag. The examination also revealed a large area of dark skin and what looked like unknown dried bodily fluids to the bottom left portion of the air bag. On the top left surface there was an area of blood with dark skin. The skin transfer started approximately 17 centimeters (6.7 inches) down from the top edge of the air bag and extended forwards [towards the front right seat, 24 centimeters (9.4 inches)], angling right to the left towards the corner and air vent port. The skin transfer was 8 centimeters (3.2 inches) wide and started 13 centimeters (5.1 inches) in from the left edge. The skin and blood transfer continued down onto the front left surface a distance of 25 centimeters (9.8 inches) and extended inwards 12 centimeters (4.7 inches) towards the center of the front surface (**Figure 15**). The other large skin and fluid transfer was to the bottom left portion of the air bag and started 15 centimeters (5.9 inches) rearward from the bottom edge of the front surface and was approximately 20 x 10 centimeters (7.9 x 3.9 inches) in area.

Figure 15: Front surface of case vehicle's deployed front right passenger air bag showing bloody and oily area around vent port in upper left quadrant and no other obvious evidence of contact (case photo #37)

CASE VEHICLE FRONT RIGHT PASSENGER KINEMATICS

Immediately prior to the crash the case vehicle's front right passenger [5-year-old, Black (non-Hispanic) female; 94 centimeters and 18 kilograms (37 inches, 40 pounds)] was seated upright with her back against the seat back, both feet sticking out from the seat cushion, and both hands on her lap. Her seat track was located between its middle and forward-most positions.

The case vehicle's front right passenger was not wearing her available, active, three-point, lap and shoulder belt. According to her autopsy, there was no evidence of belt pattern bruising and/or abrasions to the front right passenger's body. Furthermore, the inspection of the front right passenger's seat belt webbing, "D"-ring, and latch plate showed no blood smears or evidence of loading.

Figure 16: Close-up of case vehicle's contacted front right sun visor and possible contact to roof area (case photo #49)

Figure 17: Close-up of contact (i.e., scuff and hair transfer) to case vehicle's front right header and sun visor; Note: sun visor has been rotated upwards (case photo #50)

At the last second the case vehicle's driver braked, attempting to avoid the crash. As a result of this attempted avoidance maneuver and the nonuse of her available safety belts, the front right passenger leaned and moved forward just prior to impact. The case vehicle's underriding type of impact with the back of the Ford pickup enabled the case vehicle's front right passenger to slide forward on the seat and slightly upward toward the case vehicle's 0 degree Direction of Principal Force as the case vehicle decelerated. The underride type damage resulted in the air bag deploying late during the sequence of the impact. This delayed deployment occurred due to the prolonged change in time (Delta T) relative to the change in speed (magnitude of Delta V–i.e., ramp versus spike). As a result, the front right passenger was positioned directly in front of and on top of the front right air bag module's cover flap immediately prior to deployment. When the front right passenger air bag module's cover flap opened, the cover flap struck the 5-year-old passenger's chin and anterior neck, causing her head to hyper extend backwards. As the air bag deployed, it lifted her upwards into the windshield's glazing (i.e., the windshield had a "spider web" pattern with hair in it–**Figure 10** and **11** above). In

addition, the front right passenger struck the forward edge of the sun visor and front right header, depositing strands of hair (**Figures 16** and **17**). This sequence of head contacts initiating with the cover flap strike, were responsible for this occupants fatal injuries. Presumably, her left foot may have struck the center instrument panel knocking off the air flow control knob and her right knee scraped the glove compartment door as her body was being lifted upwards. After striking the sun visor and header, the passenger may have contacted the roof above the right instrument panel and front right floor area before rebounding backwards against the seat back and falling into her seat where she came to rest on the seat cushion, on her left side, with her head towards the driver. This occupant's final rest position is based on the blood evidence on the seat cushion and air bag fabric.

