



# INDIANA UNIVERSITY

## TRANSPORTATION RESEARCH CENTER

School of Public and Environmental Affairs

222 West Second Street

Bloomington, Indiana 47403-1501

(812) 855-3908 Fax: (812) 855-3537

## ON-SITE OTHER INFLATABLE OCCUPANT PROTECTION INVESTIGATION

CASE NUMBER - IN-06-014

LOCATION - INDIANA

VEHICLE - 2006 MAZDA 5

CRASH DATE - June 2006

Submitted:

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

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

**Technical Report Documentation Page**

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16. <i>Abstract</i> This report covers an on-site other inflatable occupant protection investigation involving a 2006 Mazda 5 (case vehicle) and a 2002 Ford F150 pickup truck (other vehicle), which were involved in a front to side intersection crash on a divided state highway. This crash is of special interest because the case vehicle was equipped with multiple Advanced Occupant Protection System (AOPS) features, including manufacturer certified advanced 208-compliant front air bags, front seat back-mounted side impact air bags and side curtain air bags. In addition, the case vehicle's front right passenger [14-year-old, (unknown race and ethnic origin) male] and second seat right passenger [14-year-old (unknown race and ethnic origin) male] were seated on the impacted side of the case vehicle and were hospitalized for as a result of their injuries. The case vehicle was traveling west in the inside left turn lane of a multi-lane, divided state highway. The case vehicle's driver was in the process of turning left through a "T" intersection to enter the entrance ramp to another divided state highway. The Ford was traveling eastbound in the outside through lane and entered the intersection. The front of the Ford impacted the right side of the case vehicle. The case vehicle and Ford rotated clockwise and the case vehicle's right fender and right front bumper corner impacted the Ford's right front wheel and fender. Following the impact, the Ford continued to rotate clockwise and rolled over driver side leading two quarter rolls. The case vehicle continued to rotate clockwise and came to final rest on the east shoulder of the entrance ramp heading northeast. The Ford came to final rest on its top on the southeast corner of the intersection heading southwest. The case vehicle's right side curtain air bag did not fully deploy in the crash. It was impinged at the top of the right "B"-pillar, which was severely crushed. The two restrained right side passenger's were transported to a hospital and admitted. The restrained driver was transported to a hospital and treated and released.					
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This investigation was brought to NHTSA's attention on June 16, 2006 by a newspaper article in a local newspaper. This crash involved a 2006 Mazda 5 (case vehicle) and a 2002 Ford F150 extended cab pickup truck (other vehicle), which collided front to side in a three-leg (i.e., "T") intersection of a state highway entrance ramp and a divided state highway. The crash occurred in June, 2006 at 6:11 p.m., in Indiana and was investigated by the applicable county sheriff department. This crash is of special interest because the case vehicle was equipped with multiple Advanced Occupant Protection System (AOPS) features, including dual stage front air bags, front seat back-mounted side impact air bags and side curtain air bags, and the case vehicle's front right passenger [14-year-old, (unknown race and ethnic origin) male] and second seat right passenger [14-year-old (unknown race and ethnic origin) male] were seated on the case vehicle's impacted side and sustained injuries as a result of the crash. In addition, the manufacturer of this vehicle has certified that it meets the advanced air bag requirements of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. This contractor inspected both vehicles and the scene on 19-20 June, 2006. Members of the fire department rescue crew and emergency medical personnel were interviewed on June 28, 2006. This contractor was unable to interview with the case vehicle's driver due to attorney refusal. This summary is based on the police crash report, scene and vehicle inspections, interview with rescue and emergency medical personnel, occupant kinematic principles, occupant medical records and this contractor's evaluation of the evidence.

## SUMMARY

The case vehicle was traveling west in the inside left turn lane of a multi-lane, divided state highway. The case vehicle's driver was in the process of turning left through a "T" intersection to enter the entrance ramp to another divided state highway. The Ford was traveling eastbound in the outside through lane and entered the intersection. The front of the Ford impacted the right side of the case vehicle (event 1) causing the case vehicle's front right seat back-mounted side impact and right side curtain air bags to deploy. In addition, the case vehicle's driver and front right passenger's air bags also deployed. The case vehicle and Ford rotated clockwise and the case vehicle's right fender and right front bumper corner impacted the Ford's right front wheel and fender (event 2). Following the impact, the Ford continued to rotate clockwise and rolled over driver side leading two quarter rolls (event 3). The case vehicle continued to rotate clockwise and came to final rest on the east shoulder of the entrance ramp heading northeast. The Ford came to final rest on its top on the southeast corner of the intersection heading southwest. At the time of the crash the light condition was daylight, the atmospheric condition was clear and the roadway was dry.

The case vehicle's CDCs were determined to be **02-RZAW-5 (70 degrees)** for the right side impact (event 1) and **02 RFEW-1 (60 degrees)** for the secondary impact to the right front corner (event 2). The maximum residual crush to the case vehicle's right side as result of event 1 was determined to be approximately 65 centimeters (25.6 inches) occurring at C<sub>4</sub>. The WinSMASH reconstruction program, damage only algorithm calculated the case vehicle's Total, Longitudinal, and Lateral Delta Vs for the most severe impact (i.e., event 1) respectively as: 38.0 km.p.h. (23.6 m.p.h.), -13.0 km.p.h. (-8.1 m.p.h.), and -35.7 km.p.h. (-24.0 m.p.h.). The case vehicle was towed due to damage.

The CDCs for the Ford were determined to be: **11-FDEW-3 (340 degrees)** for the impact with the right side of the case vehicle (event 1), **03-RFEW-1 (90 degrees)** for the secondary impact of the case vehicle's right fender and front right bumper corner to the Ford's right front wheel and fender (event 2) and **00-TYDO-3** for the rollover (event 3). The Ford's maximum residual front crush was determined to be 54 centimeters (21.3 inches) occurring at C<sub>6</sub>. The WinSMASH reconstruction program, damage only algorithm calculated the Total, Longitudinal, and Lateral Delta Vs for the Ford's most severe impact (i.e., event 1) respectively as: 27.0 km.p.h. (16.8 m.p.h.), -25.4 km.p.h. (-15.7 m.p.h.), and 9.2 km.p.h. (5.7 m.p.h.). Based on the extent of crush to the roof, the severity of the rollover was determined to be moderate. The Ford was towed due to damage.

