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ON-SITE REDESIGNED AIR BAG INVESTIGATION

CASE NUMBER - IN01-002
LOCATION - MINNESOTA
VEHICLE - 1999 FORD CROWN VICTORIA
POLICE INTERCEPTOR
CRASH DATE - October, 2000

Submitted:

March 12, 2003

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.

Technical Report Documentation Page

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On-site air bag deployment investigation involving a 1999 Ford Crown Victoria Police Interceptor, four-door sedan, with manual safety belts and dual front redesigned air bags, and a 2000 Ford Excursion XLT, four-door sport utility

16. *Abstract*

This report covers an on-site investigation of an air bag deployment crash that involved a 1999 Ford Crown Victoria Police Interceptor (case vehicle) and a 2000 Ford Excursion XLT (other vehicle). This crash is of special interest because the case vehicle (a police squad car) was equipped with redesigned air bags and the case vehicle's driver (22-year-old male) sustained moderate injuries when the deploying front right passenger's air bag dislodged a laptop computer from its designed docking station near the center instrument panel and hurled it into the driver's face, resulting in his injuries. The case vehicle was traveling north in the northbound lane of a two-lane, undivided, city street and was traveling at high speed with its emergency lights and siren activated, attempting to catch up to a speeding motorist. The Excursion had been stopped at the end of a "Tee"-intersection, heading west in the westbound lane of a two-lane, undivided, city street and was accelerating into the intersection, intending to turn left and travel southward. The crash occurred near the centerline of the north-south roadway, in the "Tee" intersection of the two roadways. The right front bumper corner of the case vehicle was impacted by the front of the Excursion. The initial impact resulted in the case vehicle being redirected in a northwesterly direction where it subsequently departed the west edge of the north-south roadway, and impacted a tree with its front, causing the case vehicle's driver and front right passenger supplemental restraints (redesigned air bags) to deploy. Upon impacting the tree, the case vehicle rotated approximately 30 degrees counterclockwise prior to coming to rest against the tree, heading in a northwesterly direction. The Excursion came to rest straddling the northbound lane with its front in the southbound lane, but still within the "Tee"-intersection, heading in a northwesterly direction. The case vehicle's driver was seated with his seat track located near its middle position, and the tilt steering wheel was located in its middle position. In this contractor's opinion, the case vehicle's driver was not using his available, active, three-point, lap-and-shoulder, safety belt system and sustained, according to his interview and medical records, moderate injuries which included: a fracture of his nasal spine; a dislocated right shoulder with a torn posterior glenoid labrum; fractures of 2-3 right ribs; dislocation of two teeth–resulting in nerve damage and the teeth dying; a facial contusion; a nasal laceration; and an abrasion and contusion of his left knee. This occupant's primary facial injuries were caused by contact with the laptop computer which became dislodged from the designed docking station by the deploying front right passenger's air bag. In addition, the right shoulder injuries most likely occurred when the deploying front right air bag contacted his right arm and forced it backwards.

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BACKGROUND

This on-site investigation was brought to NHTSA's attention on January 21 2001 by the Deputy Police Chief of a local police agency. This crash involved a 1999 Ford Crown Victoria Police Interceptor (case vehicle) and a 2000 Ford Excursion XLT (other vehicle). The crash occurred in October, 2000, at 8:32 a.m., in Minnesota and was investigated by the applicable city police department. This crash is of special interest because the case vehicle (a police squad car) was equipped with redesigned air bags and the case vehicle's driver [22-year-old, White (non-Hispanic) male] sustained moderate injuries when the deploying front right passenger's air bag dislodged a laptop computer from its designed docking station near the center instrument panel and hurled it into the driver's face, resulting in his injuries. This contractor inspected the scene and vehicles on 30-31 January, 2001. This contractor interviewed the driver of the case vehicle on February 6, 2001. 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, police photographs, occupant kinematic principles, occupant medical records, and this contractor's evaluation of the evidence.

SUMMARY

The case vehicle was traveling north in the northbound lane of a two-lane, undivided, city street and was traveling at high speed with its emergency lights and siren activated, attempting to catch up to a speeding motorist. The Excursion had been stopped at the end of a "Tee"-intersection, heading west in the westbound lane of a two-lane, undivided, city street and was accelerating into the intersection, intending to turn left and travel southward. The case vehicle's driver steered to the left and braked, attempting to avoid the crash. Based on the available information, the driver of the Excursion looked left then right prior to executing her left turn. Because of the case vehicle's high speed, combined with a small hill crest in the north-south roadway, approximately 150 meters (approximately 500 feet) south of the intersection, the Excursion's driver never saw the case vehicle prior to impact. The posted speed limit for both roadways is 48 km.p.h. (30 m.p.h.). The crash occurred near the centerline of the north-south roadway, in the "Tee" intersection of the two roadways; see **CRASH DIAGRAM** below.

The right front bumper corner of the case vehicle was impacted by the front of the Excursion (Note: the Excursion had been salvaged prior to this contractor's involvement). The initial impact resulted in the case vehicle being redirected in a northwesterly direction where it subsequently departed the west edge of the north-south roadway, and impacted a tree with its front, causing the case vehicle's driver and front right passenger supplemental restraints (redesigned air bags) to deploy. Upon impacting the tree, the case vehicle rotated approximately 30 degrees counterclockwise prior to coming to rest partially against the struck tree, off the west side of the road, and heading in a northwesterly direction. The Excursion came to rest straddling the northbound lane with its front in the southbound lane, but still within the "Tee"-intersection, heading in a northwesterly direction.

