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### ON-SITE REDESIGNED AIR BAG INVESTIGATION

CASE NUMBER - IN98-009  
LOCATION - MISSOURI  
VEHICLE - 1998 SATURN SL2  
CRASH DATE - January, 1998

Submitted:

January 2, 2002

Revised Submission:

August 2, 2002



Contract Number: DTNH22-94-D-17058

Prepared for:

U.S. Department of Transportation  
National Highway Traffic Safety Administration  
National Center for Statistics and Analysis  
Washington, D.C. 20590-0003

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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.

1. <i>Report No.</i> IN98-009		2. <i>Government Accession No.</i>		3. <i>Recipient's Catalog No.</i>	
4. <i>Title and Subtitle</i> On-Site Redesigned Air Bag Investigation Vehicle - 1998 Saturn SL2 Location - Missouri			5. <i>Report Date:</i> January 2, 2002; August 2, 2002		
			6. <i>Performing Organization Code</i>		
7. <i>Author(s)</i> Special Crash Investigations Team #2			8. <i>Performing Organization Report No.</i> Task #s 0157 and 0276		
9. <i>Performing Organization Name and Address</i> Transportation Research Center Indiana University 222 West Second Street Bloomington, Indiana 47403-1501			10. <i>Work Unit No. (TRAIS)</i>		
			11. <i>Contract or Grant No.</i> DTNH22-94-D-17058		
12. <i>Sponsoring Agency Name and Address</i> U.S. Department of Transportation (NRD-32) National Highway Traffic Safety Administration National Center for Statistics and Analysis Washington, D.C. 20590-0003			13. <i>Type of Report and Period Covered</i> Technical Report Crash Date: January, 1998		
			14. <i>Sponsoring Agency Code</i>		
15. <i>Supplementary Notes</i> On-site redesigned air bag deployment investigation involving a 1998 Saturn SL2, four-door sedan, with manual safety belts and dual front air bags, and a 1996 Ford E350 Club Wagon, four-door, full-size van					
16. <i>Abstract</i> This report covers an on-site investigation of an air bag deployment crash that involved a 1998 Saturn SL2 (case vehicle) and a 1996 Ford E350 Club Wagon van (other vehicle). This crash is of special interest because the case vehicle was equipped with redesigned air bags and the case vehicle's driver (69-year-old female) reportedly sustained "probable, not apparent" injuries from her deploying driver air bag. The case vehicle was traveling essentially northeastward in the outside, northeastbound through lane of a five-lane, divided, U.S. trafficway and was approaching a four-leg intersection (i.e., both the northeast and southwestbound roadways had two through lanes, while the northeast roadway had one left-hand turn lane). The Ford was traveling essentially southeastward in the southeastbound through lane of a four-lane, undivided, intersecting city roadway (i.e., there was one through lane in both the southeast and northwestbound directions, and in the southeastbound direction there was one left-hand turn lane and one through/"right-hand turn" lane). The crash occurred in the four-leg intersection of the two trafficways. The front of the case vehicle impacted the right front of the Ford, causing the case vehicle's driver and front right supplemental restraints (air bags) to deploy. The case vehicle rotated rapidly clockwise and the Ford rotated counterclockwise resulting in a side slap impact between the case vehicle's left quarter panel and the Ford's right quarter panel. The case vehicle's driver was seated on pillows and most likely hunched forward, with her back pulled away from the seat back. Her seat track was located in its forward-most position, and the tilt steering wheel was located in its down-most position. She was restrained by the lap portion of her available, active, three-point, lap-and-shoulder, safety belt system, while the shoulder belt portion was placed behind her back. According to the interview with her husband, she sustained 4 to 5 fractured left ribs, blunt head trauma, and sprains to her left shoulder and left hip. This occupant's primary chest injuries (i.e., AIS = 3) were caused by her contact with the left side interior surface of the driver's door and occurred during the side slap impact. Only the driver's reported blunt head trauma was most likely caused by her interaction with case vehicle's driver air bag.					
17. <i>Key Words</i> Redesigned Air Bag Deployment			Motor Vehicle Traffic Crash Injury Severity		18. <i>Distribution Statement</i> General Public
19. <i>Security Classif. (of this report)</i> Unclassified	20. <i>Security Classif. (of this page)</i> Unclassified		21. <i>No. of Pages</i> 9	22. <i>Price</i> \$5,300	

**TABLE OF CONTENTS**

IN98-009

Page No.