The investigation revealed that the case vehicle's right side curtain air bag did not fully deploy in this crash due to case vehicle damage. The right "B"-pillar separated from the sill during the impact and the lower portion of the pillar was crushed into the passenger compartment approximately 65 centimeters (25.6 inches). As a result, the "B"-pillar was angled into the passenger compartment approximately 25 degrees. This resulted in the right side curtain air bag becoming impinged between the top of the "B"-pillar and what appeared to be styrofoam material under the headliner. In addition, an approximate 30 centimeter (11.8 inches) section of the air bag adjacent to the right C-pillar was found folded over with the bottom edge still under the headliner.

Immediately prior to the crash the case vehicle's front right passenger (14-year-old, male) was most likely seated in an upright position with both feet on the floor. The position of his hands and arms is not known. The seat track was adjusted to between its middle and rear-most position. The position of the seat back is not known due to damage to the seat. The front right passenger was restrained by his manual, three-point, lap-and-shoulder safety belt system. He sustained facial abrasions due to contact with the side curtain air bag and a nonanatomic brain injury due to riding down the side curtain air bag and loading the grille of the striking vehicle. In addition, he sustained a fracture of the right superior pubic ramus and a contused right kidney as a result of riding down the seat back-mounted side impact air bag and loading the intruding right front door. He was transported to a hospital and admitted for treatment of his injuries. It's this contractor's opinion that the deployment of the front right passenger's side curtain and side impact air bags mitigated his interaction with the vehicle interior components and the interaction of his head with the hood of the striking vehicle and reduced his injury potential.

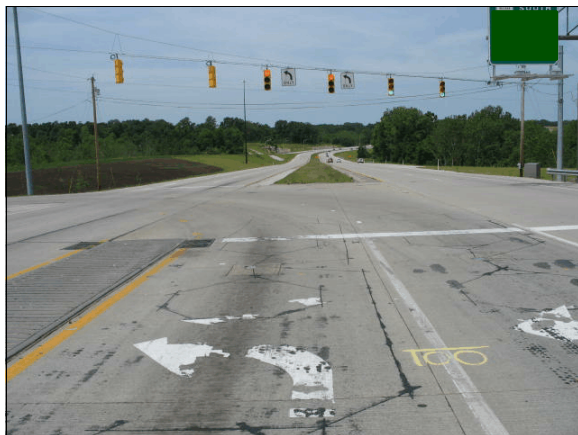
Immediately prior to the crash the case vehicle's second seat right passenger (14-year-old, male) was most likely seated in an upright position with both feet on the floor. The position of his hands and arms is not known. The passenger's seat track was adjusted to its rear-most position and the seat back was slightly reclined. He was restrained by his manual, three-point, lap-and-shoulder safety belt system. He sustained a nonanatomic brain injury due to riding down the side curtain air bag and loading the right rear window frame. In addition, he impacted his right hip on the intruding right rear door and sustained a fractured right inferior pubic ramus. It's this contractor's opinion that the deployment of the second seat right passenger's side curtain air bag mitigated the impact of the passenger's head contact with the right rear window frame and reduced his injury potential.

Immediately prior to the crash the case vehicle's driver (44-year-old, female) was most likely seated in a nominal upright driving position. She most likely had both hands on the steering wheel and her right foot on the accelerator or brake. Her seat track was adjusted to between its middle and rear-most position and her seat back was slightly reclined. She was restrained by her manual three-point, lap-and-shoulder, safety belt system. The driver sustained only minor injury. She was transported to a hospital and was treated and released. The driver's use of her safety belt system and the deployment of her air bag mitigated her interaction with the vehicle interior components as well as her likely interaction with the front right passenger and reduced her injury potential.

## CRASH CIRCUMSTANCES

***Crash Environment:*** The trafficway on which the case vehicle and Ford were traveling was a multi-lane, divided, state highway traversing in an east and west direction. Both vehicles were approaching a signalized, three-leg (i.e., T) intersection. The intersecting roadway was an entrance ramp to another divided state highway, which intersected the south side of the trafficway. On the eastern leg of the intersection, both the eastbound and westbound roadways had two through lanes while the westbound roadway also had two left turn lanes. The outside westbound through lane was 3.3 meters (10.8 feet) in width while the inside westbound through lane was 3.6 meters (11.8 feet) in width. Each turn lane was approximately 3.7 meters (12 feet) in width. Each westbound lane had a solid white stop bar at the intersection. Each eastbound through lane was approximately 3.6 meters (11.8 feet) in width. The eastbound and westbound lanes were divided by a raised concrete median 2.2 meters (7.2 feet) in width. The north and south shoulders were composed of bituminous. The north shoulder was 3.3 meters (10.8 feet) in width and was bordered by a blocked-out, "W"-beam, steel guardrail. The south shoulder was 3.1 meters (10.2 feet) in width and was also bordered by a blocked-out, "W"-beam, steel guardrail. Roadway pavement markings consisted of solid white outside edge lines, solid yellow median edge lines, broken white lane lines, solid white turn lane lines and white left turn only pavement messages with directional arrows. On the western leg of the intersection both eastbound and westbound roadways had two through lanes and were divided by a grass median. Each eastbound through lane was approximately 3.6 meters (11.8 feet) in width and was bordered by an outside bituminous shoulder 3.1 meters (10.2 feet) in width. The inside westbound through lane was 3.6 meters (11.8 feet) in width while the outside westbound through lane was 3.3 meters (10.8 feet) in width and was bordered by an outside bituminous shoulder 3.3 meters (10.8 feet) in width. The grass median was approximately 7.1 meters (19 feet) in width. The bituminous median shoulders were each approximately 1.2 meters (3.9 feet) in width. The roadway pavement markings consisted of white outside edge lines, yellow median edge lines and broken white lane lines. Each eastbound lane had a solid white stop bar at the intersection. The southbound entrance ramp had two lanes. The left lane was 3.7 meters (12 feet) in width while the right lane was 3.3 meters (10.8 feet) in width. Each lane was bordered by a bituminous shoulder approximately 1.3 meters (4.3 feet) in width. There was also a gravel shoulder adjacent to each bituminous shoulder. At the time of the crash the light condition was daylight, the atmospheric condition was clear, and the roadway pavement was dry, travel polished concrete with an estimated coefficient of friction of 0.65. The speed limit was 89 km.p.h. (55 m.p.h.). Traffic density was moderate, and the site of the crash was a rural. See the Crash Diagram at the end of this report.