The 1999 Ford Crown Victoria Interceptor was a rear wheel drive, four-door sedan (VIN: 2FAFP71W6XX------). The case vehicle was equipped with four-wheel, anti-lock brakes. Based on the vehicle inspection, the CDCs for the case vehicle were determined to be: **02-**

RYAW-2 (50) and **12-FLEN-2 (0)**. The WinSMASH reconstruction program, barrier algorithm, was used on the case vehicle's highest severity impact (2nd event). The Total, Longitudinal, and Lateral Delta Vs are, respectively: 25.2 km.p.h. (15.7m.p.h.), -25.2 km.p.h. (-15.7 m.p.h.), and 0.0 km.p.h. (0.0 m.p.h.). The WinSMASH reconstruction program, missing vehicle algorithm, was used on the case vehicle's second highest severity impact (1st event). The Total, Longitudinal, and Lateral Delta Vs are, respectively: 17.3 km.p.h. (10.7 m.p.h.), -11.1 km.p.h. (-6.9 m.p.h.), and -13.2 km.p.h. (-8.2 m.p.h.). The case vehicle was towed due to damage.

The case vehicle's contact with the Excursion (1st event) involved its right front side. Direct damage was also present on the front bumper, and the direct damage began at the front right bumper corner and extended 15 centimeters (5.9 inches) inward from the bumper corner. On the right side, the direct damage began at the right front bumper corner and extended, a measured distance of 245 centimeters (96.5 inches), rearward to just behind the right "B"-pillar [i.e., 73 centimeters (28.7 inches) forward of the right rear axle]. In addition, there was direct contact to the case vehicle's right "A"-pillar from the hood of the Excursion as it raked down the right side. Maximum crush was measured as 22 centimeters (8.7 inches) at C_5. The case vehicle's impact with the tree was to the front left. Direct damage began 10 centimeters (3.9 inches) inward from the front left bumper corner and extended 25 centimeters (9.8 inches) along the front bumper towards the vehicle's center. The residual maximum crush for the tree impact was measured as 60 centimeters (23.6 inches) between C_1 and C_2. The case vehicle's front end was shifted to the left approximately 8 centimeters (3.1 inches). The wheelbase on the case vehicle's left side was shortened 17 centimeters (6.7 inches) with the right side remaining essentially unaltered. As a result of the impacts, the case vehicle's front bumper, bumper fascia, grille, hood, radiator, right and left headlight and turn signal assemblies, right and left fenders, right front and rear doors, roof, and right "A"-pillar were directly damaged and crushed either rearward or inward or both. The right front door glazing was disintegrated from the initial impact, and the windshield's glazing was cracked from both impacts as well as from the case vehicle's hood being pushed rearward into it. The case vehicle's left and right front tires were physically restricted, and the right front tire was deflated. The hood and left fender sustained induced damage as well and there was remote buckling to the roof near the right "A"-pillar area. No obvious induced damage or remote buckling was noted to the remainder of the case vehicle's exterior.

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 the air bag fabric revealed that the cover flaps opened at the designated tear points and left side of the module cover was partially pulled away from the hub, most likely because the air bag's deployment path was momentarily blocked. In addition, there was no evidence of damage during the deployment to the air bag or the cover flap themselves. The driver's air bag was designed with four tethers, each approximately 6 centimeters (2.4 inches) in width and sewn, relative to the center of the air bag, at the 8, 10, 2, and 4 o'clock positions. The driver's air bag had two vent ports, approximately 1.5 centimeters (0.6 inches) in diameter, located at the 11 and 1 o'clock positions. The deployed driver's air bag was round with diameter 58 centimeters (22.8 inches). An inspection of the driver's air bag fabric revealed no contact evidence readily apparent on the driver's air bag, but there were black scuffs on the air bag from the flap cover that most likely occurred during the air bag's inhibited deployment.

The front right passenger's air bag was located in the middle of the instrument panel. An inspection of the front right air bag module's cover flaps and air bag revealed that the cover flap opened at the designated tear points even though the module cover flap had been distorted by intrusion from the case vehicle's impact with the Excursion. Furthermore, there was no evidence of damage during the deployment to the cover flap. The inspection of the front right air bag revealed that during the deployment a black scuff resulted on the left side surface and, in addition, there was what appeared to be snagging–although barely visible, in the air bags fabric on the upper left side of the front surface, most likely from contacting the case vehicle's mounted laptop computer. The front right passenger's air bag was designed without any tethers. The front right air bag had one vent port, approximately 6 centimeters (2.4 inches) in diameter, located at the 8:30 o'clock position. The deployed front right air bag was rectangular with a height of approximately 58 centimeters (22.8 inches) and a width of approximately 64 centimeters (25.2 inches). An inspection of the front right passenger's air bag fabric revealed only a small area of blood smear, located 3 centimeters (1.2 inches) down from the top seam on the upper left corner of the air bag's front surface.

The case vehicle was equipped with a **R**estraints **C**ontrol **M**odule. The module was removed from the vehicle and sent to Ford motor company for analysis. According to Ford, this unit has a 220 millisecond memory, about 100 milliseconds before the algorithm wake-up and about 120 milliseconds after algorithm enable if there is a deployment. According to Ford's analysis, the module recorded 66 data points (milliseconds) of unwavering negative one-third "G" that could easily be mild pre-crash braking or possibly a slightly bad zero offset. In any case, the results are typically of what should be expected. The next 154 data points are just blank, unwritten data storage area. The conclusion is that the unit started recording but then lost power before it finished. In this contractor's opinion, the initial side impact (**50** degree Direction of Principal Force) to the case vehicle's front right corner, followed by the Excursion continuing down the case vehicle's right side, disabled the power to the **RCM** so that when the case vehicle hit the tree (2^{nd} impact) the deployment was never recorded. This opinion was expressed to a Ford engineer, and the engineer responded by indicating that the case vehicle does have a reserve power supply capable of deploying the air bag, but after power is lost, the reserve power supply is not used for recording (i.e., **RCM**) purposes. Based on the recorded data, Ford could not rule out a deployment on the first impact. The engineer also indicated that if our manual reconstruction or instinct says the Longitudinal Delta V was under 13 km.p.h. (8 m.p.h.) barrier equivalent, then a deployment on the first impact is most unlikely.