BACKGROUND . . . . . 1

CRASH CIRCUMSTANCES . . . . . 1

CASE VEHICLE: 1998 SATURN SL2 . . . . . 3

    CASE VEHICLE OCCUPANT . . . . . 6

    CASE VEHICLE DRIVER INJURIES . . . . . 7

OTHER VEHICLE: 1996 FORD E350 CLUB WAGON . . . . . 7

CRASH DIAGRAM . . . . . 9

SELECTED PHOTOGRAPHS

    Figure 1: Case vehicle’s northeastward travel path . . . . . 1

    Figure 2: Ford’s southeastward travel path . . . . . 1

    Figure 3: Head-on view of case vehicle’s frontal damage . . . . . 2

    Figure 4: Ford’s right side damage viewed from right of back . . . . . 3

    Figure 5: Case vehicle’s left back damage viewed from front of left . . . . . 3

    Figure 6: Case vehicle’s frontal damage viewed from right of front . . . . . 3

    Figure 7: Case vehicle’s left back damage viewed from back along  
            reference line . . . . . 4

    Figure 8: Case vehicle’s deployed driver air bag . . . . . 4

    Figure 9: Case vehicle’s deployed front right passenger air bag . . . . . 5

    Figure 10: Possible contact evidence to left side of case vehicle’s wind-  
            shield header . . . . . 5

    Figure 11: Case vehicle’s shear capsule separation . . . . . 6

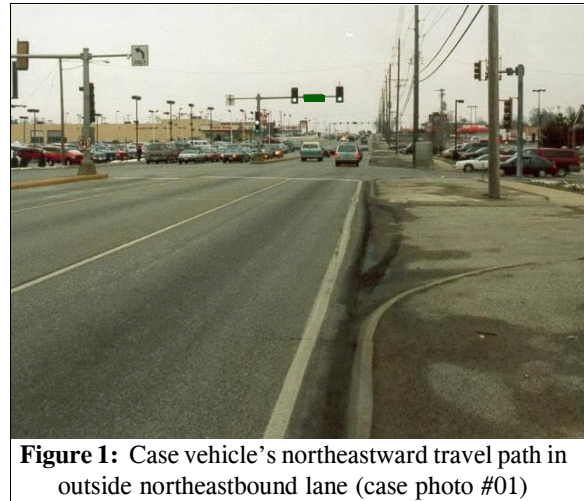
    Figure 12: Ford’s non-deployed driver air bag . . . . . 8

    Figure 13: Ford’s replaced right fender and repaired right front door . . . . . 8

This on-site investigation was brought to NHTSA's attention on January 14, 1998, by NASS GES sampling activities. This crash involved a 1998 Saturn SL2 (case vehicle) and a 1996 Ford E350 Club Wagon van (other vehicle). The crash occurred in January, 1998, at 6:50 p.m., in Missouri, and was investigated by the applicable city police department. This crash is of special interest because the case vehicle was equipped with redesigned air bags and the case vehicle's driver [69-year-old, White (non-Hispanic) female] reportedly sustained "probable, not apparent" injuries from her deploying driver air bag. This contractor inspected the scene and vehicles on January 23, 1998. This contractor interviewed the husband of the case vehicle's driver on March 24, 1998. This report is based on the Police Crash Report, an interview with the husband of the case vehicle's driver, scene and vehicle inspections, occupant kinematic principles, and this contractor's evaluation of the evidence.

### CRASH CIRCUMSTANCES

The case vehicle was traveling essentially northeastward in the outside, northeastbound through lane of a five-lane, divided, U.S. trafficway (**Figure 1**) and was approaching a four-leg intersection (i.e., both the northeast and southwestbound roadways had two through lanes, while the northeast roadway had one left-hand turn lane). According to Police Crash Report, the driver intended to turn right at the intersection and travel southeastward. According to the driver's husband (i.e., interviewee, who was not involved in the crash), she intended to continue through the intersection in her northeast path of travel. Based upon the case vehicle's crush profile (i.e., primarily front left damage), the closing trajectories of the two vehicles more closely resembled a perpendicular impact configuration than they did an acute angle configuration. If the case vehicle had been turning right, then this contractor would have expected a much greater amount of left front damage than was present. The Ford was traveling essentially southeastward in the inside southeastbound through lane of a four-lane, undivided, intersecting city roadway (**Figure 2**) and intended to continue its southeastbound travel path (i.e., there was one through lane in both the southeast and northwestbound directions; however, in the southeastbound direction, there was one left-hand turn lane and one through/"right-hand turn" lane). The case vehicle's driver made no avoidance maneuvers prior to the crash. The crash occurred in the four-leg intersection of the two trafficways.