**Pre-Crash:** The case vehicle was traveling west in the inside left turn lane (**Figure 1**). The case vehicle's driver was in the process of turning left to enter the entrance ramp (**Figure 2**). The Ford was traveling eastbound in the outside through lane (**Figure 3**). The Ford's driver was intending to continue eastbound through the intersection. According to the police crash report, the Ford's driver stated he was talking to his passenger and entered the intersection on a red light. It is unknown if the case vehicle's driver made any avoidance maneuvers prior to the crash. The evidence indicated that the Ford's driver steered right in an attempt to avoid the crash. It is not known if he also applied the brakes. The crash occurred in the "T" intersection within the interchange area of the two state highways (**Figure 4**).



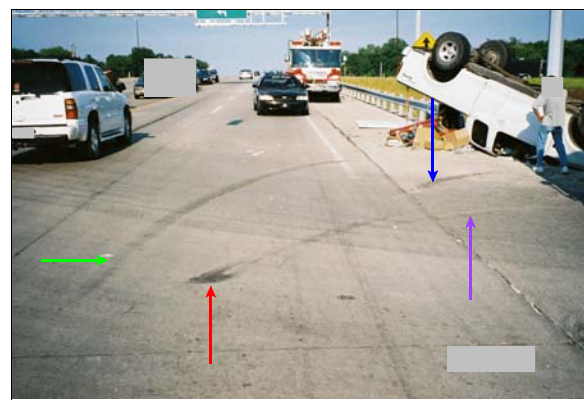
**Figure 1:** Approach of case vehicle westbound in inside left turn lane, number shows feet to impact



**Figure 2:** Approach of case vehicle to impact turning left onto the entrance ramp, red arrow shows impact scrub from case vehicle's right rear tire



**Figure 3:** Approach of Ford to intersection, number on pavement shows feet to impact



**Figure 4:** View east to point of impact and final rest of Ford, red arrow shows impact scrub from case vehicle's right rear tire, purple arrow shows case vehicle's left rear tire mark, green arrow shows Ford's left rear yaw mark, blue arrow shows Ford's left front yaw mark

**Crash:** The front of the Ford (**Figure 5** below) impacted the right side of the case vehicle (**Figure 6** below), causing the case vehicle's front right passenger seat-back mounted side impact air bag and the right side curtain air bag to deploy. In addition, the case vehicle's driver air bag and front right passenger air bag deployed. It is unknown whether more than one stage of the dual-stage front air bags activated. The impact caused the case vehicle to rotate rapidly clockwise and the Ford also rotated clockwise. As a result, the case vehicle's right front fender and right front bumper corner impacted the Ford's



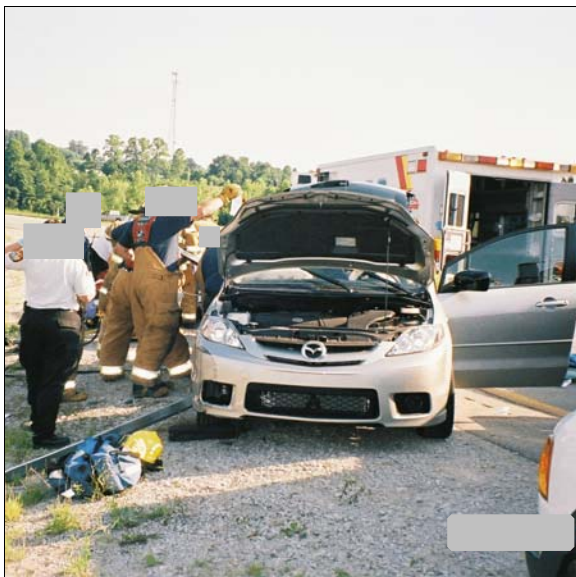
right front wheel and right fender. The Ford continued to rotate clockwise and travel southeast. As the Ford rotated, it began to roll left and loaded its left side suspension. The Ford's left front wheel rim gouged the pavement and it rolled over driver side leading as it reached a near broadside orientation. The Ford rolled over two quarter rolls onto its top. The case vehicle continued to rotate clockwise and traveled southeast to the east shoulder of the entrance ramp.



**Figure 5:** Right front view of damage to front of Ford from impact with the right side of the case vehicle and rollover damage to roof and hood.



**Figure 6:** Damage to case vehicle's right side due to impact with front of Ford, right side doors placed back on vehicle in approximate crushed position



**Figure 7:** Police photo showing case vehicle's rest position on east shoulder of entrance ramp, view is to southwest



**Figure 8:** Police photo showing Ford's rest position, on southeast corner of intersection, photo taken from east shoulder of entrance ramp looking northwest

**Post-Crash:** As a result of the impact, the case vehicle rotated clockwise a total of approximately 195 degrees, traveled southeast and came to final rest on the east shoulder of the entrance ramp heading northeast (**Figure 7**). The Ford rotated clockwise a total of approximately 135 degrees and came to final rest on its top on the southeast corner of the intersection just off the shoulder

heading southwest (**Figure 8**).

### CASE VEHICLE

The 2006 Mazda 5 was a front wheel drive, four-door station wagon (VIN: JM1CR293360-----) equipped with 2.3 L, inline four cylinder engine; four-speed automatic transmission and four wheel, anti-lock brakes. The front seating row was equipped with

bucket seats with adjustable head restraints, driver seat position sensor, front right passenger weight sensor, tilt and telescopic steering column, energy absorbing brake and accelerator pedal assembly, dual stage driver and front right passenger air bags, seat back-mounted side impact air bags, and manual, three-point, lap-and-shoulder safety belt systems with pretensioners, force limiters and adjustable upper anchors. The second seating row was equipped with bucket seats with adjustable head restraints and manual, three point, lap-and-shoulder safety belt systems. The third seating row was equipped with a split bench seat with folding backs, adjustable head restraints and manual, three-point, lap-and-shoulder safety belt systems. The case vehicle was also equipped with side curtain air bags that provided coverage for all three seat rows. The second and third seat rows were equipped with a LATCH system for securing child safety seats. In addition, the manufacturer of this vehicle has certified that it meets the advanced air bag requirements of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The case vehicle's wheelbase was 275 centimeters (108.3 inches). The case vehicle's odometer reading at the time of the vehicle inspection was 79 kilometers (49 miles).