Inspection of the case vehicle's interior revealed that there were knee contacts to the driver's knee bolster. Furthermore, the right "A"-pillar and right instrument panel were intruded inward (i.e., both longitudinally and laterally), resulting in the front right passenger's air bag module being angled inward and, as a consequence, the air bag's normal deployment path was altered. Finally, the shear capsules on the case vehicle's steering column were collapsed approximately 3 centimeters (1.2 inches) on both sides with the right side collapse being slightly greater than the left side collapse.

The 2000 Ford Excursion XLT was a four wheel drive, four-door, sport utility vehicle (VIN: 1FMNU41S9YE------). The Excursion's front contacted the case vehicle's right front corner. The case vehicle continued across the Excursion's front in an end-swiping motion that resulted in direct contact continuing down the case vehicle's right side and caused the Excursion to rotated clockwise. The Excursions's hood directly contacted the case vehicle's right "A"-pillar. Based on the available photographs, the CDC for the Excursion was estimated as: **11-FYEW-2 (320)**. The WinSMASH reconstruction program, missing vehicle algorithm, was used on the Excursion's highest severity impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 10.1 km.p.h. (6.3 m.p.h.), -8.7 km.p.h. (-5.4 m.p.h.), and +5.0 km.p.h. (+3.1 m.p.h.). In this contractor's opinion, based on the available photographs, these results appear low (**Figure 5** above). The Excursion was towed due to damage.

Immediately prior to the crash the case vehicle's driver [173 centimeters and 70 kilograms (68 inches, 155 pounds)] was seated in an upright posture with his back against the seat back, his left foot on the floor, his right foot on the brake, and both hands on the steering wheel, simultaneously bracing and steering to the left. His seat track was located near its middle position, the seat back was upright, and the tilt steering wheel was located in its middle position.

In this contractor's opinion, the case vehicle's driver was not using his available, active, three-point, lap-and-shoulder, safety belt system. According to the case vehicle's driver, he was definitely wearing his seat belt, but he had no belt pattern bruising and/or abrasions to his body. In addition, the inspection of the driver's seat belt webbing, "D"-ring, and latch plate showed no evidence of loading or blood smears. The case vehicle's driver indicated that he was bleeding profusely, post-crash, from his nose and mouth and that there was blood all over his shirt. Based on this contractor's experience and the lack of physical evidence, it is this contractor's opinion that the case vehicle's driver was not restrained.

The case vehicle's driver steered to the left and braked, attempting to avoid the crash. As a result of these attempted avoidance maneuvers and the nonuse of his available safety belts, the case vehicle's driver most likely moved slightly forward and to his right just prior to impact–despite the fact that he attempted to constrain his forward movement by bracing himself against the steering wheel. The case vehicle's impact with the Excursion enabled the case vehicle's driver to continue forward toward the **50** degree Direction of Principal Force and slightly upward as the case vehicle decelerated. As a result, the left side of his chest contacted the steering wheel, his knees contacted his knee bolster, and his right chest may have come into contact with the specially equipped radio control center console. As the case vehicle was redirected to the left, the driver rebounded off the steering wheel towards the right and most likely came into contact with the specially equipped radio control center console. As the vehicle was headed off the roadway and toward the tree, the driver was still most likely leaning toward the right.

The case vehicle's laptop computer was positioned in its docking station near the center instrument panel, which was immediately adjacent to the now intruded right instrument panel. The case vehicle's impact with the tree caused both air bags to deploy. The deploying front right passenger air bag contacted the back right corner of the laptop computer and docking station, lifting the laptop off its docking station and propelling it into the face of the case vehicle's driver. The impact with the tree resulted in the case vehicle's driver moving forward into the right side of the deploying driver's air bag and re-contacting the driver's knee bolsters. Because of the driver's posture prior to impacting the tree (i.e., leaning forward and to his right), the deploying driver's air bag impacted the left side of the driver's chest, while leaving his face open for contact by the propelled laptop. Because of his close proximity to the driver's air bag module, the air bag's deployment was slightly inhibited, causing a portion of the air bag's plastic module on the steering wheel hub to be partially pulled away from its housing. According to the case vehicle's driver, at final rest he remained, restrained, in his seat near his original seating position, bleeding from the nose and mouth. He called for assistance prior to exiting his squad car to check on the driver and occupants of the Excursion.

The driver was transported by ambulance to the hospital. He sustained moderate injuries and was treated and released. In addition, he had multiple follow-up visits to medical facilities. Based on the driver's interview and his medical records, his injuries included: a fracture of his nasal spine; a dislocated right shoulder with a torn posterior glenoid labrum; fractures of 2-3 right ribs; dislocation of two teeth–resulting in nerve damage and the teeth dying; a facial contusion; a nasal laceration; and an abrasion and contusion of his left knee. This occupant's primary facial injuries were caused by contact with the laptop computer which became dislodged from the designed docking station by the deploying front right passenger's air bag. In addition, the right shoulder injuries most likely occurred when the deploying front right air bag contacted his right arm and forced it backwards.

CRASH CIRCUMSTANCES

The case vehicle was traveling north in the northbound lane of a two-lane, undivided, city street (**Figure 1**) and was traveling at high speed with its emergency lights and siren activated, attempting to catch up to a speeding motorist. The Excursion had been stopped at the end of a "Tee"-intersection, heading west in the westbound lane of a two-lane, undivided, city street and was accelerating into the intersection, intending to turn left and travel southward. The case vehicle's driver steered to the left and braked, attempting to avoid the crash. Based on the available information, the driver of the Excursion looked left then right prior to executing her left turn. Because of the case vehicle's high speed, combined with a small hill crest in the north-south roadway, approximately 150 meters (approximately 500 feet) south of the intersection, the Excursion's driver never saw the case vehicle prior to impact. The posted speed limit for both roadways is 48 km.p.h. (30 m.p.h.). The crash occurred near the centerline of the north-south roadway, in the "Tee" intersection of the two roadways; see **CRASH DIAGRAM** below.

