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SCI/NASS COMBINATION FORD SAFETY CANOPY SPECIAL STUDY INVESTIGATION

CASE NUMBER - NASS-2004-49-034E

LOCATION - Texas

VEHICLE - 2003 FORD EXPEDITION

CRASH DATE - February 2004

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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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16. <i>Abstract</i> This SCI/NASS combination report covers a Ford safety canopy deployment investigation involving a 2003 Ford Expedition "Eddie Bauer" (case vehicle) and a 2002 Hyundai Elantra (other vehicle). The case vehicle was traveling north in the center northbound lane of a three-lane roadway that was part of a divided local trafficway. The other vehicle was traveling south in the center southbound lane of the same trafficway. The northbound and southbound roadways were separated by a curbed grass median. It was dark but lighted, the weather was clear and the concrete road surface was dry and free of defects. For some unknown reason, the case vehicle veered to its left and entered the median, mounting a barrier curb and sustaining a non-horizontal impact to the undercarriage. The case vehicle traveled into the median and the front of the case vehicle impacted a speed limit sign, shearing the sign post off its foundation. The case vehicle continued across the median, entered the southbound lanes and the front of the case vehicle impacted the front of the other vehicle, causing the case vehicle's driver and front right passenger frontal air bags to deploy. At some point during the collision sequence, the case vehicle's left and right roof rail-mounted safety canopy air bags also deployed. The case vehicle rotated approximately 90 degrees counterclockwise and came to rest straddling the southbound lanes, heading west. The other vehicle rotated approximately 90 degrees counterclockwise and was pushed rearward, coming to rest with its rear wheels on the roadside, heading east. The other vehicle was equipped with dual frontal air bags, both of which deployed, and seat back-mounted side impact air bags for the two front row outboard positions. The other vehicle's driver's side impact air bag deployed and the passenger's side impact air bag did not deploy. Both vehicles were towed due to disabling damage. The case vehicle's driver fled the scene on foot and there is no knowledge of this person. The case vehicle's front right passenger was not injured and there was no other occupant in the case vehicle.					
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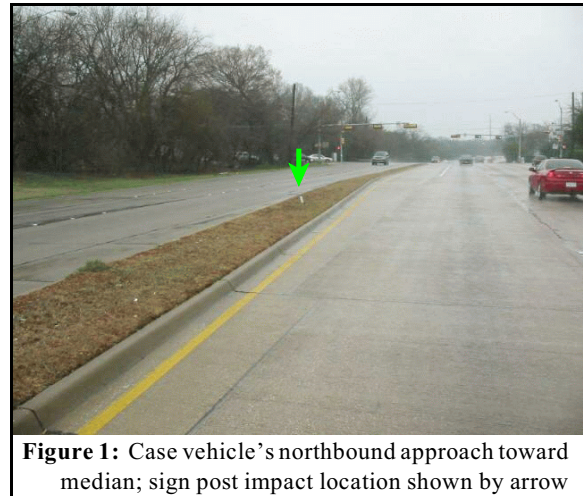
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This SCI/NASS combination investigation was brought to the NHTSA's attention in early March 2004 by NASS-CDS sampling activities. This crash involved a 2003 Ford Expedition "Eddie Bauer" (case vehicle) and a 2002 Hyundai Elantra GLS (other vehicle). The crash occurred in February 2004, at 12:01 a.m., in Texas, and was investigated by the applicable municipal police. This crash is of special interest because the case vehicle was equipped with multiple advanced occupant protection system (AOPS) features, including the optional Ford safety canopy system that did deploy. It should be noted that the case vehicle's driver fled the scene on foot and was never identified. The case vehicle's front right passenger could not be located during the NASS investigation and there is no interview information available. In addition, permission to harvest the case vehicle's Event Data Recorder was denied by the insurance company. This report is based on the coded NASS case and this contractor's evaluation of the evidence.

CRASH CIRCUMSTANCES

The case vehicle was traveling north in the center northbound lane of a three-lane roadway that was part of a divided local trafficway. There were three lanes in each direction with left turn lanes in intersection areas for a total of seven lanes, separated by a curbed grass median without a positive barrier. The median was approximately 1.5 meters [5 feet] wide, with barrier curbs on both sides. The other vehicle was traveling south in the center southbound lane of the same trafficway. It was dark but lighted, the weather was clear and the concrete road surface was dry and free of defects. The speed limit in both directions was 72 km.p.h. [45 m.p.h.]. For some unknown reason, the case vehicle veered to its left and entered the median. There is no evidence that the case vehicle's driver attempted any avoidance actions.