The various sensors in the case vehicle's advanced occupant restraint system analyze a combination of factors including the predicted crash severity to determine the front air bag inflation level appropriate for the severity of the crash. For the front right seat position, an occupant weight sensor in the seat cushion determines if an occupant is on the seat and enables or suppresses deployment of the air bag based on the amount of weight on the seat. Side impact sensors detect a side impact and determine if the front seat back-mounted side impact air bags and side curtain air bags should be deployed.

## CASE VEHICLE DAMAGE

**Exterior Damage:** The case vehicle's initial impact with the Ford involved both the right side doors and the right quarter panel. The direct damage extended vertically from the sill to the right roof side rail. The direct damage began 58 centimeters (22.8 inches) rear of the right front axle and extended 240 centimeters (94.5 inches) rearward along the right side of the vehicle. Both right side doors, the sill and the quarter panel were crushed into the passenger compartment. The impact separated the right "B" pillar at the sill. The "B"-pillar was crushed inward nearly to the center of the case vehicle (**Figure 9**). Both right side doors had been cut off the vehicle by rescue personnel. They were positioned back on the vehicle as near as possible to their original crushed position. However, the precise crushed location of the doors could not be established due to the deformation of the structures. The crush measurements were then taken at the mid-door level. Adjustments to the crush values were made based on the extent of crush to the right B-pillar, measurements from an exemplar vehicle and judgement. Based on this process, the maximum residual crush was determined to be



**Figure 9:** Overview of right "B"-pillar intrusion

approximately 65 centimeters (25.6 inches) occurring at C<sub>4</sub>. A second set of crush measurements was also taken at the sill level. The maximum residual crush at this level was determined to be 7 centimeters (2.8 inches) occurring at C<sub>5</sub>. The table below shows the average of the case vehicle's mid-door and sill level crush measurements.

Units	Event	Direct Damage		Field L	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>	C <sub>6</sub>	Direct	Field L
		Width CDC	Max Crush								±D	±D
cm	1	240	65	172	0	10	20	34	16	0	-37	-49
in		94.5	25.6	67.7	0.0	3.9	7.9	13.4	6.3	0.0	-14.6	-19.3

The case vehicle's second impact with the Ford involved the front portion of the right fender, front bumper corner and the headlamp/turn signal assembly (**Figure 10**). The fender and bumper fascia and the headlamp/turn signal assembly lens were directly damaged and the fender was slightly crushed. There was extensive black rubber transfer on the fender and bumper fascia indicating that this portion of the vehicle had impacted the Ford's right front tire. The direct damage began 15 centimeters (5.9 inches) forward of the right front axle and extended 56 centimeters (22 inches) along the fender and right side of the bumper fascia. The residual maximum crush was measured as 1 centimeter (0.4 inch) occurring at C<sub>2</sub> and C<sub>3</sub>. The table below shows the case vehicle's right fender crush measurements



**Figure 10:** Damage to right front corner of case vehicle due to secondary impact with V2's right front wheel

Units	Event	Direct Damage		Field L	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>	C <sub>6</sub>	Direct	Field L
		Width CDC	Max Crush								±D	±D
cm	2	56	1	56	0	1	1	1	0	0	175	175
in		22.0	0.4	22.0	0.0	0.4	0.4	0.4	0.0	0.0	68.9	68.9

The case vehicle's right side wheelbase was extended 2 centimeters (0.8 inch). The left side wheelbase was reduced 1 centimeter (0.4 inch). The totality of the case vehicle's induced damage involved the right fender, right quarter panel and roof. In addition, the windshield was cracked.

The case vehicle's recommended tire size was: P205/50R17, and the vehicle was equipped with tires of this size. The case vehicle's tire data are shown in the table below.

Tire	Measured Pressure		Recommend Pressure		Tread Depth		Damage	Restricted	Deflated
	kpa	psi	kpa	psi	milli-meters	32 <sup>nd</sup> of an inch			
LF	228	33	234	34	8	10	None	No	No
RF	221	32	234	34	8	10	Scuff on sidewall	No	No
LR	214	31	234	34	8	10	None	No	No
RR	214	31	234	34	8	10	None to tire, but wheel bent in at top	No	No

**Vehicle Interior:** Inspection of the case vehicle’s interior (Figures 11, 12 and Figure 13 below) revealed probable occupant contact evidence on the right side curtain air bag, front right seat back-mounted side impact air bag, both right side doors, left side of the center console, the right roof side rail, glove box door and instrument panel below the glove box door. No other occupant contact evidence was found. Both right side doors and the right “B”-pillar had intruded significantly into the passenger compartment. The lower portion of the right “B”-pillar intruded laterally approximately 65 centimeters (25.6 inches) into the second seat row and approximately 55 centimeters (21.7 inches) into the front seat row. In addition, the right front door intruded laterally approximately 46 centimeters (18.1 inches) into the front seat row and the right rear door intruded approximately 50 centimeters (19.7 inches) into the second seat row. Finally, there was no compression of the energy absorbing steering column and no deformation to the steering wheel.



**Figure 11:** Overview of steering wheel and instrument panel, yellow tape shows occupant contact mark on center console



**Figure 12:** Overview of center and front right instrument panel, yellow tape shows occupant contact mark on glove box door and lower instrument panel

**Damage Classification:** Based on the vehicle inspection, the case vehicle’s CDCs were determined to be **02-RZAW-5 (70 degrees)** for the right side impact (event 1) and **02 RFEW-1 (60 degrees)** for the secondary impact (event 2) to the right front corner. The WinSMASH reconstruction program, damage only algorithm was used to reconstruct the case vehicle's Delta Vs for the right side impact. The Total, Longitudinal, and Lateral Delta Vs are,

respectively: 38.0 km.p.h. (23.6 m.p.h.), -13.0 km.p.h. (-8.1 m.p.h.), and -35.7 km.p.h. (-22.1 m.p.h.). The crash fit the reconstruction model and the results appeared reasonable. The case vehicle was towed due to damage.

#### AUTOMATIC RESTRAINT SYSTEM

The case vehicle was equipped with manufacturer certified advanced 208-compliant front air bags as well as front seat back-mounted side impact air bags and side curtain air bags. The driver and front right passenger air bags, the front right seat back-mounted side impact air bag and the right side curtain air bag deployed in this crash as a result of the case vehicle's right side impact with the front of the Ford.