Figure 1: Southward view in northbound lane from beyond intersecting roadway showing case vehicle's northbound travel path from hill crest to impact in Tee intersection (case photo #05)

The case vehicle's city roadway was straight and level (i.e., actual slope was 0.7%, negative to the north) at the area of impact. As noted above there was a hill crest south of the "Tee" intersection. The northbound roadway had a 2.2% grade negative to the north (i.e., a downgrade in the case vehicle's direction of travel), near the hill crest. The hill crest would momentarily block the presence of the case vehicle from the driver of the Excursion's line-of-sight. The pavement was bituminous, but new/sharp. The width of the northbound lane was 4.1 meters (13.5 feet) and the southbound lane was 4.2 meters (13.8 feet). The east side of the road had a 1.8 meter (5.9 foot) bituminous shoulder which was bordered by a barrier curb, and the west side had a 1.8 meter (5.9 foot) bituminous shoulder, prior to a 3.0 meter (9.8 foot) wide dirt area used for parking. Pavement markings consisted of a broken yellow centerline for both north and southbound traffic, augmented by a single solid yellow "no passing" line for northbound traffic. In addition, solid white edge lines were present on both the east and west sides. The estimated coefficient of friction was 0.75. Traffic controls consisted of only a **NO PASSING ZONE** warning sign (Manual on Uniform Traffic Control Devices, W14-3). The statutory speed limit was 48 km.p.h. (30 m.p.h.). No regulatory speed limit sign was posted near the crash site.

The other vehicle's city roadway was straight and level (i.e., actual slope was 1.2%, positive to the west) at the mouth of the intersection. The pavement was also new bituminous, and the width of the roadway was 11.8 meters (38.7 feet). The east-west roadway was bordered by mountable curbs on both the north and south sides. Parking was allowed on both side of the road. The estimated coefficient of friction was 0.70. Traffic controls consisted of a regulatory STOP sign (Manual on Uniform Traffic Control Devices, R1-1) prior to the intersection. The statutory speed limit was 48 km.p.h. (30 m.p.h.). No regulatory speed limit sign was posted near the crash site.

Figure 2: Case vehicle's damaged right front viewed from right of front which resulted from impact with Excursion's front; Note: frontal damage from tree impact (case photo #17)

At the time of the crash the light condition was daylight, the atmospheric condition was clear, and the road pavement was dry. Traffic density was moderate, and the site of the crash was urban residential on the east side of the roadway and a soccer park was present on the west side of the roadway.

Figure 3: Close-up of case vehicle's front right bumper corner showing 15 cm (5.9 in) of direct damage (outward from yellow tape) on bumper (case photo #11)

The right front bumper corner of the case vehicle (**Figure 2** and **Figure 3**) was impacted by the front (**Figure 4** below) of the Excursion (Note: the Excursion had been salvaged prior to this contractor's involvement). The initial impact resulted in the case vehicle being redirected in a northwesterly direction where it subsequently departed the west edge of the north-south roadway, and impacted a tree (**Figure 5** below) with its front (**Figure 6** below), causing the case vehicle's driver and front right passenger supplemental restraints (redesigned air bags) to deploy. Upon impacting the tree, the case vehicle rotated approximately 30 degrees counterclockwise prior to coming to rest partially against the struck tree, off the west side of the road, and heading in a northwesterly direction (**Figure 7**). The Excursion came to rest straddling the northbound lane with its front in the southbound lane, but still within the "Tee"-intersection, heading in a northwesterly direction (**Figure 8** below).

Figure 4: On-scene view looking southeast at Excursion's frontal damage; Note: direct contact to front edge of hood from impacting case vehicle's right "A"-pillar (case photo #39)

Figure 6: Case vehicle's frontal deformation from both impacts; Note: tree impact (highlighted by yellow tape and arrows) and outward movement of front right bumper (case photo #09)

CASE VEHICLE

The 1999 Ford Crown Victoria Police Interceptor was a rear wheel drive, five-passenger, four-door sedan (VIN: 2FAFP71W6XX------) equipped with a 4.6L, V-8 engine and a four-speed automatic transmission. Braking was

Figure 5: On-scene close-up view looking south at case vehicle's final rest position off west side of roadway against struck tree (case photo #38)

Figure 7: On-scene view looking south-southwest at case vehicle's final rest position off west side of roadway against a tree (case photo #44)

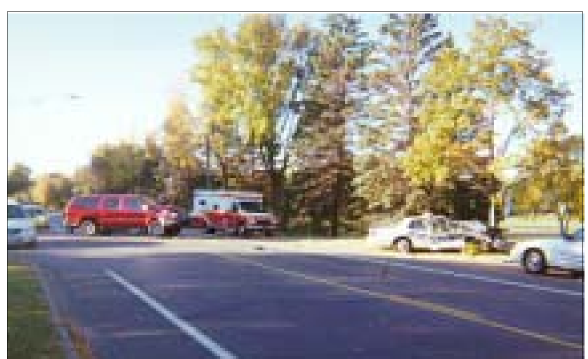


Figure 8: On-scene view looking in a south-southwesterly direction at final rest positions of the case vehicle–against a tree off the west side of the roadway, and the Excursion–straddling the northbound lane (case photo #40)

achieved by a power-assisted, front disc and rear drum, four-wheel, anti-lock system. The case vehicle's wheelbase was 291 centimeters (114.7 inches), and the odometer reading at inspection was 23,464 kilometers (14,580 miles).

Inspection of the vehicle's interior revealed adjustable front bucket seats with adjustable head restraints; a non-adjustable back bench seat without head restraints for the back 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, upper anchorage adjusters for the "D"-rings, but the position of both the driver's and front right passenger's upper anchorage adjusters in unknown. The vehicle was equipped with knee bolsters for both the driver and front right passenger. The driver's knee bolster had contact evidence both left and right of the steering column. The front right passenger knee bolster was not contacted. 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 a tree off the west side of the trafficway.