**Figure 1:** Case vehicle's northeastward travel path in outside northeastbound lane (case photo #01)



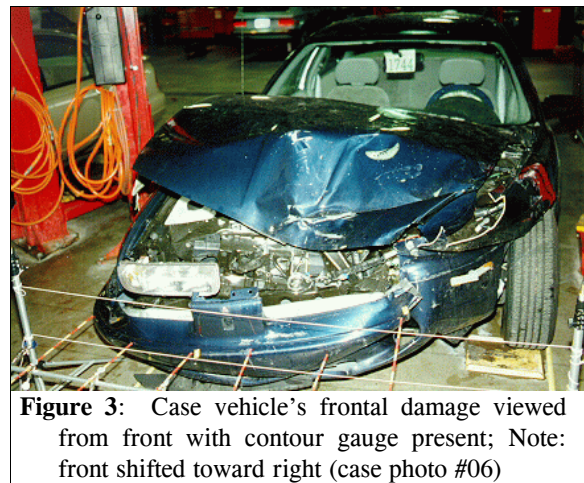
**Figure 2:** Ford's southeastward travel path in inside southeastbound through lane (i.e., lane to left of white lane line); Note: photo taken from "outside through"/"right-hand turn" lane (case photo #04)

The U.S. highway was straight and level at the area of impact. The pavement was bituminous but traveled, and the width of the case vehicle's outside travel lane was 3.6 meters (11.8 feet). The southeast side of the northeastbound roadway had a narrow (but unmeasured, **Figure 1** above) paved shoulder while the northwest side had no shoulder prior to the 1.2 meter (3.9 foot) wide unprotected, yellow painted, raised paved median. The roadway was bordered by concrete barrier curbs on both the southeast side and as a part of the median. The three northeast lanes were separated by solid white lane lines and a solid white edge line was present along the right-hand side of the roadway (**Figure 1** above). The estimated coefficient of friction was 0.60 when wet. A regulatory left turn ONLY arrow (MUTCD, R3-5) was mounted over the roadway's left-hand turn lane, supplemented by a left-hand turn arrow painted on the pavement.

The city street was also straight and level [i.e., had a slight (unmeasured) positive slope to the southeast] on the northwest leg of the intersection. The pavement was bituminous but traveled, and the width of the Ford's outside travel lane was 2.9 meters (9.5 feet). There were no shoulders present and the roadway was bordered by barrier curbs. Pavement markings consisted of a double solid yellow centerline for both the northwest and southeastbound traffic, and the three lanes on the northwest leg of the intersection were divided by solid white lines. In addition, no edge line was present for the southeastbound traffic (**Figure 2** above). The estimated coefficient of friction was 0.60 when wet. A regulatory left turn ONLY arrow (MUTCD, R3-5) was mounted over the roadway's left-hand turn lane.

On-colors, pre-timed, vertical mounted, traffic control signals were located within the four-leg intersection and controlled the flow of traffic. The speed limit for the case vehicle was 64 km.p.h. (40 m.p.h.) but only 40 km.p.h. (25 m.p.h.) for the Ford. According to the Police Crash Report, it was estimated that both the pre-impact and at-impact travel speeds for the case vehicle was between 32-40 km.p.h. (20-25 m.p.h.). At the time of the crash the light condition was dark, but illuminated by overhead street lamps at the area of impact, the atmospheric condition was raining, and the road pavement was wet. Traffic density was heavy, and the site of the crash was urban commercial.