The right side curtain air bag was located along the right roof side rail under the headliner. The air bag was approximately rectangular in shape and extended along the front, second and third seat rows. It was designed to provide protection to an occupant's head during a side impact. The evidence indicated that the side curtain air bag did not fully deploy during the crash (Figure 14). Upon inspection, the air bag was found bunched-up and impinged behind the headliner at the top of the right "B"-pillar (Figure 15). The damage to the case vehicle indicated the air bag was blocked from full deployment at the top of the right "B"-pillar due to the extensive crush of the pillar. The right "B"-pillar separated from the sill during the impact and the lower portion of the pillar was crushed into the passenger compartment approximately 65 centimeters (25.6 inches). As a result, the "B"-pillar was angled inward into the passenger compartment approximately 25 degrees. Examination of the non-deployed portion of the side curtain air bag at the upper "B"-pillar indicated the displacement of the pillar resulted in the air bag becoming impinged between the top of the "B"-pillar and what appeared to be styrofoam material under the headliner. In addition, an approximate 30 centimeter section of the air bag adjacent to the right C-pillar (Figure 16



Figure 13: Overview of interior from rear hatch



Figure 14: Overview of right side curtain air bag, it did not break out of the headliner at the "B"-pillar, each increment on rods is 5 cm (2 in)



Figure 15: Close view of air bag bunched up behind headliner at right "B"-pillar, view is from back of "B"-pillar

below) was found folded over with bottom edge still under the headliner. Following documentation of the air bag in its “as-found” condition, the air bag was fully unfolded and inspected (**Figures 17 and 18** below). The inspection revealed no damage to the air bag due to the deployment. However, the bottom outside surface of the air bag adjacent to the second seat row had numerous small cuts in it due to interaction with glass fragments from the right rear door window glazing during the crash. The area was approximately 30 centimeters (11.8 inches) in length and 10 centimeters (3.9 inches) in height. In addition, an area of probable occupant contact was observed on the side curtain air bag adjacent to the front right seat position (**Figure 17**), and the second seat right passenger position (**Figure 18**). The side curtain air bag was approximately 203 centimeters (79.9 inches) in length and 33 centimeters (13 inches) in height. The air bag was designed with irregularly shaped inflatable chambers adjacent to each seat position. The air bag was anchored to the right “A”-pillar by a cloth cord approximately 45 centimeters (17.7 inches) in length and 1.5 centimeters (0.6 inches) in width. There was no anchor cord at the back of the air bag. The air bag was designed without tethers or vent ports.

The front right passenger’s seat back-mounted side impact air bag was located in the outboard side of the front right seat back (**Figure 19** below). The deployed air bag was approximately kidney-shaped. It was designed to provide protection to the hip and thorax area during a side impact. The air bag was approximately 53 centimeters (20.9 inches) in height. The upper portion of the air bag was approximately 25 centimeters (9.8 inches) in width while the bottom portion was approximately 15 centimeters (5.9 inches) in width. The air bag was designed without tethers or vent ports. There was no module flap on the side of the seat back. The air bag deployed through a tear-seam in the side of the seat back. There was no evidence of



**Figure 16:** Overview of side curtain air bag adjacent to second seat right position, air bag did not break out of headliner at “B”-pillar and did not completely unfold at “C”-pillar (arrow)



**Figure 17:** Right side curtain air bag adjacent to front right seat position, yellow tape on air bag shows location of possible skin transfer from front right occupant



**Figure 18:** Overview of right side curtain air bag adjacent to second seat right passenger, yellow tape shows location of possible occupant contact mark

damage to the air bag due to deployment. However, the intrusion of the door produced a black scuff and a 1 centimeter (0.4 inch) cut in the fabric on the outside bottom portion of the air bag. A scuff and fabric transfer were observed on the inside bottom portion of the air bag in addition to a small black scuff. A long narrow black scuff was also observed on the inside top portion of the air bag.

The case vehicle's driver air bag was located in the steering wheel hub. The air bag module cover consisted of three asymmetrical flaps made of pliable vinyl positioned within an overall approximate hexagonal shape. The top flap was essentially a rectangle, except that the bottom was semicircular-shaped so as to accommodate the manufacturer's logo. The overall dimensions of the top flap were approximately 9 centimeters (3.5 inches) in width and 11 centimeters (4.3 inches) in height. The overall dimensions of each of the two bottom flaps were approximately 7 centimeters (2.8 inches) in width, approximately 3 centimeters (1.2 inches) in height at the inside tear seam and 4 centimeters (1.6 inches) in height at their outer edge. The distance between the mid-center of the driver's seat back as positioned at the time of the vehicle inspection [i.e., distance from seat back to air bag module was 55 centimeters (21.7 inches), seat back slightly reclined] and the front surface of the air bag fabric at approximate full excursion was 29 centimeters (11.4 inches). An inspection of the air bag module cover flaps and the air bag fabric revealed that the cover flaps opened at the designated tear points (**Figure 20**). There was no

evidence of damage during the deployment to the air bag or the module cover flaps, and no evidence of occupant contact to the air bag. However, a few small holes were observed in the air bag that were most likely caused by flying glass fragments from the right front window glazing, which cut the air bag fabric during the crash. The deployed driver's air bag (**Figure 21** below) was round with a diameter of approximately 57 centimeters (22.4 inches). The air bag was designed with one tether, approximately 5.5 centimeters (2.2 inches) in width and had two vent ports, each approximately 3 centimeters (1.2 inches) in diameter, located at the 11 and 1 o'clock positions.