CASE VEHICLE DAMAGE

The case vehicle's contact with the Excursion (1st event) involved its right front side. Direct damage was also present on the front bumper, and the direct damage began at the front right bumper corner and extended 15 centimeters (5.9 inches) inward from the bumper corner (**Figure 3** above). On the right side, the direct damage began at the right front bumper corner and extended, a measured distance of 245 centimeters (96.5 inches), rearward to just behind the right "B"-pillar [i.e., 73 centimeters (28.7 inches) forward of the right rear axle]. In addition, there was direct contact to the case vehicle's right "A"-pillar (**Figure 9**) from the hood of the Excursion as it raked down the right side (**Figure 4** above). Maximum crush was measured as 22 centimeters (8.7 inches) at C_5. The case vehicle's impact with the tree was to the front left. Direct damage began 10 centimeters (3.9 inches) inward from the front left bumper corner and extended 25 centimeters (9.8 inches) along the front bumper towards the vehicle's center. The residual maximum crush for the tree impact was measured as 60 centimeters (23.6 inches) between C_1 and C_2 (**Figure 6** above). The case vehicle's front end was shifted to the left approximately 8 centimeters (3.1 inches). The wheelbase on the case vehicle's left side was shortened 17 centimeters (6.7 inches) with the right side remaining essentially unaltered. As a result of the impacts, the case vehicle's front bumper, bumper fascia, grille, hood, radiator, right and left headlight and turn signal assemblies, right and left fenders, right front and rear doors, roof, and right "A"-pillar were directly damaged and crushed either rearward or inward or both. The right front door glazing was disintegrated from the initial impact, and the

Figure 9: Close-up of direct damage to case vehicle's right "A"-pillar from contact with hood of Excursion (case photo #45)

windshield's glazing was cracked from both impacts as well as from the case vehicle's hood being pushed rearward into it. The case vehicle's left and right front tires were physically restricted, and the right front tire was deflated. The hood and left fender sustained induced damage as well and there was remote buckling to the roof near the right "A"-pillar area. No obvious induced damage or remote buckling was noted to the remainder of the case vehicle's exterior.

Figure 10: Knee contacts (highlighted) on case vehicle's driver knee bolster (case photo #23)

Inspection of the case vehicle's interior revealed that there were knee contacts to the driver's knee bolster (**Figure 10**). Furthermore, the right "A"-pillar and right instrument panel were intruded inward (i.e., both longitudinally and laterally), resulting in the front right passenger's air bag module being angled inward (**Figure 11**) and, as a consequence, the air bag's normal deployment path was altered. Finally, the shear capsules on the case vehicle's steering column were collapsed approximately 3 centimeters (1.2 inches) on both sides with the right side collapse being slightly greater than the left side collapse (**Figure 12**).

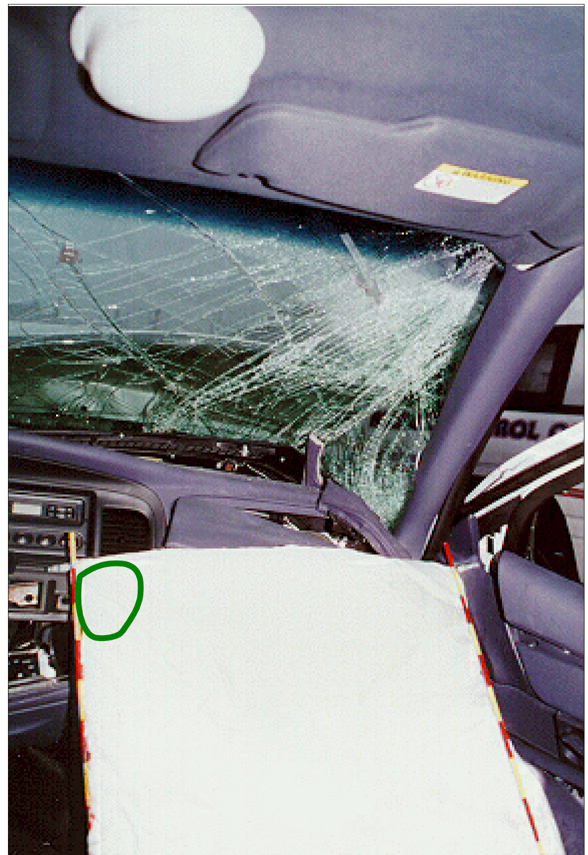


Figure 11: Vertical view of case vehicle's deployed front right passenger air bag; Note: intruding right instrument panel and "A"-pillar which deformed the cover flap (case photo #28)

Figure 12: Under instrument panel view using mirror of case vehicle's shear capsule, indicating movement to steering column from loading by driver (case photo #24a)

Based on the vehicle inspection, the CDCs for the case vehicle were determined to be: **02-RYAW-2 (50)** and **12-FLEN-2 (0)**. The WinSMASH reconstruction program, barrier algorithm, was used on the case vehicle's highest severity impact (2nd event). The Total, Longitudinal, and Lateral Delta Vs are, respectively: 25.2 km.p.h. (15.7m.p.h.), -25.2 km.p.h. (-15.7 m.p.h.), and 0.0 km.p.h. (0.0 m.p.h.). The WinSMASH reconstruction program, missing vehicle algorithm, was used on the case vehicle's second highest severity impact

(1st event). The Total, Longitudinal, and Lateral Delta Vs are, respectively: 17.3 km.p.h. (10.7 m.p.h.), -11.1 km.p.h. (-6.9 m.p.h.), and -13.2 km.p.h. (-8.2 m.p.h.). The case vehicle was towed due to damage.