The front (**Figure 3** below) of the case vehicle impacted the right front of the Ford (**Figure 4** below), causing the case vehicle's driver and front right supplemental restraints (air bags) to deploy. The case vehicle rotated rapidly clockwise and the Ford rotated counterclockwise resulting in a side slap impact between the case vehicle's left quarter panel (**Figure 5** below) and the Ford's right quarter panel (**Figure 4** below). According to the Police Crash Report, the case vehicle was redirected southeastward while continuing to rotate clockwise. The case vehicle reportedly came to rest heading southward in a vacant lot located off the south quadrant of the intersection. In all, the case vehicle rotated approximately 160 degrees clockwise from its original path of travel. The Ford was redirected



**Figure 3:** Case vehicle's frontal damage viewed from front with contour gauge present; Note: front shifted toward right (case photo #06)



eastward following the side slap impact and reportedly came to rest heading eastward, straddling the curb on the east quadrant of the intersection. In all, the Ford rotated approximately 60 degrees counterclockwise from its original travel path.



**Figure 4:** Ford's damaged right side showing primary impact to the right fender (replaced) and side slap impact to the right quarter panel (case photo #33)

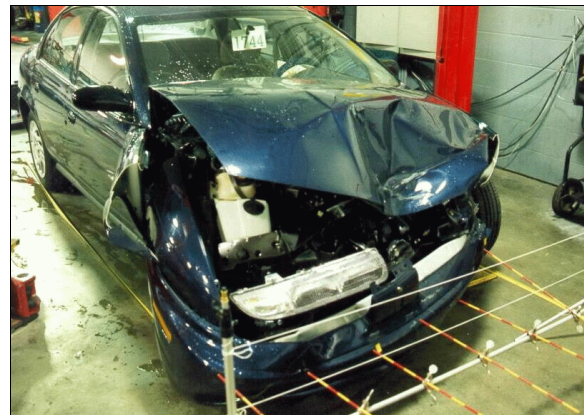


**Figure 5:** Case vehicle's side slap damage viewed from front of left (case photo #10)

## CASE VEHICLE

The 1998 Saturn SL2 was a front wheel drive, five-passenger, four-door notchback sedan (VIN: 1G8ZK5273WZ-----) equipped with a 1.9L, L-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 260 centimeters (102.4 inches), and the odometer reading at inspection was 8,253 kilometers (5,128 miles).

The case vehicle's initial contact with the Ford involved the front left two-thirds (**Figure 3** above and **Figure 6**). Direct damage began 13 centimeters (5.1 inches) to the right of center and extended, a measured distance of 72 centimeters (28.3 inches), along the front bumper to the front left bumper corner. Maximum crush for the frontal impact was measured as 20 centimeters (7.9 inches) at  $C_1$ . The wheelbase on the case vehicle's left and right sides was shortened only about 1 centimeter (0.4 inches). For the side slap impact, direct damage began 35 centimeters (13.8 inches) in front of the left rear axle and extended, a measured distance of 120 centimeters (47.2 inches), along the left side to the left rear bumper corner (**Figure 5** and **Figure 7** below). Maximum crush for the side slap impact was measured as 12 centimeters (4.7 inches) at  $C_3$ . During the initial impact, the case vehicle's front bumper, bumper fascia, grille, hood, radiator, left headlight and turn signal assemblies, and left fender were directly damaged and crushed rearward. None of the case vehicle's tires were physically



**Figure 6:** Case vehicle's frontal damage viewed from right of front with contour gauge present; Note: rightward shift of front (case photo #20)

restricted or deflated. The right headlight and turn signal assemblies sustained induced damage as well as both the right and left fenders. During the side slap impact, the case vehicle's left rear door, left quarter panel, left brake light and turn signal assemblies, and left bumper corner were directly damaged and crushed inward.

Based on the vehicle inspection, the CDCs for the case vehicle were determined to be: **70-FDEW-1 (310)** and **09-LBEW-2 (270)**. The WinSMASH reconstruction program, missing vehicle algorithm, was used on the case vehicle's highest severity (i.e., frontal) impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 31.8 km.p.h. (19.8 m.p.h.), -20.5 km.p.h. (-12.7 m.p.h.), and +24.4 km.p.h. (+15.2 m.p.h.). Likewise, the WinSMASH reconstruction program, missing vehicle algorithm, was used on the case vehicle's second highest severity (i.e., side slap) impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 10.0 km.p.h. (6.2 m.p.h.), 0.0 km.p.h. (0.0 m.p.h.), and +10.0 km.p.h. (+6.2 m.p.h.). The case vehicle was towed 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. The case vehicle's driver air bag was located in the steering wheel hub. The module cover consisted of interlocking, asymmetrical "I"-configuration cover flaps made of thick vinyl with overall dimensions of 8 centimeters (3.1 inches) at the left horizontal seam, 9 centimeters (3.5 inches) at the right horizontal seam, and 13 centimeters (5.1 inches) vertically. The two flaps interlocked in a jigsaw fashion with a tab-like portion of the right cover flap inset within the left cover 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; however, there was some scuffing on the left upper quadrant of the air bag from its interaction with the cover flaps. The driver's air bag was designed with two 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