The sequence of crash events began when the case vehicle entered the median. The details of the case vehicle's interaction with the barrier curb and the grass/soil in the median are not fully understood and the NASS case indicates an undercarriage impact to the curb as the first harmful event (**Figure 1**). The case vehicle's approach toward the median curb was a shallow angle and each of the four wheels mounted the curb separately. The case vehicle continued along the median and the front of the case vehicle impacted a speed limit sign, shearing the sign post off from its foundation and bending the post (**Figure 2**). The case vehicle continued across the median and entered southbound lanes. The front of the case vehicle impacted the front of the other vehicle,

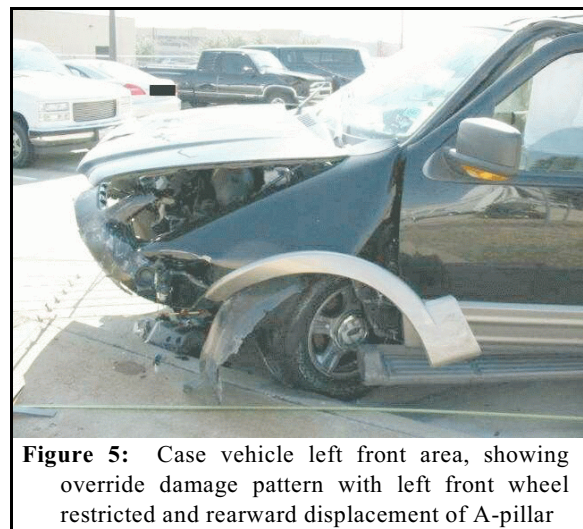
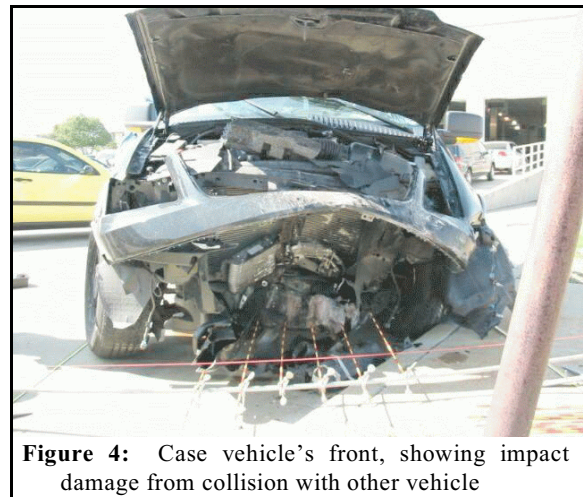
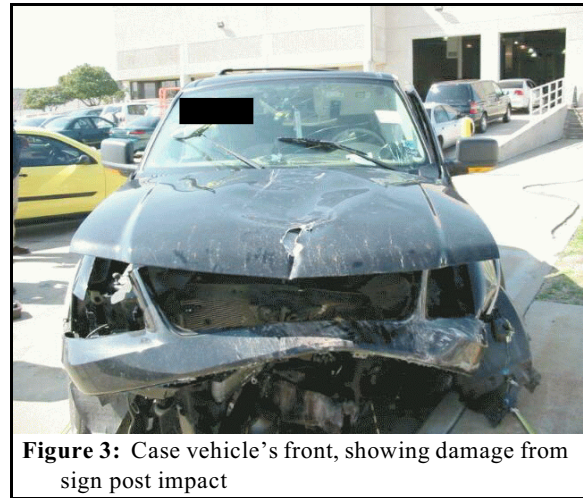


causing the case vehicle's driver and front right passenger frontal air bags to deploy. The case vehicle rotated approximately 90 degrees counterclockwise and came to rest straddling the inside and center southbound lanes, heading west. At some point during the collision sequence, the case vehicle's left and right roof rail-mounted safety canopy air bags also deployed. The other vehicle rotated approximately 90 degrees counterclockwise and was pushed rearward, coming to rest with its rear wheels on the roadside and its front wheels in the outside southbound lane, heading east. The other vehicle was equipped with dual frontal air bags, both of which deployed, and seat back-mounted side impact air bags for the two front row outboard positions. The other vehicle's driver's side impact air bag deployed and the passenger's side impact air bag did not deploy.