**Figure 19:** Inside surface of front right passenger's side impact air bag

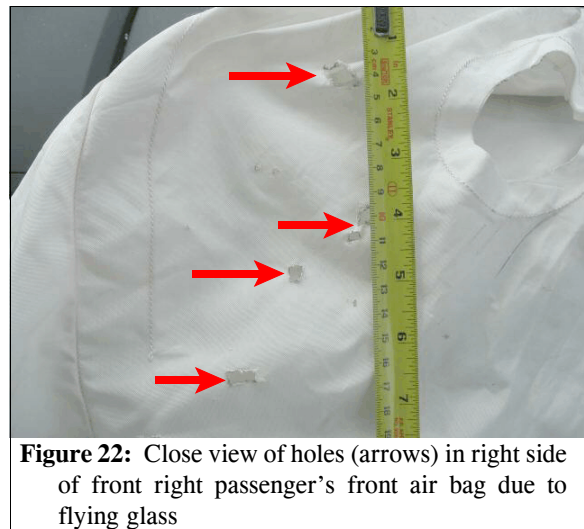


**Figure 20:** Case vehicle driver's air bag module flaps

The case vehicle's front right passenger air bag was located in the top of the instrument panel. The module cover consisted of a single rectangular cover flap with rounded corners constructed of stiff vinyl. The cover flap was 19 centimeters (7.5 inches) in width and 15 centimeters (5.9 inches) in height. The distance between the front of the instrument panel and the leading edge of the cover flap was approximately 6 centimeters (2.4 inches). An inspection of the air bag module cover flap and the air bag fabric revealed that the cover flap opened at the designated tear points. There was no evidence of damage during the deployment to the air bag or the module cover flap, and no evidence of occupant contact to the air bag. Numerous small holes were observed in the front and both sides of the air bag (**Figure 22** below). The fabric at the edges of these holes was discolored and brittle and appeared to be melted. The holes were most likely formed when flying glass fragments from the right front window glazing impacted and cut the air bag fabric during the crash. The deployed front right passenger air bag (**Figure 23** below) was rectangular in shape and was 54 centimeters (21.5 inches) in height and 42 centimeters (16.5 inches) in width. The air bag was designed without tethers and had two vent ports, each approximately 7 centimeters (2.8 inches) in diameter, located at the 10 and 2 o'clock positions. There was no evidence of occupant contact to the front right passenger air bag; however, some blood splatter, most likely from the front right passenger, was observed on the front of the air bag.



**Figure 21:** Case vehicle driver's air bag



**Figure 22:** Close view of holes (arrows) in right side of front right passenger's front air bag due to flying glass

### CASE VEHICLE FRONT RIGHT PASSENGER KINEMATICS

Immediately prior to the crash the case vehicle's front right passenger [14-year-old (unknown race and ethnic origin) male; 160 centimeters and 54 kilograms (63 inches, 120 pounds)] was most likely seated in an upright position with both feet on the floor. The position of his hands and arms is not known. The front right passenger's seat was severely damaged due to the crash, but it appeared that the seat track was adjusted between its middle and rear-most positions. The seat back adjustment is not known due to the damage to the seat. It is not known if the front right passenger was wearing glasses or contact lenses at the time of the crash.



The front right passenger was restrained by his manual, three-point, lap-and-shoulder safety belt system. The safety belt assembly was damaged by the crush to the right front door and “B”-pillar. It was found jammed with a portion of the safety belt extended out of the damaged retractor consistent with usage during the crash.

The case vehicle’s impact with the Ford deployed the right side curtain air bag, the front right passenger’s seat back-mounted side impact air bag, and most likely actuated the front right passenger’s safety belt pretensioner and force limiter. The passenger moved forward and primarily rightward opposite the case vehicle’s 70 degree direction of principal force as the case vehicle decelerated longitudinally and accelerated laterally to the left. The passenger loaded his safety belt and the right side of his head impacted the partially deployed side curtain air bag abrading his face (**Figure 17** above). He rode down the side curtain air bag and his head loaded the grille of the striking vehicle causing a nonatomic brain injury. His right upper arm, shoulder, thorax and hip also impacted his deployed seat back-mounted side impact air bag. The force of the crash and the right front door intrusion caused the passenger to ride down the side impact air bag and his right hip loaded the right front door (**Figure 24**) causing a fracture of his right superior pubic ramus and a contusion to his right kidney. In addition, the passenger’s right leg and right arm also impacted the intruded right front door, and the left side of his body most likely contacted the right side of the driver’s body. The front right passenger remained restrained in his seat as the case vehicle rotated clockwise to final rest. Rescue personnel removed the right front door and removed the front right passenger from the case vehicle. The deployment of the front right passenger’s side curtain and side impact air bags mitigated his interaction with the vehicle interior components and the interaction of his head with the hood of the striking vehicle and reduced his injury potential.



**Figure 23:** Case vehicle’s front right passenger front air bag



**Figure 24:** Overview of case vehicle’s right front door, yellow tape shows likely occupant contact marks

**CASE VEHICLE FRONT RIGHT PASSENGER INJURIES**

IN-06-014

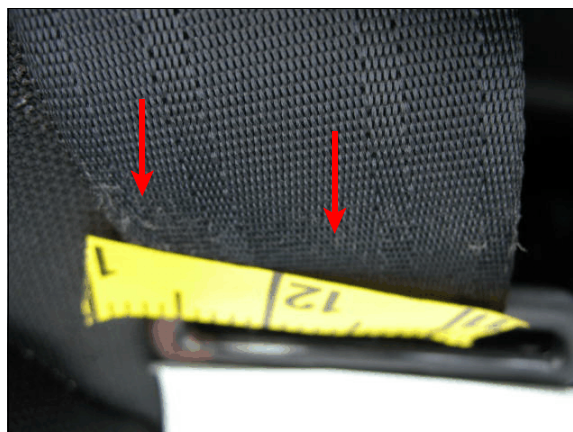
The front right passenger was transported by ambulance to a local hospital. He was admitted and spent two days in the hospital. The table below shows the case vehicle’s front right passenger’s injuries and injury mechanisms.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Nonanatomic brain injury with prior loss of consciousness of unknown length, awake on initial observation, GCS = 15, but later some vomiting and disorientation	moderate 160406.2,0	Exterior of other motor vehicle: grille	Probable	Hospitalization records
2	Fracture, non-displaced, subtle, right superior pubic ramus	moderate 852602.2,5	Right side interior hardware and/or armrest	Probable	Hospitalization records
	Probable mild diastasis of right sacroiliac joint with widening noted	Not coded	Right side interior hardware and/or armrest	Certain	Emergency room records
	Possible fracture {contour abnormality} anterosuperior right sacral ala, subtle	Not coded	Right side interior hardware and/or armrest	Certain	Emergency room records
3	Contusion {hematoma}, mid to lower pole, right kidney	moderate 541612.2,1	Right side interior surface, excluding hardware and/or armrest	Certain	Hospitalization records
4	Abrasions, scabs, face, not further specified	minor 290202.1,9	Air bag, right side inflatable curtain	Probable	Hospitalization records
5	Contusion, small, head (head, ears, eyes, nose, throat), not further specified	minor 290402.1,9	Unknown contact mechanism	Unknown	Hospitalization records
6	Abrasion right lower abdomen and right side consistent with seat belt injury	minor 590202.1,1	Lap portion of safety belt system	Certain	Emergency room records
7	Contusion {bruising} right pelvis, not further specified	minor 890402.1,1	Lap portion of safety belt system	Probable	Emergency room records
8	Laceration(s) {cuts, not significant}, not further specified	minor 990600.1,9	Unknown contact mechanism	Unknown	Hospitalization records

Immediately prior to the crash the case vehicle's second seat right passenger [14-year-old ( unknown race and ethnic origin) male, 170 centimeters and 57 kilograms (67 inches, 125 pounds)] was most likely seated in an upright position with both feet on the floor. The position of his hands and arms is not known. The passenger's seat track was adjusted to its rear-most position and the seat back was slightly reclined. It is not known if the passenger was wearing glasses or contact lenses at the time of the crash.