Figure 7: Case vehicle's side slap damage viewed from back along reference line (case photo #14)

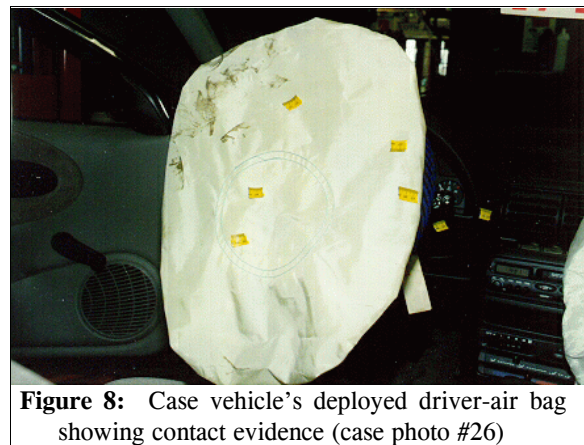


Figure 8: Case vehicle's deployed driver-air bag showing contact evidence (case photo #26)



air bag was elliptical with a height of approximately 54 centimeters (21.3 inches) and a width of approximately 41 centimeters (16.1 inches). An inspection of the driver's air bag revealed four areas of scattered scuffs on the air bag's front surface (**Figure 8** above). There was an obliquely oriented scuff mark located within the inner circular stitching, the center of which was located 3 centimeters (1.2 inches) below the longitudinal centerline of the air bag and 5 centimeters (2.0 inches) left of the vertical centerline. Furthermore, there was a spot within the inner circular stitching that was located toward the 12 o'clock position. In addition, there was a transversely oriented scuff mark located 15 centimeters (5.9 inches) above the longitudinal centerline of the air bag and 5 centimeters (2.0 inches) right of the vertical centerline. Finally, there was a 5 centimeter (2.0 inch) obliquely oriented scuff located 2 centimeters (0.8 inches) inward of the right circular edge near the 3 o'clock position.

The front right passenger's air bag was located in the middle of the instrument panel. There was a single, essentially rectangular, modular, cover flap. The cover flap was made of a thick vinyl over a thick cardboard type frame. The flap's dimensions were 31 centimeters (12.2 inches) at the lower horizontal seam and 12 centimeters (4.7 inches) along both vertical seams. The profile of the case vehicle's instrument panel resulted in a 4 centimeter (1.6 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 revealed that the cover flap opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover flap. The front right passenger's air bag was designed with one tether, measuring 36 centimeters (14.1 inches) in width. The front right air bag had no vent ports. The deployed front right air bag was rectangular with a height of approximately 38 centimeters (15.0 inches) and a width of approximately 70 centimeters (27.6 inches). An inspection of the front surface revealed that there was no contact evidence readily apparent on the front right air bag (**Figure 9**).

Inspection of the case vehicle's interior revealed a possible skin deposit on the windshield's header, just to the right of the sun visor (**Figure 10**). Furthermore, there were two scrape marks on the center instrument panel, just to the right of the right edge of the steering wheel's rim. In addition, the shear capsule was displaced 4 centimeters (1.6 inches—**Figure 11** below).