CASE VEHICLE FRONT RIGHT PASSENGER INJURIES

The front right occupant was removed from the vehicle by the driver (i.e., mother), and because of the child's apparent injury and the rural location of the crash, she was transported directly from the scene to the hospital by the driver of the Ford pickup. She sustained fatal injuries and was pronounced dead 1 hour and 20 minutes post-crash. Based on her autopsy, the injuries sustained by the case vehicle's front right passenger included: a transection of her proximal spinal cord with associated atlanto-occipital dislocation and a fracture of C_1; a large subdural hemorrhage; diffuse, bilateral subarachnoid hemorrhages; moderate cerebral edema; a lacerated larynx; bilateral lung contusions; a large, gaping, laceration of her anterior neck with surrounding abrasions superior and inferior to the laceration across the whole anterior neck, a contusion (cephalhematoma) to her scalp, and multiple abrasions and contusions scattered about her face, shoulders, right upper chest, and right mid-superior back. This occupant's primary cervical and neck injuries were caused directly by her contact with the front right passenger air bag module's cover flap. Her brain injuries were caused by the case vehicle's front right sun visor and header as a result of being redirected by the deploying front right air bag.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Laceration {transection} of proximal cervical spinal cord with atlanto-occipital dislocation and fracture (unspecified) of C_1	640276.6 untreatable	Front right module's cover flap	Certain	Autopsy
2	Hemorrhage, subdural, 60 cc, location not specified [Aspect = Unknown]	140656.5 critical	Windshield header and/or sun visor, front right	Probable	Autopsy
3	Edema, cerebral, moderate with 2+ uncal notching, location not specified [Aspect = Unknown]	140664.4 severe	Windshield header and/or sun visor, front right	Probable	Autopsy
4 5	Hemorrhage, subarachnoid, diffuse but involving both the right and left cerebral hemispheres	140684.3 140684.3 serious	Windshield header and/or sun visor, front right	Probable	Autopsy

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
6	Hemorrhage, subarachnoid, diffuse but involving both right and left cerebellar hemispheres	140466.3 serious	Windshield header and/or sun visor, front right	Probable	Autopsy
7	Laceration, 1 cm (0.4 in), larynx {mucosal surface of false vocal cord[1]}	340606.3 serious	Front right module's cover flap	Certain	Autopsy
8	Contusions, multiple, bilateral lungs, up to 2 cm (0.8 in), predominately in the perihilar areas	441410.4 severe	Air bag, front right passenger's	Certain	Autopsy
9	Laceration, 17 cm (6.7 in), gaping, over anterior neck, horizontally	390604.2 moderate	Front right module's cover flap	Certain	Autopsy
10	Contusion, scalp {cephalhematoma} [Aspect = Unknown]	190402.1 minor	Windshield header and/or sun visor, front right	Certain	Autopsy
11	Abrasion, 0.5 cm (0.2 in), anterior right temple of scalp	190202.1 minor	Windshield header and/or sun visor, front right	Probable	Autopsy
12	Abrasions right face including: abrasion, 1.5 cm (0.6 in), lateral to right eye and abrasions (2), 1 cm (0.4 in), right cheek, lateral to right angle of mouth	290202.1 minor	Windshield's glazing	Probable	Autopsy
13	Abrasion, 2 cm (0.8 in) located within contusion to left cheek, cited below	290202.1 minor	Windshield's glazing	Probable	Autopsy

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

cord (kord): any long, rounded, flexible structure; see also *chorda*.

vocal c., false: a fold of mucous membrane covering muscle in the larynx and separating the ventricle from the vestibule; called also *plica vestibularis*

Vocal c., true: a fold of mucous membrane covering the vocalis muscle in the larynx forming the inferior boundary of the ventricle. Called also *plica vocalis*.

plica (pli′ke) and pl. pli′cae: a general term for a ridge or fold, as of peritoneum or other membrane.

p. vestibula′ris: vestibular fold: a fold of mucous membrane in the larynx, separating the ventricle from the vestibule; called also *false vocal cord*, *false vocal fold*.

p. voca′lis: a fold of mucous membrane in the larynx, forming the inferior boundary of the ventricle, the vocalis muscle being situated dep to it; called also *true vocal cord* and *vocal fold*.

ventricle (ven′tri-kel): a small cavity, such as one of the several cavities of the brain, or one of the lower chambers of the heart; called also *ventriculus*.

v. of larynx: ventriculus laryngis.

