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ON-SITE SIDE IMPACT INFLATABLE OCCUPANT PROTECTION INVESTIGATION

CASE NUMBER - IN09026
LOCATION - TEXAS
VEHICLE - 2003 FORD EXPEDITION EDDIE BAUER
CRASH DATE - June 2009

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. *Abstract*

The on-site investigation focused on the side impact inflatable curtain (IC) air bags, the crash dynamics, and the sources of the driver's injuries of a 2003 Ford Expedition Eddie Bauer. The Ford was occupied by a restrained 26-year-old female driver, a 3-year-old male second row center passenger, and a 1-year-old male second row right passenger. Both second row passengers were restrained in child safety seats. The Ford's driver was traveling northwest in the outside through lane of a divided city street approaching a 4-leg intersection. The Mazda was traveling southwest. Both vehicles entered the intersection and the front plane of the Mazda impacted the right side plane of the Ford (event 1). The force direction on the Ford was within the 1 o'clock sector and the impact force was sufficient to trigger deployment of the side impact IC air bags. The Ford rotated clockwise and rolled over (event 2) left side leading 8 quarter turns. The vehicle came to final rest on its wheels heading south on the northeast side of the road. The occupants of the Ford were treated at the scene by emergency medical responders. The driver sustained minor injuries and the second row passengers were uninjured. Both vehicles were towed due to damage.

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IN09026

The on-site investigation focused on the side impact inflatable curtain (IC) air bags, the crash dynamics, and the sources of the driver's injuries of a 2003 Ford Expedition Eddie Bauer (**Figure 1**). This crash was brought to our attention by the National Highway Traffic Safety Administration (NHTSA) on July 31, 2009 through the sampling activities of the National Automotive Sampling System-General Estimates System (NASS-GES). This investigation was assigned on August 13, 2009. The crash involved the Ford and a 2003 Mazda 6. The crash occurred in June, 2009, at 2124 hours, in Texas and was investigated by the city police department. Both vehicles and the crash scene were inspected on August 19 and 20, 2009. The Ford's driver was interviewed on August 21, 2009. This report is based on the police crash report, scene and vehicle inspections, driver interview, occupant kinematic principles, and evaluation of the evidence.

Figure 1: The damaged 2003 Ford Expedition Eddie Bauer

CRASH CIRCUMSTANCES

Crash Environment: The trafficway that the Ford was traveling on was a 7-lane, divided, city street, traversing in a northwest-southeast direction and approached a 4-leg intersection. The trafficway was divided by a grass median that was bordered by 15 cm (6 in) curbs. On the southeast leg of the intersection, the Ford's roadway had 3 through lanes and a left turn lane. Each lane was approximately 3.4 m (11.2 ft) in width and the roadway was bordered by a 15 cm (6 in) curb and sidewalk. The roadway pavement markings consisted of broken white lane lines and solid white left turn lane line. The roadway had a negative 5% grade and was uncontrolled at the intersection. The speed limit was 64 km/h (40 mph). The trafficway that the Mazda was traveling on was a 2-lane, undivided, city street, traversing in a northeasterly and southwesterly direction. On the northeast leg of the intersection, the roadway had one through lane in each direction and was controlled by a stop sign. There were no pavement markings and the roadway was level. The speed limit was 48 km/h (30 mph). At the time of the crash the light condition was dark with overhead artificial lighting and the weather was clear. The traffic density was light and the roadway surface was dry concrete. The Crash Diagram is on page 11 of this report.

Pre-Crash: The Ford was occupied by a restrained 26-year-old female driver, a 3-year-old male second row center passenger, and a 1-year-old male second row right passenger. Both second row passengers were restrained in child safety seats. The Ford's driver was traveling northwest in the outside through lane (**Figure 2**) at a driver estimated speed of 81 km/h (50 mph). The driver intended to continue straight through the intersection. The Mazda's restrained 22-year-old male driver was traveling southwest (**Figure 3**) and intended to continue straight through the intersection. The Ford's driver stated during the SCI interview that she did not see the approaching Mazda and took no actions to avoid the crash, which occurred within the intersection.