The second seat right passenger was restrained by his manual, three-point, lap-and-shoulder safety belt system. A load mark was found on the safety belt in a location consistent with usage of the safety belt during the crash. The safety belt had pulled on the latch plate belt guide during the crash forming an abrasion on the belt (**Figure 26**).

The case vehicle's impact with the Ford deployed the right side curtain air bag, and locked the second seat right passenger's safety belt retractor. As a result of the impact, the passenger moved forward and primarily rightward opposite the case vehicle's 70 degree direction of principal force as the case vehicle decelerated longitudinally and accelerated laterally to the left. He loaded his safety belt system and his head impacted the partially deployed side curtain air bag (**Figure 18** above) abrading his face. He rode down the air bag and his head impacted the right rear door window frame causing a nonanatomic brain injury. The passenger's right hip impacted the intruding right rear door (**Figure 27**) causing a transverse fracture of the right inferior pubic ramus. In addition, his right shin impacted the intruding right "B"-pillar abrading his shin, and his right leg, right arm and thorax loaded the intruding right rear door. He remained restrained in his seat as the case vehicle rotated clockwise to final rest. Rescue personnel removed the right rear door and removed the second seat right passenger from the case vehicle. Emergency medical records indicated that the passenger's left foot was entrapped and it required 10 minutes to extricate him from the vehicle. It was not reported how or where his foot was entrapped. The deployment of the second seat right passenger's side curtain air bag mitigated the impact of the passenger's head contact with the right rear window frame and reduced his injury potential.



**Figure 26:** Abrasion in fabric of second row right safety belt from latch plate belt guide



**Figure 27:** Overview of right rear door, yellow tape shows likely occupant contact marks

**CASE VEHICLE SECOND SEAT RIGHT PASSENGER INJURIES**

IN-06-014

The second seat right passenger was transported by ambulance to a local hospital. He was admitted and spent two days in the hospital. The table below shows the second seat right passenger’s injuries and injury mechanisms.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Nonanatomic brain injury with temporary loss of consciousness know to be less than 31 minutes	moderate 160202.2,0	Right rear window frame	Probable	Hospitalization records
2	Fracture, transverse, non-displaced medial right inferior pubic ramus adjacent to pubic symphysis with minimal free fluid in pelvis	moderate 852602.2,5	Right side interior surface, excluding hardware and/or armrest	Probable	Hospitalization records
3	Abrasion central forehead, not further specified	minor 290202.1,7	Air bag, right side inflatable curtain	Probable	Hospitalization records
4	Abrasions right side of face, near nasal area	minor 290202.1,1	Air bag, right side inflatable curtain	Probable	Emergency room records
5	Abrasions nose, not further specified	minor 290202.1,4	Air bag, right side inflatable curtain	Probable	Emergency room records
6	Lacerations, multiple, right forehead {frontal} region with glass in wound	minor 290602.1,7	Noncontact injury: flying glass, right rear glazing	Certain	Hospitalization records
7	Lacerations nasal area, not further specified	minor 290602.1,4	Noncontact injury: flying glass, right rear glazing	Certain	Hospitalization records
8	Laceration upper lip, not further specified	minor 290602.1,8	Noncontact injury: flying glass, right rear glazing	Certain	Emergency room records
9	Abrasion right medial palm, not further specified	minor 790202.1,1	Noncontact injury: flying glass, right rear glazing	Probable	Emergency room records
10	Contusion {bruise} right lateral hip, not further specified	minor 890402.1,1	Lap portion of safety belt system	Probable	Emergency room records
11	Abrasion left lower leg, not further specified	minor 890202.1,2	Seat back, front right passenger’s	Probable	Emergency room records
12	Abrasion, small, over right shin {tibia/fibula}, not further specified	minor 890202.1,1	Right side interior surface rearward of right “B”-pillar	Probable	EMS treatment record

Immediately prior to the crash the case vehicle's driver [44-year-old ( unknown race and ethnic origin) female, unknown height and 100 kilograms (220 pounds)] was most likely seated in a nominal upright driving position. She most likely had both hands on the steering wheel and her right foot on the accelerator or brake. Her seat track was adjusted to between its middle and rear-most position and her seat back was slightly reclined. It is not known if the driver was wearing glasses or contact lenses at the time of the crash.

The case vehicle's driver was restrained by her manual, three-point, lap-and-shoulder, safety belt system. The safety belt pretensioner had actuated in the crash and her safety belt was jammed with a portion of the safety belt extended out of the retractor consistent with safety belt usage during the crash. In addition, the driver had contusions on her chest and left shoulder consistent with safety belt use in the crash. No load marks were observed on the safety belt of “D”-ring.

The case vehicle’s impact with the Ford actuated the driver’s safety belt pretensioner and force limiter and caused the driver to move forward and to her right opposite the case vehicle’s 70 degree direction of principal force as the case vehicle decelerated longitudinally and accelerated laterally to the left. The driver loaded her safety belt causing a contusion to her left shoulder and chest. Her face and upper chest most likely contacted her deployed air bag and her right hand contacted her deployed air bag contusing her hand. In addition, the driver’s right knee impacted the center console and her right upper torso most likely impacted the right front passenger. The driver remained restrained in her seat as the case vehicle rotated clockwise to final rest. It is not known how the driver exited the vehicle. The driver’s use of her safety belt system and the deployment of her air bag mitigated her interaction with the vehicle interior components as well as her likely interaction with the front right passenger and reduced her injury potential.