vestibule (ves′ti-bul): a space or cavity at the entrance to a canal; called also *vestibulum*.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
14	Contusion, 5 cm (2.0 in), left cheek, posterior to left eye	290402.1 minor	Windshield's glazing	Probable	Autopsy
15	Abrasion, 2 cm (0.8 in) over chin and abrasions (2), 2 cm (0.8 in) over right angle of jaw	290202.1 minor	Windshield's glazing	Probable	Autopsy
16	Abrasions anterior neck, horizontally located superior [14 x 4 cm (5.5 x 1.6 in)] and inferior [20 cm (7.9 in)] to gaping laceration (cited above)	390202.1 minor	Front right module's cover flap	Certain	Autopsy
17	Contusion, up to 4 cm (1.6 in) right upper chest	490402.1 minor	Air bag, front right passenger's	Certain	Autopsy
18	Abrasion, 7 cm (2.8 in) superior right shoulder	790202.1 minor	Air bag, front right passenger's	Certain	Autopsy
19	Contusion, 2 cm (0.8 in) anterior left shoulder	790402.1 minor	Air bag, front right passenger's	Certain	Autopsy
20	Abrasion, 6 cm (2.4 in) right mid-superior back [Aspect = Right]	690202.1 minor	Seat back, front right passenger's	Probable	Autopsy

CASE VEHICLE DRIVER KINEMATICS

Immediately prior to the crash the case vehicle's driver [35-year-old, Black (non-Hispanic) female; 160 centimeters and 57 kilograms (63 inches, 125 pounds)] was seated in an upright posture with her back against the seat back, her left foot on the floor, her right foot on the brake, and both hands on the steering wheel. Her seat track was located in its middle position. The case vehicle was not equipped with a tilt steering wheel. The case vehicle's driver was not wearing her available, active, three-point, lap-and-shoulder, safety belt system. Inspection of the driver's seat belt webbing, "D"-ring, and latch plate showed no visible evidence of loading.

At the last second the case vehicle's driver braked, attempting to avoid the crash. As a result of this attempted avoidance maneuver and the nonuse of her available safety belts, the driver moved forward just prior to impact and tried to brace with her arms against the steering wheel rim. The case vehicle's underriding type of impact with the back of Ford pickup enabled the case vehicle's driver to continue forward and slightly upward toward the case vehicle's 0 degree Direction of Principal Force as the case vehicle decelerated. The underride type damage resulted in the driver's air bag deploying late during the sequence of the impact. This delayed deployment occurred due to the prolonged change in time (Delta T) relative to the change in speed (magnitude of Delta V–i.e., ramp versus spike). As a result, the driver was leaning forward into the deploying air bag. The deploying air bag caught the driver's right forearm and threw her hand

into the center instrument panel, knocking off the air flow control knob and lacerating her right thumb (**Figure 18**). As the deploying air bag continued to expand, it also struck the driver in the chest driving her upwards and back into her seat back. In addition, her scalp possibly contacted the roof as she moved rearward. At final rest the driver was close to the same seating position as prior to the crash. Following the crash the driver exited the case vehicle, without any assistance, and removed the front right passenger and the back left passenger, placing them into the Ford pickup where they were transported directly to the hospital.

Figure 18: Case vehicle's center instrument panel showing missing air flow knob most likely knocked off by right hand of case vehicle's driver (case photo #36)

CASE VEHICLE DRIVER INJURIES

The case vehicle's driver was transported by the driver of the Ford pickup to the hospital. The case vehicle's driver sustained minor injuries and was treated and released. According to her interview, the only injury she sustained was a right thumb laceration.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Laceration {scratch} right thumb	790600.1 minor	Center instrument panel and below	Probable	Interviewee (same person)

CASE VEHICLE BACK LEFT PASSENGER KINEMATICS

Immediately prior to the crash the case vehicle's back left passenger [8-year-old, Black (non-Hispanic) male; 122 centimeters and 29 kilograms (48 inches, 65 pounds)] was seated in an upright posture with his back against the seat back, both feet sticking out from the seat cushion, and both hands reportedly on his lap. His seat track and seat back were not adjustable. Despite the driver's statement to the contrary, the case vehicle's back left passenger was not using his available, active, three-point, lap-and-shoulder, safety belt system. The inspection of the back left passenger's seat belt webbing and latch plate showed no evidence of loading.