AUTOMATIC RESTRAINT SYSTEM

The case vehicle was equipped with a Supplemental Restraint System (SRS) that contained frontal redesigned air bags at the driver and front right passenger positions. Both frontal air bags deployed as a result of the frontal impact with a tree. The case vehicle's driver air bag was located in the steering wheel hub. The module cover consisted of a single, essentially rectangular, cover flap made of thick vinyl with overall dimensions of 14.5 centimeters (5.7 inches) at the top horizontal seam and 12 centimeters (4.7 inches) vertically. An inspection of the air bag module's cover flaps and the air bag fabric revealed that the cover flaps opened at the designated tear points and left side of the module cover was partially pulled away from the hub (**Figure 13**), most likely because the air bag's deployment path was momentarily blocked. In addition, there was no evidence of damage during the deployment to the air bag or the cover flap themselves. The driver's air bag was designed with four tethers, each approximately 6 centimeters (2.4 inches) in width and sewn, relative to the center of the air bag, at the 8, 10, 2, and 4 o'clock positions. The driver's air bag had two vent ports, approximately 1.5 centimeters (0.6 inches) in diameter, located at the 11 and 1 o'clock positions. The deployed driver's air bag was round with diameter 58 centimeters (22.8 inches). An inspection of the driver's air bag fabric revealed no contact evidence readily apparent on the driver's air bag, but there were black scuffs on the air bag from the flap cover that most likely occurred during the air bag's inhibited deployment (**Figure 14**).

Figure 13: Close-up of case vehicle's steering wheel showing air bag module partially separated from hub during air bag's deployment (case photo #25)

Figure 14: Case vehicle's driver air bag showing no visible evidence of contact but a number of black scuff marks (case photo #26)

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 39 centimeters (15.4 inches) at the lower horizontal seam and 15 centimeters (5.9 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 flaps and air bag revealed that the cover flap opened at the designated tear points even though the module cover flap had been distorted by intrusion from the case vehicle's impact with the Excursion (**Figure 11** above). Furthermore, there was no evidence of damage during the deployment to the cover flap. The inspection of the front right air bag revealed that during the deployment a black scuff resulted on the left side surface (**Figure 15**) and, in addition, there was what appeared to be snagging–although barely visible, in the air bags fabric on the upper left side of the front surface, most likely from contacting the case vehicle's mounted laptop computer. The front right passenger's air bag was designed without any tethers. The front right air bag had one vent port, approximately 6 centimeters (2.4 inches) in diameter, located at the 8:30 o'clock position. The deployed front right air bag was rectangular with a height of approximately 58 centimeters (22.8 inches) and a width of approximately 64 centimeters (25.2 inches). An inspection of the front right passenger's air bag fabric revealed only a small area of blood smear, located 3 centimeters (1.2 inches) down from the top seam on the upper left corner of the air bag's front surface (**Figure 16**).

Figure 15: Case vehicle's front right passenger's air bag showing black scuff mark (highlighted) on right side of air bag from contact with black laptop computer or docking station (case photo #30a)

Figure 16: Close-up of upper left front corner (highlighted) of the case vehicle's front right passenger's air bag showing small area of blood evidence (case photo #29)

RESTRAINTS CONTROL MODULE

The case vehicle was equipped with a **R**estraints **C**ontrol **M**odule. The module was removed from the vehicle and sent to Ford motor company for analysis. According to Ford, this unit has a 220 millisecond memory, about 100 milliseconds before the algorithm wake-up and about 120 milliseconds after algorithm enable if there is a deployment. According to Ford's analysis, the module recorded 66 data points (milliseconds) of unwavering negative one-third "G" that could easily be mild pre-crash braking or possibly a slightly bad zero offset. In any case, the results are typically of what should be expected. The next 154 data points are just blank, unwritten data storage area. The conclusion is that the unit started recording but then lost power before it finished. In this contractor's opinion, the initial side impact (**50** degree Direction of Principal Force) to the case vehicle's front right corner, followed by the Excursion continuing down the case vehicle's right side, disabled the power to the **RCM** so that when the case vehicle hit the tree (2nd impact) the deployment was never recorded. This opinion was expressed to a Ford engineer, and the engineer responded by indicating that the case vehicle does have a reserve power supply capable of deploying the air bag, but after power is lost, the reserve power supply is not used for recording (i.e., **RCM**) purposes. Based on the recorded data, Ford could not rule out a deployment on the first impact. The engineer also indicated that if our manual reconstruction or instinct says the Longitudinal Delta V was under 13 km.p.h. (8 m.p.h.) barrier equivalent, then a deployment on the first impact is most unlikely.

CASE VEHICLE DRIVER KINEMATICS

Immediately prior to the crash the case vehicle's driver [173 centimeters and 70 kilograms (68 inches, 155 pounds)] was seated in an upright posture with his back against the seat back, his left foot on the floor, his right foot on the brake, and both hands on the steering wheel, simultaneously bracing and steering to the left. His seat track was located near its middle position, the seat back was upright, and the tilt steering wheel was located in its middle position.

In this contractor's opinion, the case vehicle's driver was not using his available, active, three-point, lap-and-shoulder, safety belt system. According to the case vehicle's driver, he was definitely wearing his seat belt, but he had no belt pattern bruising and/or abrasions to his body. In addition, the inspection of the driver's seat belt webbing, "D"-ring, and latch plate showed no evidence of loading or blood smears (**Figure 17** and **Figure 18** below). The case vehicle's driver indicated that he was bleeding profusely, post-crash, from his nose and mouth and that there was blood all over his shirt. Based on this contractor's experience and the lack of physical evidence, it is this contractor's opinion that the case vehicle's driver was not restrained.