#### CASE VEHICLE DRIVER INJURIES

The police crash report indicated the driver sustained a “B” (non-incapacitating-evident) injury and was transported by ambulance to a local hospital. The driver was treated and released from the emergency room. The table below shows the case vehicle driver’s injuries and injury mechanisms.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Contusion chest, not further specified	minor 490402.1,4	Torso portion of safety belt system	Certain	Emergency room records
2	Contusion left shoulder, not further specified	minor 790402.1,2	Torso portion of safety belt system	Certain	Emergency room records
3	Contusion {bruising} right hand and/or thumb, not further specified	minor 790402.1,1	Air bag, driver’s	Possible	Emergency room records
4	Contusions, tenderness, swelling, not further specified	minor 990400.1,9	Unknown contact mechanism	Unknown	Emergency room records

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
5	Laceration, 1.5 cm (0.6 in) right upper arm, not further specified	minor 790602.1,1	Noncontact injury: flying glass, right front glazing	Probable	Emergency room records

## OTHER VEHICLE

The 2002 Ford F150 was a four wheel drive, four-door pick up truck (VIN: 1FTRX18WX2N-----). The Ford was equipped with a 4.6L, V8 engine; four speed automatic transmission with overdrive; driver and front right passenger manual, three point, lap-and-shoulder safety belt systems and redesigned driver and front right passenger air bags and a front right passenger air bag suppression switch, which was found in the on position. The Ford's driver and front right passenger air bags did not deploy as a result of the impact with the case vehicle. The Ford's crash severity was most likely just below the air bag system's deployment threshold.

**Exterior Damage:** The Ford's initial impact with the case vehicle's right side involved the front end of the vehicle (**Figure 28**). The front bumper, grille, hood and right headlamp/turn signal were directly contacted and crushed rearward and to the right. The direct damage began at the right bumper corner and extended 155 centimeters along the bumper, hood and grille. Crush measurements were taken at the bumper level. The maximum residual crush was measured as 54 centimeters (21.3 inches) occurring at C<sub>6</sub>. The table below shows the Ford's front bumper crush.



**Figure 28:** Damage to front of Ford from impact with the right side of the case vehicle and damage to the roof from the rollover

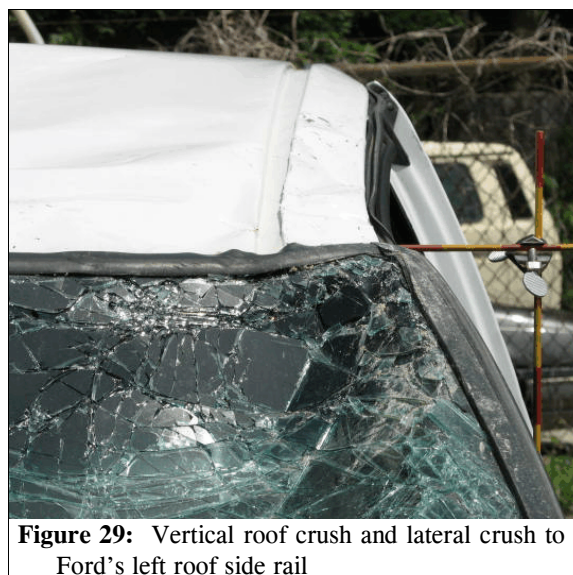
Units	Event	Direct Damage		Field L	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>	C <sub>6</sub>	Direct	Field L
		Width CDC	Max Crush								±D	±D
cm	1	155	54	157	21	29	37	46	49	54	5	0
in		61.0	21.3	61.8	8.3	11.4	14.6	18.1	19.3	21.3	2.0	0.0

The Ford's secondary impact with the case vehicle's right fender involved the Ford's right fender and right front tire. There was minor damage to the Ford's fender and scuffing to the tire, but no residual crush. The rollover involved the left side, roof and top of the hood. The front portion of the roof, both "A"-pillars and the windshield header were crushed downward. The maximum vertical crush occurred to the roof adjacent to the left roof side rail just behind the left

“A”-pillar (**Figure 29**) and was determined to be 17 centimeters (6.7 inches). The maximum lateral crush occurred to the left roof side rail at the same location (**Figure 29**). It was determined to be 3 centimeters (1.2 inches).

The Ford’s right side wheelbase was reduced 15 centimeters (5.9 inches) while the left side wheelbase was extended 3 centimeters (1.2 inches). The totality of the Ford’s induced damage involved the hood, right fender, roof and the back left corner of the cab.

The Ford’s recommended tire size was P255/70R16; however, the Ford was equipped with tires size LT305/70R16. The case vehicle’s tire data are shown in the table below.



**Figure 29:** Vertical roof crush and lateral crush to Ford’s left roof side rail

Tire	Measured Pressure		Recommend Pressure		Tread Depth		Damage	Restricted	Deflated
	kpa	psi	kpa	psi	milli-meters	32 <sup>nd</sup> of an inch			
LF	0	0	207	30	10	12	None	No	No
RF	207	30	207	30	10	12	None	Yes	No
LR	255	37	221	32	9	11	None	No	No
RR	255	37	221	32	9	11	None	No	No

**Damage Classification:** Based on the vehicle inspection, the CDCs for the Ford were determined to be: **11-FDEW-3 (340 degrees)** for the impact with the right side of the case vehicle (event 1), **03-RFEW-1 (90 degrees)** for the secondary impact of the case vehicle’s right fender and front right bumper corner to the Ford’s right front wheel and fender(event 2) and **00-TYDO-3** for the rollover (event 3). The WinSMASH reconstruction program, damage only algorithm was used to reconstruct the Ford's Delta Vs for the front impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 27.0 km.p.h. (16.8 m.p.h.), -25.4 km.p.h. (-15.7 m.p.h.), and 9.2 km.p.h. (5.7 m.p.h.). The crash fits the reconstruction model and the results appeared reasonable. Based on the extent of crush to the roof, the severity of the rollover was determined to be moderate. The Ford was towed due to damage.

**Ford’s Occupants:** According to the police crash report, the Ford’s driver [36-year-old, White (non-Hispanic) male] and front right passenger [unknown age, White (non-Hispanic) male) were restrained by their manual, three-point, lap-and-shoulder, safety belt systems. The police crash report indicated neither occupant was transported by ambulance to the hospital, and both refused

medical treatment at the scene. According to the police crash report, the front right passenger indicated he did not sustain any injuries as a result of the this crash.