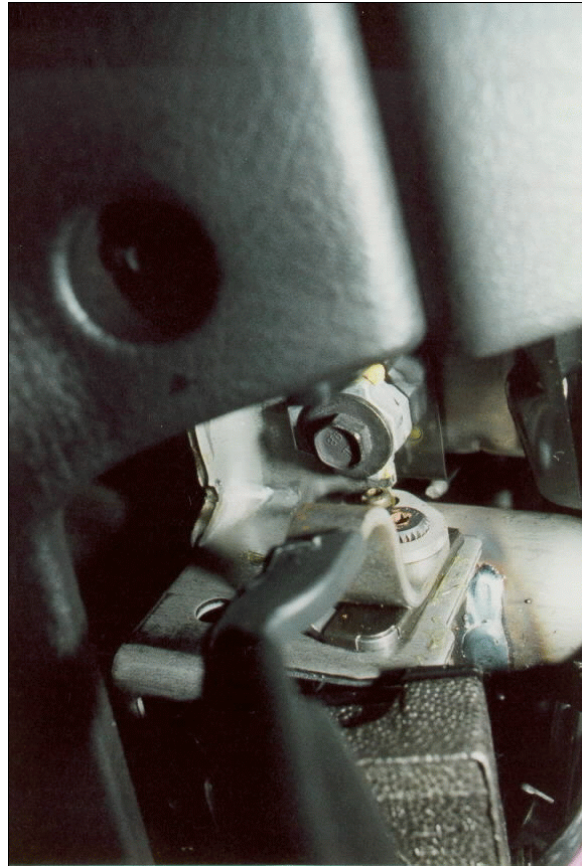
**Figure 9:** Case vehicle's deployed front right passenger air bag showing no obvious contact evidence (case photo #27)



**Figure 10:** Possible contact evidence (i.e., yellow tape) on windshield header next to driver's sun visor (case photo #22)

## CASE VEHICLE OCCUPANT

Immediately prior to the crash, the case vehicle's driver [155 centimeters and 54 kilograms (61 inches, 120 pounds)] was seated on pillows and most likely hunched forward, with her back pulled away from the seat back, her left foot on the floor, her right foot on the accelerator, and both hands on the steering wheel. Her seat track was located in its forward-most position, the seat back was upright, and the tilt steering wheel was located in its down-most position. During the vehicle inspection, the driver's seat track was located between its middle and rearmost positions, the seat back was slightly reclined, and the tilt steering wheel was located in its upmost position. These differences most likely resulted either from extrication efforts or occurred during the vehicle's removal operations. According to the driver's husband (interviewee), the driver preferred to sit on pillows with her seat track fully forward, have her seat back in the completely upright position, and her tilt steering wheel in its down-most position. The driver's adjustable shoulder belt upper anchorage was located in the full up position. In this contractor's opinion, this combination of pillows, leaning posture, seat track location, and tilt steering wheel position is compatible with the driver's short stature.



**Figure 11:** Case vehicle's shear capsule separation (case photo #24)

The case vehicle's driver was restrained by the lap portion of her available, active, three-point, lap-and-shoulder, safety belt system, while the shoulder belt portion was placed behind her back. Furthermore, there was possible evidence of belt usage to the driver's left hip, but the inspection of her seat belt webbing, "D"-ring, and latch plate showed no detectable evidence of loading.

The case vehicle's driver made no known pre-crash avoidance maneuvers. As a result and independent of the improper use of her available safety belts, her pre-impact body position did not change just prior to impact. The case vehicle's primary impact with the Ford enabled the case vehicle's driver to continue forward, slightly upward, and leftward toward the case vehicle's 310 degree Direction of Principal Force as the case vehicle decelerated. Her misuse of the safety belt system (i.e., locating her shoulder belt behind her body), however, most likely manifested itself in causing her to jackknife forward over the lap belt during the primary impact. The driver's short stature [155 centimeters (61 inches)] and the likely position of her seat track (i.e., fully forward) allowed the driver to be within the excursion of the driver's air bag. The down-most position of the tilt steering column in conjunction with her reported use of seat pillows most likely enable the driver to absorb the air bag's deployment force over a wide area of face, chest, and

abdomen and, thus, sustain only a reported blunt head trauma from her air bag. The front left bumper corner of the case vehicle snagged the lower right "A"-pillar (i.e., the back of the wheel well) of the Ford, causing the case vehicle to begin rotating rapidly clockwise, resulting in the side slap impact. The clockwise movement of the case vehicle caused the driver to move to her left into the driver's door panel. The driver most likely rebounded back forward into her deflating driver air bag and steering wheel as the case vehicle moved toward its final rest position. The driver's posture at final rest is unknown; she was unable to exit under her own power and had to be removed from her vehicle. Given the driver's seating position, she was most likely leaning forward and to her left against the combination of her steering wheel and left interior door surface.