Figure 17: Webbing from case vehicle's driver safety belt system showing no visible evidence of loading or blood on webbing (case photo #31)

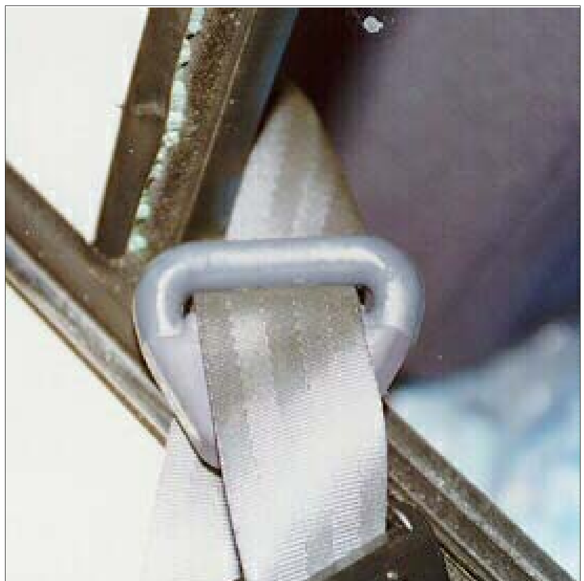


Figure 18: Close-up of "D"-ring on case vehicle's driver safety belt system showing no visible evidence of loading (case photo #32)

The case vehicle's driver steered to the left and braked, attempting to avoid the crash. As a result of these attempted avoidance maneuvers and the nonuse of his available safety belts, the case vehicle's driver most likely moved slightly forward and to his right just prior to impact–despite the fact that he attempted to constrain his forward movement by bracing himself against the steering wheel. The case vehicle's impact with the Excursion enabled the case vehicle's driver to continue forward toward the **50** degree Direction of Principal Force and slightly upward as the case vehicle decelerated.

As a result, the left side of his chest contacted the steering wheel, his knees contacted his knee bolster, and his right chest may have come into contact with the specially equipped radio control center console. As the case vehicle was redirected to the left, the driver rebounded off the steering wheel towards the right and most likely came into contact with the specially equipped radio control center console. As the vehicle was headed off the roadway and toward the tree, the driver was still most likely leaning toward the right.

The case vehicle's laptop computer was positioned in its docking station near the center instrument panel, which was immediately adjacent to the now intruded right instrument panel. The case vehicle's impact with the tree caused both air bags to deploy. The deploying front right passenger air bag contacted the back right corner of the laptop computer and docking station, lifting the laptop off its docking station and propelling it into the face of the case vehicle's driver (**Figures 19** and **20**). The impact with the tree resulted in the case vehicle's driver moving forward into the right side of the deploying driver's air bag and re-contacting the driver's knee bolsters. Because of the driver's posture prior to impacting the tree (i.e., leaning forward and to his right), the deploying driver's air bag impacted the left side of the driver's chest, while leaving his face open for contact by the propelled laptop. Because of his close proximity to the driver's air bag module, the air bag's deployment was slightly inhibited, causing a portion of the air bag's plastic module on the steering wheel hub to be partially pulled away from its housing (**Figure 13** above). According to the case vehicle's driver, at final rest he remained, restrained, in his seat near his original seating position, bleeding from the nose and mouth. He called for assistance prior to exiting his squad car to check on the driver and occupants of the Excursion.

Figure 19: Post-crash view of case vehicle's front seating area showing damage to laptop computer and specially equipped center floor console (case photo #43)

Figure 20: Interior view of an exemplar, undamaged Ford Crown Victoria, police vehicle showing laptop's position in docking station (case photo #47)

CASE VEHICLE DRIVER INJURIES

The driver was transported by ambulance to the hospital. He sustained moderate injuries and was treated and released. In addition, he had multiple follow-up visits to medical facilities. Based on the driver's interview and his medical records, his injuries included: a fracture of his nasal spine; a dislocated right shoulder with a torn posterior glenoid labrum; fractures of 2-3 right ribs; dislocation of two teeth–resulting in nerve damage and the teeth dying; a facial contusion; a nasal laceration; and an abrasion and contusion of his left knee. This occupant's primary facial injuries were caused by contact with the laptop computer which became dislodged from the designed docking station by the deploying front right passenger's air bag. In addition, the right shoulder injuries most likely occurred when the deploying front right air bag contacted his right arm and forced it backwards.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1 2	Laceration {tear} right shoulder (i.e., posterior glenoid labrum[1]) with dislocation {separation}	751040.2 moderate 751030.2 moderate	Air bag, front right passenger's	Probable	Emergency room records
3	Fracture right ribs (2-3), with costochondral pain right 10th, 11th, and 12th ribs	450220.2moderate	Interior fixed object: radio control center console	Possible	Interviewee (same person)
4	Fracture inferior nasal spine (of maxilla) with septal deviation requiring septoplasty	250800.2 minor	Interior loose object: laptop computer set in motion	Certain	Emergency room records
5	Dislocation two teeth, not further specified	251402.1 minor	Interior loose object: laptop computer set in motion	Certain	Interviewee (same person)
6	Contusion left facial area, near eye	290402.1 minor	Interior loose object: laptop computer set in motion	Certain	Interviewee (same person)
7	Laceration {epistaxis} left nose with clotted blood in both nares	251090.1 minor	Interior loose object: laptop computer set in motion	Certain	Emergency room records
8	Abrasion, minimal, left knee with tenderness	890202.1 minor	Knee bolster, driver's, left of steering column	Certain	Emergency room records
9	Contusion left knee	890402.1 minor	Knee bolster, driver's, left of steering column	Certain	Emergency room records

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

cavitas (kav′i-tes) pl. cavita′tes: a hollow space or depression

c. glenoida′lis: glenoid cavity; a depression in the lateral angle of the scapula for articulation with the humerus; called also *glenoid fossa of scapula*.

glenoid (gle′noid): resembling a pit or socket; see ***cavitas glenoidalis***.

labrum (la′brem) pl. la′bra: 1. A general term for an edge, brim, or lip. 2. any liplike part or structure, such as the shelflike projection of the head that anteriorly covers the mandibles of and forms the roof of the mouth of arthropods.

l. acetabula′re: acetabular lip: a ring of fibrocartilage attached to the rim of the acetabulum of the hip bone, increasing the depth of the cavity.