Crash: The front plane of the Mazda (**Figure 4**) impacted the right side plane of the Ford (**Figure 5**, event 1). The direction of force on the Ford was within the 1 o'clock sector and the impact force was sufficient to trigger the deployment of the side impact IC air bags. The impact caused both vehicles to rotate clockwise and the Ford rolled over left side leading (event 2). The Ford returned to its wheels on the roadway after rolling over 8 quarter turns and traveled backward in a northerly direction. It departed the northeast side of the road where it came to final rest heading south (**Figure 6**). The Mazda came to final rest in the mouth of the intersection on the inside northwestbound lane heading west.

Figure 2: Approach of the Ford; arrow shows approach of the Mazda

Figure 3: Approach of the Mazda; arrow shows approach of the Ford

Figure 4: Front plane damage on the Mazda from impact with the right side plane of the Ford

Figure 5: Damage on the right side plane of the Ford from impact by the front plane of the Mazda

Post-Crash: The police were notified of the crash at 2141 hours and arrived at the crash scene at 2200 hours. The Ford's driver exited the vehicle through the left front door and removed the second row passengers from the vehicle. The driver and both passengers were treated at the crash scene by emergency medical responders. The Mazda's driver and front right passenger were also treated at the crash scene. Both vehicles were towed due to damage.

The Ford was not equipped with Electronic Stability Control (ESC) or rollover sensing. No rollover rating information was available for the Ford since the 2003 model had not been tested by the NHTSA[1].

The initial right side plane impact on the Ford induced a clockwise rotation. As the vehicle rotated, the friction force between the left side tires and the concrete pavement caused the vehicle to roll over left side leading. The damage on the vehicle indicated that it rolled over 8 quarter turns. There was insufficient evidence on the roadway to determine the location of rollover initiation or the distance traveled during the rollover.

Figure 6: Look back from Ford's area of final rest to area of rollover on the roadway

CASE VEHICLE

The 2003 Ford Expedition Eddie Bauer was a rear wheel drive, 4-door sport utility vehicle (VIN: 1FMFU17L63L------) equipped with a 5.4-liter, V8 engine, automatic transmission, and 4-wheel anti-lock brakes. The front row was equipped with bucket seats, integral head restraints, lap-and-shoulder safety belts, redesigned driver and front right passenger frontal air bags, and side impact IC air bags. The second row was equipped with a split bench seat with folding backs, adjustable head restraints in the outboard seating positions, integral head restraint in the center seating position, lap-and-shoulder safety belts, and Lower Anchors and Tethers for Children (LATCH). The third row was equipped with a split bench seat with folding backs, adjustable head restraints in the outboard seating positions, and lap-and-shoulder safety belts. The vehicle's specified wheelbase was 299 cm (117.7 in).

CASE VEHICLE DAMAGE

Exterior Damage: The impact with the Mazda involved the right side plane of the Ford. The right quarter panel and right rear wheel were directly damaged. The direct damage began 247 cm (97.2 in) rear of the right front axle and extended 164 cm (64.6 in) rearward along the right side. The crush measurements were taken at the lower door level and the residual maximum crush was 3 cm (1.2 in) occurring at C_4. The vehicle's sill height was 50 cm (19.7). While the lower C-pillar sustained minor direct damage, there was no crush on the right rear door. The induced damage involved the right quarter panel and right rear door. The table below shows the right side crush profile.

1 www.safercar.gov, 8/28/09

Units	Event	Direct Damage		Field L	C_1	C_2	C_3	C_4	C_5	C_6	Direct	Field L
		Width CDC	Max Crush								±D	±D
cm	1	164	3	164	0	2	2	3	2	0	-178	-178
in		64.6	1.2	64.6	0.0	0.8	0.8	1.2	0.8	0.0	-70.1	-70.1

The rollover involved the Ford's top plane, both side planes, and the undercarriage. The direct damage on the top plane involved the hood and extended onto the roof to just rear of the B-pillars and also involved the rear lateral support of the luggage rack. The damage involved the full width of the roof, 114 cm (44.9 in). The direct damage on the right side plane began at the front of the fender and involved the A-pillar, right roof side rail, running board, right rear door and quarter panel. The damage on the left side plane began on the A-pillar and involved the front and rear doors, roof side rail, and the quarter panel. The maximum vertical crush was 4 cm (2 in) and occurred on the windshield header 5 cm (2 in) inboard of the right A-pillar (**Figure 7**). The maximum lateral crush was 3 cm (1.2 in) and involved the right A-pillar.