#### CASE VEHICLE DRIVER INJURIES

The driver was transported by ambulance to the hospital. She sustained serious injuries and was treated and released. According to the interview with her husband, the injuries sustained by the case vehicle's driver included: 4 to 5 fractured left ribs, blunt head trauma, and sprains to her left shoulder and left hip. The driver's husband reported that the driver believes she was unconscious for a short period of time, perhaps 15-to-30 seconds. This occupant's primary chest injuries (i.e., AIS = 3) were caused by her contact with the left side interior surface of the driver's door and occurred during the side slap impact. Only the driver's reported blunt head trauma was most likely caused by her interaction with case vehicle's driver air bag.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Blunt head trauma with momentary loss of consciousness	115099.7 unknown	Air bag, driver's	Probable	Interviewee (relative)
2	Fractured left ribs, 4 or 5, not further specified	450230.3 serious	Left side interior surface, excluding hardware and/or armrest	Probable	Interviewee (relative)
3	Sprained left shoulder	751020.1 minor	Left side window sill	Probable	Interviewee (relative)
4	Sprained left hip	850606.1 minor	Left side interior hardware and/or armrest	Probable	Interviewee (relative)

#### OTHER VEHICLE

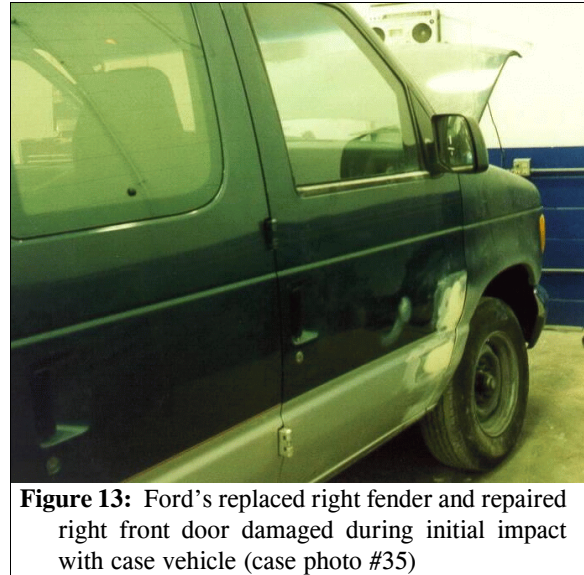
The 1996 Ford E350 Club Wagon was a rear wheel drive, 4x2, twelve-passenger, four-door, full-sized van (VIN: 1FBHE31H4TH-----) equipped with a 5.8L, V-8 engine and a three-speed automatic transmission. Braking was achieved by a power-assisted, front disc and rear drum, four-wheel, anti-lock system. The Ford was equipped with a driver (only) supplemental restraint (air bag) that did not deploy during either the primary impact on the right front or side slap impact



to the right back (**Figure 12**). The case vehicle's wheelbase was 351 centimeters (138.0 inches), and the odometer reading at inspection was 44,022 kilometers (27,354 miles).



**Figure 12:** Ford's driver seating area showing non-deployed driver air bag (case photo #38)



**Figure 13:** Ford's replaced right fender and repaired right front door damaged during initial impact with case vehicle (case photo #35)

Based on the vehicle inspection, the CDCs for the Ford are estimated as: **01-RYEW-1 (40)** and **03-RBEW-1 (90)**. The Ford's exact damage is not determinable because the vehicle was virtually repaired (**Figure 4** above and **Figure 13**). The WinSMASH reconstruction program, missing vehicle algorithm, was used on the Ford's highest severity (i.e., right side) impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 13.4 km.p.h. (8.3 m.p.h.), -11.0 km.p.h. (-6.8 m.p.h.), and -7.7 km.p.h. (-4.8 m.p.h.). Likewise, the WinSMASH reconstruction program, missing vehicle algorithm, was used on the Ford's second highest severity (i.e., side slap) impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 4.2 km.p.h. (2.6 m.p.h.), 0.0 km.p.h. (0.0 m.p.h.), and -4.2 km.p.h. (-2.6 m.p.h.). The Ford was towed due to damage.

The Ford's **driver** (42-year-old, unknown race or ethnic female; unknown height and weight), **front right passenger** (22-year-old, unknown race or ethnic male; unknown height and weight), and **second seat right passenger** (11-year-old, unknown race or ethnic male; unknown height and weight) were all reported to be restrained by their available, active, three-point, lap-and-shoulder safety belt systems. According to the Police Crash Report, all three occupants reportedly sustained no injuries, refused medical treatment at the scene, and were not transported to a medical facility.



**CRASH DIAGRAM**

IN98-009