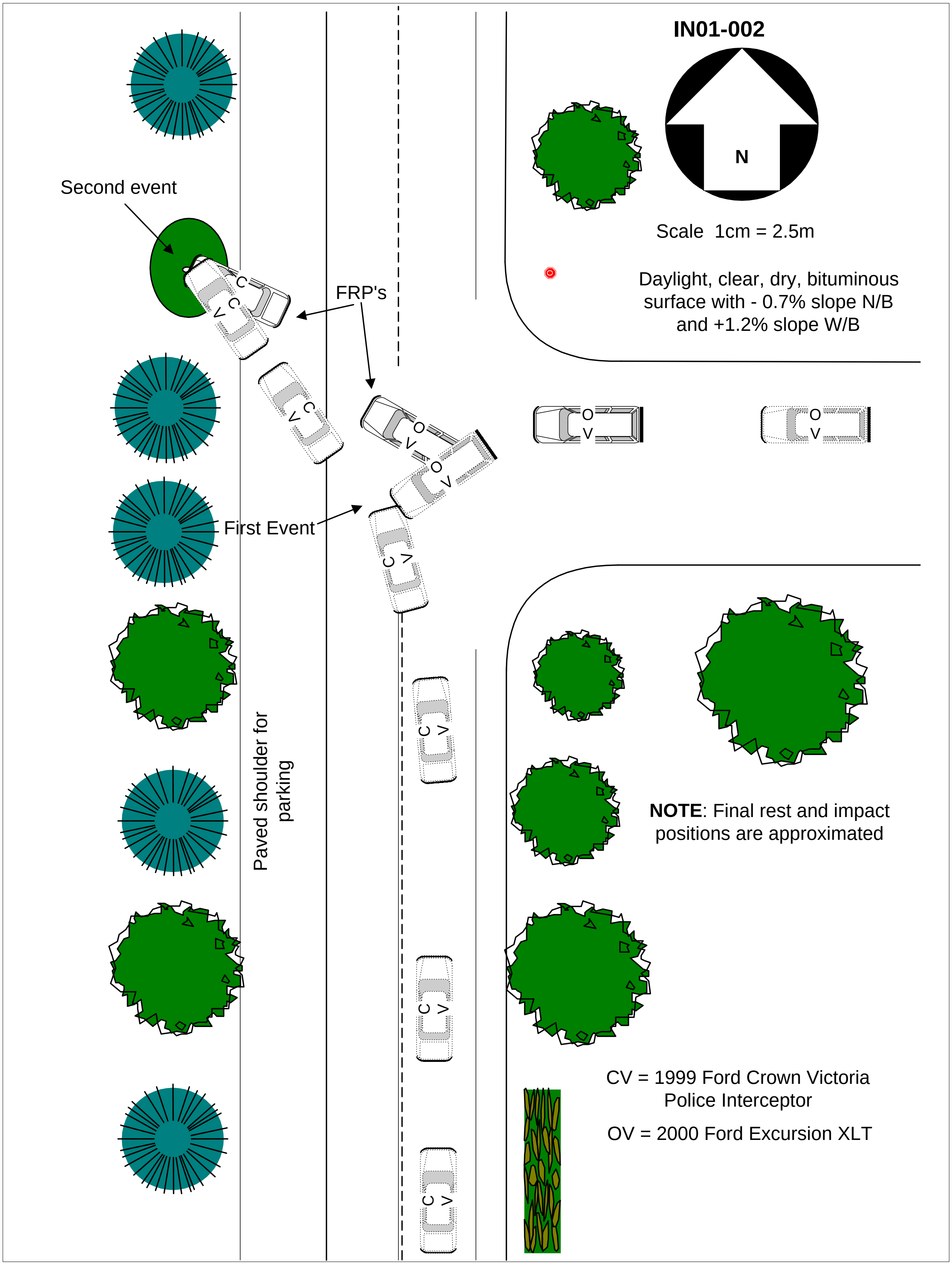
l. articula′ris: articular lip: a prominent fibrocartilaginous rim around the periphery of certain joints, such as the acetabulum of the hip bone and the glenoid cavity of the scapula; see also ***l. acetabulare*** and ***l. glenoidale***.

l. glenoida′le: glenoid lip: a ring of fibrocartilage attached to the rim of the glenoid cavity of the scapula, increasing the depth of the cavity.

Based on the VIN and manufacturer's specifications, the 2000 Ford Excursion XLT was a four wheel drive, seven-passenger, four-door, sport utility vehicle (VIN: 1FMNU41S9YE------) equipped with a 6.8L, V-10 engine and a four-speed automatic transmission. Braking was achieved by a power-assisted, front and rear disc, four-wheel, anti-lock system. The Excursion's wheelbase was 348 centimeters (137.0 inches), and the odometer reading is unknown because the Excursion was not inspected.

Figure 21: On-scene view looking east at Excursion's frontal damage; Note: Excursion's front has been shifted toward right (case photo #39a)

The Excursion's front contacted (**Figure 21**) the case vehicle's right front corner. The case vehicle continued across the Excursion's front in an end-swiping motion that resulted in direct contact continuing down the case vehicle's right side and caused the Excursion to rotated clockwise. The Excursions's hood (**Figure 4** above) directly contacted the case vehicle's right "A"-pillar. Based on the available photographs, the CDC for the Excursion was estimated as: **11-FYEW-2 (320)**. The WinSMASH reconstruction program, missing vehicle algorithm, was used on the Excursion's highest severity impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 10.1 km.p.h. (6.3 m.p.h.), -8.7 km.p.h. (-5.4 m.p.h.), and +5.0 km.p.h. (+3.1 m.p.h.). In this contractor's opinion, based on the available photographs, these results appear low (**Figure 5** above). The Excursion was towed due to damage.


IN01-002
N
Scale 1cm = 2.5m
Daylight, clear, dry, bituminous surface with - 0.7% slope N/B and +1.2% slope W/B
Second event
FRP's
First Event
Paved shoulder for parking
NOTE: Final rest and impact positions are approximated
CV = 1999 Ford Crown Victoria Police Interceptor
OV = 2000 Ford Excursion XLT