Figure 7: The location of the maximum vertical and lateral crush

Damage Classification: The Collision Deformation Classifications (CDC) were **01-RZEW-1** (**30** degrees) for the right side plane impact (event 1) and **00-TDDO-2** for the rollover (event 2). The Damage algorithm of the WinSMASH program calculated the Ford's total Delta V for the right side plane impact as 9 km/h (6 mph). The longitudinal and lateral velocity changes were -7.8 km/h (-4.8 mph) and -4.5 km/h (-2.8 mph), respectively. The results were low since the Ford's right rear wheel was directly engaged in the impact and the sheet metal on the vehicle's quarter panel sustained an average of only 1 cm (0.4 in) of crush. The severity of the rollover damage was minor based on the extent of the roof crush.

The vehicle manufacturer's recommended tire size was P265/70R17. The Ford was equipped with tires of the recommended size. The vehicle's tire data are shown in the table below.

Tire	*Measured Pressure*		*Vehicle Manufacturer's Recommended Cold Tire Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kPa	psi	kPa	psi	milli-meters	32nd of an inch			
LF	207	30	241	35	8	10	None	No	No
LR	145	21	241	35	7	9	None	No	No
RR	Flat	Flat	241	35	6	8	Sidewall cut	No	Yes
RF	207	30	241	35	8	10	None	No	No

Vehicle Interior: The inspection of the interior of the Ford revealed no discernable evidence of occupant contact. All of the vehicle's doors and the rear tailgate remained closed and operational. The pre-crash status of all the window glazings was fixed or closed. The windshield was in place and cracked due to impact forces, while the left front, right front, third left, third right, backlight, and roof glazings were disintegrated due to impact forces. The windshield had collapsed into the passenger compartment due to weathering.

The vehicle sustained four passenger compartment intrusions, which occurred in the front row right. The right A-pillar, windshield header, and roof all intruded vertically 3 cm (1.2 in), while the right roof side rail intruded vertically1 cm (0.4 in).

AUTOMATIC RESTRAINT SYSTEM

The Ford was equipped with redesigned driver and front passenger frontal air bags and side impact IC air bags. Based on the Holmatro Rescuer's Guide to Vehicle Safety Systems, the vehicle's side impact sensors were located within the lower B- and C-pillars. The frontal air bags did not deploy in this crash. Both inflatable side curtain air bags deployed during the crash.

The side impact IC air bags were located along the roof side rails (**Figures 8** and **9**) inside the headliner and extended from the A-pillar to the C-pillar. The air bags were designed with inflation chambers adjacent to the outboard seating positions. There were no external vent ports. The deployed IC air bags were 140 cm (55.1 in) in width and 45 cm (17.7 in) in height. They were attached at the A-pillars by a 36 cm (14.1 in) nylon rope and at the C-pillars by an 8 cm (3.1 in) nylon rope. The gap between the front of each air bag and the A-pillar was 18 cm (7.1 in). Each air bag extended vertically to 3 cm (1.2 in) above the beltline. Inspection of the deployed IC air bags

Figure 8: The left side impact IC air bag

revealed no damage and no discernable evidence of occupant contact.

Figure 9: The right side impact IC air bag

MANUAL RESTRAINT SYSTEM

The Ford was equipped with lap-and-shoulder safety belts for all the vehicle's seating positions. The driver's safety belt consisted of continuous loop belt webbing, an Emergency Locking Retractor (ELR), a sliding latch plate, and an adjustable upper anchor that was in the full-down position. The front passenger safety belt consisted of continuous loop belt webbing, an ELR/Automatic Locking Retractor (ALR), a sliding latch plate, and an adjustable upper anchor that was located in the full-down position. Both front row safety belts were equipped with buckle-mounted pretensioners. The second and third row safety belts were similarly equipped as the front passenger safety belt with the exception of an integral lap-and-shoulder belt in the center seat positions. The second row left upper anchor was located in the full-down position, while the second row right upper anchor was located in the full-up position. The third row was equipped with fixed upper anchors. The second and third row safety belts were not equipped with pretensioners.