The low Delta V associated with this crash could explain the lack of evidence found on this passenger's belt restraint system. However, this contractor believes that since the driver and front right passenger were not restrained, the back left passenger was most likely not restrained as well.

At the last second the case vehicle's driver braked, attempting to avoid the crash. As a result of this attempted avoidance maneuver and the nonuse of his available safety belts, the back left passenger moved forward just prior to impact. The case vehicle's underriding type of impact with

the back of Ford pickup enabled the case vehicle's back left passenger to continue forward and slightly upward toward the case vehicle's 0 degree Direction of Principal Force as the case vehicle decelerated. The interior inspection of the back seat area and specifically the driver's seat back showed no apparent evidence of contact from this passenger. Presumably, the driver's braking maneuver and subsequent impact would have caused this passenger to be thrown into the driver's padded seat back. Because of the low Delta V the back left passenger's impact to the driver's seat back would have been relatively minor and would not have automatically shown visible evidence. At final rest the back left passenger most likely ended up on the floor behind the driver's seat. This passenger was transported along with the case vehicle's driver and front right passenger directly from the scene to the hospital by the driver of the Ford pickup.

CASE VEHICLE BACK LEFT PASSENGER INJURIES

The case vehicle's back left passenger was transported by the driver of the Ford pickup to the hospital. The case vehicle's back left passenger did not sustain any injuries as a result of this crash.

OTHER VEHICLE

The 1995 Ford Ranger is a rear wheel drive, two-passenger, two-door, regular cab, standard bed (i.e., six-foot), pickup truck (VIN: 1FTCR10A5SU------) equipped with a 2.3L, I-4 engine and a five-speed manual transmission with Over Drive. Braking was achieved by a power-assisted, hydraulic, self- adjusting, front disc and rear drum, two-wheel, anti-lock system. Four wheel anti-lock brakes are an option for this model, but it is unknown if the Ford pickup was so equipped. The Ford pickup's wheelbase was 274 centimeters (107.9 inches), and the odometer reading at inspection was 81,267 kilometers (50,497 miles).

The interior of the Ford pickup was equipped with bucket seats but the type of head restraint (integral versus adjustable) for the driver and front right passenger is unknown. Active, three-point, lap-and-shoulder, safety belt systems were available for both front outboard seating positions, and the Ford pickup was equipped with only a driver air bag.

The Ford pickup's contact with the case vehicle involved its back step-up bumper (**Figure 19**). The back step-up bumper showed no visible deformation, only cracking and deep scratches to the plastic bumper cover (**Figure 20** below). Direct damage was concentrated to the center third of the vehicle and began 35 centimeters (13.8 inches) to the left of center and extended, a measured distance of 62 centimeters (24.4 inches) to the right (passenger side). Maximum crush was estimated as less than 0.5 centimeter (0.2 inches)--**Figure 5** above and **Figure 20** below]. The underside of the bumper showed approximately

Figure 19: Ford Ranger's contacted but undeformed back bumper (case photo #65)

120 centimeters (47.2 inches) of contact. Based on the vehicle inspection, the CDC for Ford pickup was determined to be: **06-BDLN-1 (180)**. The WinSMASH reconstruction program, damage only algorithm, was used on the Ford pickup's highest severity impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 11.8 km.p.h. (7.3 m.p.h.), +11.8 km.p.h. (+7.3 m.p.h.), and 0.0 km.p.h. (0.0 m.p.h.). The Ford pickup was driven from the scene.