CASE VEHICLE

The case vehicle was a 2003 Ford Expedition "Eddie Bauer" rear wheel drive, four-door, seven-passenger, sport utility vehicle (VIN: 1FMFU17LX3L-----), equipped with a 5.4 liter V8 gasoline engine and an automatic transmission with a column-mounted selector lever. Four wheel anti-lock brakes were standard for this model. The case vehicle was equipped with multi-stage frontal air bags and safety belt pretensioners for the two front seats, and roof rail-mounted safety canopy air bags that provided inflatable protection for the front and second seat rows. Its odometer reading is not known. Its wheel base was 302 centimeters [119.0 inches]. The case vehicle was towed due to disabling damage.

The case vehicle sustained heavy damage across the entire front (**Figures 3 and 4**) and the NASS case is coded to indicate front override for the impact involving the other vehicle (third event). The grille and both headlamp/turn signal assemblies were shattered and broken away. The plastic bumper cover was lifted upward and the steel bumper was sheared away from its mounting on the left and right frame rails and crushed



rearward. The lower portion of the radiator was crushed rearward against the engine block. The leading end of the left fender was crushed rearward and the top of the fender was folded downward. The left front wheel was pushed rearward against the left A-pillar, with the left wheelbase shortened by 45 centimeters [17.7 inches]. The A-pillar was displaced rearward and there was buckling of the roof above the driver's door (**Figure 5**). The NASS researcher measured 25 centimeters [9.8 inches] of rearward intrusion by the floor pan in the driver's footwell. The right fender sustained minor damage and the right front wheel moved forward slightly, extending the right wheelbase by 6 centimeters [2.4 inches]. Maximum crush was measured as 60 centimeters [23.6 inches], slightly inboard of the left frame rail. The case vehicle's impact with the speed limit sign resulted in a deep crease in the center of the leading edge of the hood. The speed limit sign post whipped down onto the hood, leaving dents and scraping back to the cowl, and the sign impacted the base of the windshield near the center, causing cracks to fan upward and outward through the center of the windshield (**Figure 3**). There was no other glazing damage. The left front tire was restricted but not deflated, the left rear tire was deflated but not otherwise damaged and both left wheels had areas of abrading on their outside edges but no significant damage. The right side wheels and tires did not sustain any visible damage.

The CDC for the case vehicle's first impact with the curb is coded **00-U999-?**, which indicates a non-horizontal impact to the undercarriage with further details not known. The estimated severity for this impact is coded "unknown" and this impact is ranked as the third most severe among three impacts. The CDC for the case vehicle's impact with the speed limit sign was determined to be **12-FCAN-6 (0)**, with the extent zone reflecting the sign making contact with the windshield. This impact was of low severity for the case vehicle and, because it involved a yielding object, is out of scope for the WinSMASH reconstruction program. The CDC for the case vehicle's most severe impact, with the Hyundai, was determined to be **12-FDEW-3 (0)**. The WinSMASH reconstruction program, damage algorithm based on the measured crush profiles of both vehicles, was used. The total, longitudinal and lateral deltaVs for the case vehicle are, respectively: 32 km.p.h [19.9 m.p.h.], -32 km.p.h [-19.9 m.p.h.] and 0 km.p.h. [0 m.p.h.]. This was a crash of moderate severity (24-40 km.p.h. [15-25 m.p.h.]) for the case vehicle.

AUTOMATIC RESTRAINT SYSTEM

The case vehicle was equipped with front impact air bags with multi-stage inflators and safety belt buckle pretensioners for the driver and front right passenger. The case vehicle was also equipped with the Ford safety canopy system, which is installed in the left and right roof rails and provides inflatable protection for the front and second row outboard seat positions, for a total of four air bags in the vehicle. Both frontal air bags and both safety canopies deployed during the crash.