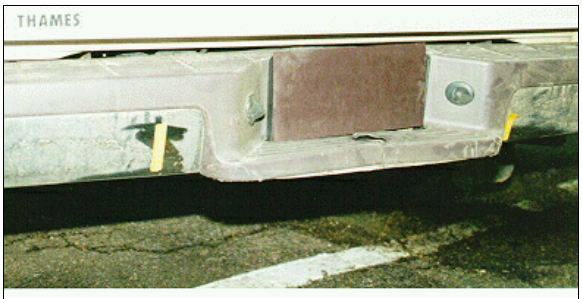
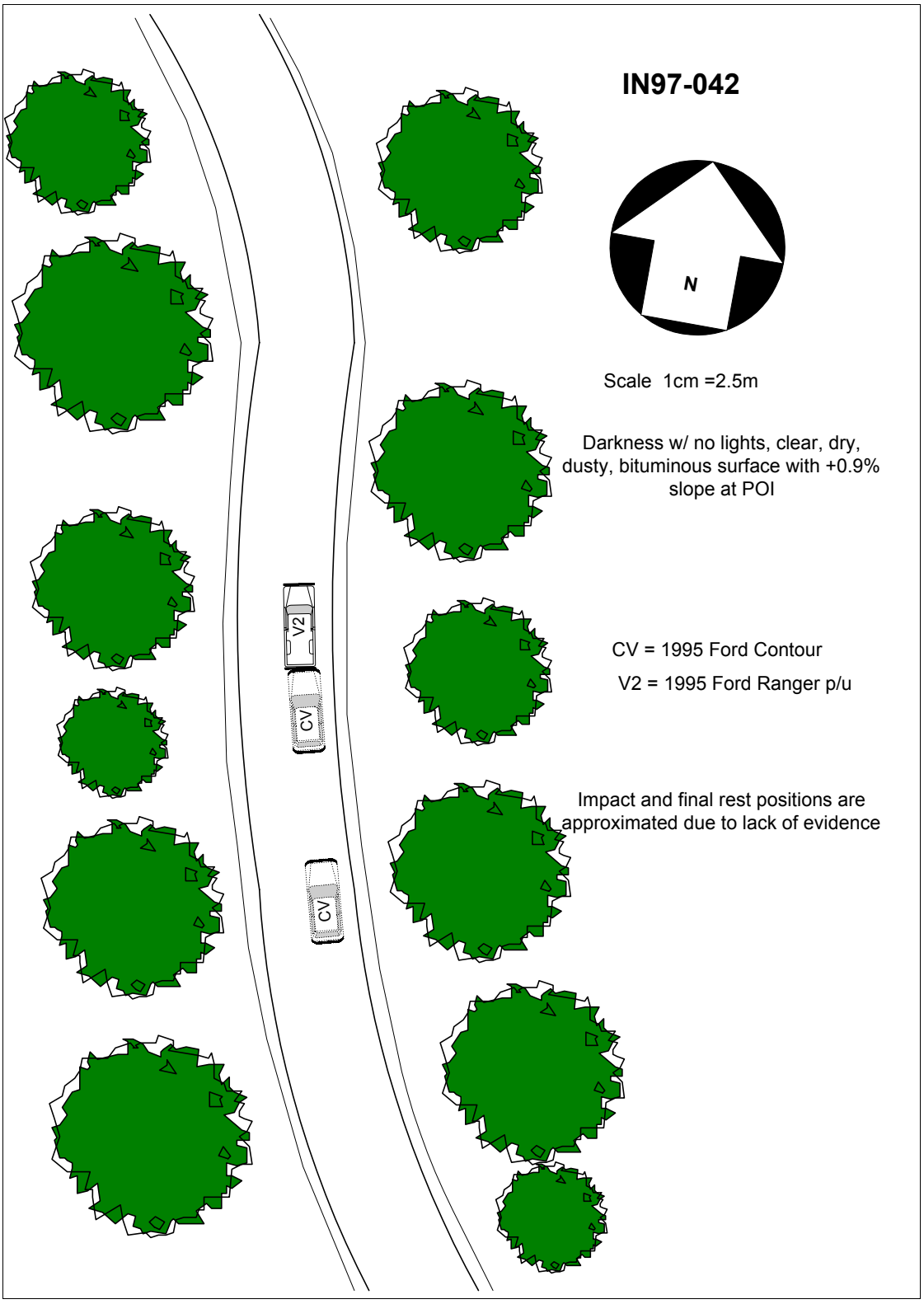


Figure 20: Close-up of scratches on Ford Ranger's back bumper (case photo #72)


IN97-042
N
Scale 1cm =2.5m
Darkness w/ no lights, clear, dry, dusty, bituminous surface with +0.9% slope at POI
CV = 1995 Ford Contour
V2 = 1995 Ford Ranger p/u
Impact and final rest positions are approximated due to lack of evidence
V2
CV
CV