The driver's frontal air bag was installed in the steering wheel hub (**Figure 6**), with a single



Figure 6: Front of driver's air bag; left safety canopy is partially visible on the left in this photos

cover flap. The cover flap was irregular in shape measured as 25 centimeters [9.8 inches] horizontally along the top (hinge) edge, tapering to 16 centimeters [6.3 inches] horizontally along the bottom edge, and 13 centimeters [5.1 inches] vertically. The cover flap opened along the designated tear points and there is no evidence of damage to the cover flap. The deployed air bag was round with a diameter of 55 centimeters [21.7 inches]. There were two tether straps near the center. Two vent ports, of unknown diameter, were located at the ten and two o'clock positions on the back. There was a light scuff on the air bag fabric on the front near the center and no other evidence of occupant contact nor any damage on the driver's air bag.

The front right passenger's frontal air bag was installed in the middle position on the right side of the instrument panel (**Figure 7**), with a single cover flap. The cover flap was rectangular, measuring 37 centimeters [14.6 inches] horizontally and 17 centimeters [6.7 inches] vertically. The cover flap opened at the designated tear points and there was no evidence of damage to the cover flap. The deployed air bag was rectangular, measuring 55 centimeters [21.7 inches] horizontally and 60 centimeters [23.6 inches] vertically. There was no tether strap. Two vent ports, of unknown diameter, were located in the center of the left and right fabric side panels. There was no evidence of occupant contact nor any damage on the front right passenger's air bag.



Figure 7: Front of front right passenger's air bag; right side canopy is hanging from above in this view



Figure 8: Left side safety canopy



Figure 9: Right side safety canopy

The two safety canopy air bags were installed in the left and right roof rails, extending from the top of the A-pillar to the top of the C-pillar (**Figures 8 and 9**). There was no cover flap as such. Rather, the expanding canopy bag causes the headliner to separate from the side panel and the canopy bag emerges through this opening. There was no evidence of damage to the headliner on either side. In addition to being attached along the length of the roof rail, each canopy had short

exterior fabric straps at the front and back lower corners of the canopy, tethered to the A- and C-pillars, respectively. The deployed canopy air bags were rectangular, measuring 136 centimeters [53.5 inches] horizontally and 46 centimeters [18.1 inches] vertically. There were no interior tether straps and no vent ports. Both air bags were manufactured with a series of interior baffles arranged in concentric half-circles. There was no evidence of occupant contact nor any damage to either of the safety canopies. The left A-pillar was displaced rearward by the impact with the other vehicle and this caused the roof to buckle above the driver's door. There is no evidence that the deformation of the left roof rail compromised the deployment of the left safety canopy.

The Ford safety canopy system is designed to deploy when the vehicle sustains a rollover or a side impact, neither of which happened in this crash. With the case vehicle's EDR not available, the circumstances that caused the safety canopy to deploy are not known.

The NASS case is coded to indicate that the safety canopy deployment was associated with the undercarriage impact (first harmful event). It is thought that the case vehicle's chassis may have been flexed or torqued as the vehicle bounced, one wheel at a time, over the near curb, into the median and then bounced down the far curb and back onto the road surface. This flexing stress to the chassis/frame may have caused the Restraints Control Module (RCM) to "wake up" and deploy the safety canopy system without any rollover or side impact.

Another scenario that may have caused the safety canopy to deploy is derived from the fact that, immediately following the case vehicle's impact with the other vehicle (event #3 in the NASS case), the case vehicle rotated approximately 90 degrees counterclockwise. This rapid spinning (i.e., counterclockwise rotation about the vertical axis) probably resulted in lateral loading of the tires on the right side and the case vehicle probably tipped to the right (i.e., brief clockwise rotation about the longitudinal axis) as it spun out and came to rest. This roll-type motion may have caused the RCM to "wake up" and anticipate a rollover, causing the safety canopy system to deploy.

CASE VEHICLE DRIVER

The case vehicle driver fled the scene on foot, was never identified and there is no knowledge of this person. The driver's seat track was adjusted at the full-rearward position, the seat back was slightly reclined and the tilt steering wheel was adjusted at the full up position. There is no indication that the driver attempted any avoidance actions prior to the first harmful event. The driver's safety belt pretensioner did not actuate because the driver was not using the available, manual, three-point, lap-and-shoulder safety belt system.

CASE VEHICLE FRONT RIGHT PASSENGER

The case vehicle's front right passenger was a 28-year-old male who could not be located and was not interviewed, and there is no other knowledge of this person. The front right seat track was adjusted at the full-rearward position and the seat back was slightly reclined. There is no indication that the driver attempted any avoidance actions prior to the first harmful event. The front right passenger's safety belt pretensioner did not actuate because the passenger was not using the available, manual, three-point, lap-and-shoulder safety belt system.

The other vehicle was a 2002 Hyundai Elantra GLS front wheel drive, four-door, five-passenger sedan (VIN: KMHDN45DX2U-----), equipped with a four cylinder 2.0 liter gasoline engine and an automatic transmission with a console mounted selector lever. Four wheel anti-lock brakes were an option for this model, but it is not known if this vehicle was so equipped. The Elantra was equipped with redesigned frontal air bags and seat back-mounted side impact air bags for the two front row outboard seat positions. The odometer reading is not known due to the non-functional electronic instrument cluster. Its wheelbase was 261 centimeters [102.7 inches]. The Elantra was towed due to disabling front suspension and engine damage.

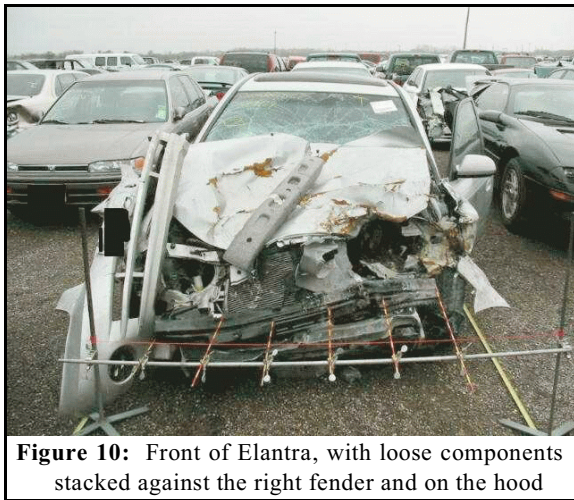


Figure 10: Front of Elantra, with loose components stacked against the right fender and on the hood

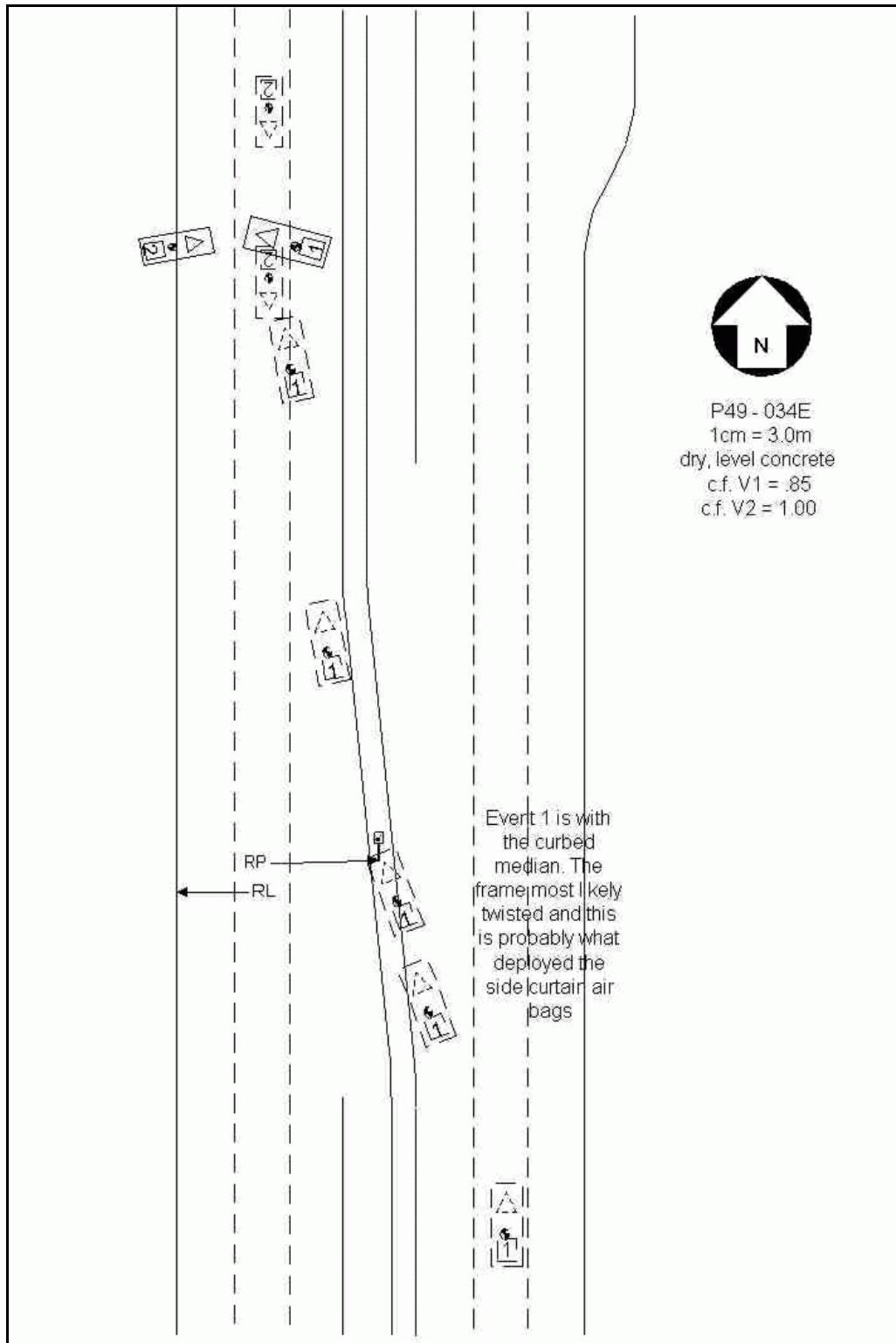


Figure 11: Elantra's front and left side, showing underide damage pattern

The Elantra sustained direct contact damage across the entire front, heavier on the left, and the NASS case is coded to indicate front underide (**Figures 10 and 11**). The grille and both turn signal/headlamp assemblies were shattered and broken away. The bumper cover and the energy absorbing foam bumper were torn off, with the steel bumper and radiator crushed rearward and with damage extending into the engine compartment. The hood was deformed and displaced rearward, such that it impacted and caused extensive fracture of the windshield. Maximum crush was measured as 39 centimeters [15.4 inches] at the front left bumper corner. The left fender was heavily deformed and crushed rearward. The wheelbase on the left side was shortened by 11 centimeters [4.3 inches], with the left front wheel displaced rearward against the left A-pillar and its rotation restricted. The right fender showed minor induced damage and the right front wheel moved forward, extending the wheelbase on the right by 2 centimeters [0.8 inches]. Other than the fractured windshield, there was no glazing damage. None of the tires were deflated.

The CDC for the Elantra's single impact was determined to be **12-FDEW-2 (350)**. The WinSMASH reconstruction program, damage algorithm based on the measured crush profiles of both vehicles, was used. The total, longitudinal and lateral deltaVs for the Elantra are, respectively: 55 km.p.h [34.2 m.p.h.], -54 km.p.h [-33.6 m.p.h.] and +10 km.p.h. [+6.2 m.p.h.]. This was a crash of high severity (greater than 40 km.p.h [25 m.p.h.]) for the Elantra.

The Elantra's driver (23-year-old female) was restrained by the available, manual, three-point, lap-and-shoulder safety belt system. The steering wheel-mounted frontal air bag and the driver's seat back-mounted side impact air bag deployed. The driver sustained fractured bones in her right leg plus various abrasions and contusions, and was hospitalized for four days. The Elantra's front right passenger (31-year-old male) was restrained by the available, manual, three-point, lap-and-shoulder safety belt system and the instrument panel-mounted front right passenger's air bag deployed. He sustained minor soft tissues injuries and was transported via ambulance to a hospital, where he was treated and released at the emergency department.



The impact with the median curb should be viewed as possibly causing the safety canopy deployment. The case vehicle's rapid counterclockwise rotation as it came to rest after the impact with the other vehicle is also possibly a cause for the safety canopy deployment.