The inspection of the driver's safety belt assembly revealed historical usage scratches on the latch plate. There were no load marks on the safety belt webbing, D-ring, or latch plate belt guide. The buckle-mounted pretensioner did not actuate during the crash. The driver stated during the SCI interview that she was restrained by the lap-and-shoulder safety belt.

Inspection of the second row center safety belt assembly revealed historical usage scratches on the latch plate. The belt webbing was stained with an unknown bright red substance but was otherwise unremarkable. The driver stated that the second row center passenger was seated in a Belt Positioning Booster Safety Seat (BSS). He was restrained by the lap portion of the safety belt and had the shoulder portion behind his back.

Inspection of the second row right safety belt assembly revealed historical usage scratches on the latch plate. The safety belt was otherwise unremarkable and exhibited no evidence of loading. The driver stated that the second row right passenger was restrained in a forward facing child safety seat (FSS), and the lap-and-shoulder safety belt was used to secure the FSS in the vehicle. The driver had disposed of both child seats on the advice of an emergency responder. The remaining seat positions were unoccupied.

CASE VEHICLE DRIVER KINEMATICS

Based on the SCI interview, the Ford's driver [26-year-old, female; 163 cm (64 in) and 86 kg (190 lbs)] was seated in an upright posture with her back against the seat back. The seat track was adjusted to between the middle and forward positions and the seat back was slightly reclined.

The tilt steering column was located in the center position. While the crash occurred at night, the driver stated that she was wearing sunglasses.

Occupant kinematics principles suggest that the right side plane impact on the Ford initially displaced the driver forward and right within the safety belt opposite the 1 o'clock direction of force. The driver was redirected to the left and toward the roof as the vehicle rotated clockwise and rolled over left side leading. The driver remained restrained in her seat throughout the rollover event. While the driver probably contacted the deployed left IC air bag during the rollover, no discernable evidence of such contact was observed during the vehicle inspection. The driver stated that she sustained a contusion on her forehead from contacting the center roof console door, which came open during the rollover. She also reported multiple small lacerations on the left side of her neck and both arms, which were due to flying glass fragments. Following the crash, the driver exited the vehicle through the left front door. She was unable to open the left rear door since it was locked and reentered the vehicle through the left front door. She climbed over the center console into the second row and removed both passengers from their child safety seats and then removed them from the vehicle.

CASE VEHICLE DRIVER INJURIES

The driver of the Ford sustained minor injuries and was treated at the crash scene by emergency medical responders. She missed no work days due to the crash and did not seek follow-up treatment. The table below presents the driver's injuries and injury sources.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source	Source Confidence	Source of Injury Data
1	Contusion (bruise) forehead at hairline	minor 290402.1,7	Sunroof components: edge of roof door	Probable	Interviewee (same person)
2	Lacerations (cuts), small, left side of neck, not further specified	minor 390602.1,2	Noncontact injury: flying glass, unknown source	Certain	Interviewee (same person)
3	Lacerations (cuts), small, arms, not further specified	minor 790602.1,3	Noncontact injury: flying glass, unknown source	Certain	Interviewee (same person)

CASE VEHICLE SECOND ROW CENTER PASSENGER KINEMATICS

The Ford's second row center passenger [3-year-old, male; 97 cm (38 in) and 20 kg (45 lbs)] was seated in the BSS. The passenger was asleep at the time of the crash.

The initial impact on the right side plane of the Ford displaced the second row center passenger forward and right within the BSS opposite the 1 o'clock direction of force. He was redirected to the left and toward the roof within the BSS as the vehicle rolled over left side

leading. There was no discernable evidence that the passenger contacted any surfaces in the second row area. He remained restrained in the BSS throughout the crash sequence and was removed from the vehicle by the driver.

CASE VEHICLE SECOND ROW CENTER PASSENGER INJURIES

The Ford's second row center passenger was examined at the crash scene by emergency medical responders and determined to be uninjured. The driver took the passenger to a pediatrician approximately one week after the crash for a routine examination and no crash related injuries were diagnosed.

CASE VEHICLE SECOND ROW RIGHT PASSENGER KINEMATICS

The Ford's second row right passenger [1-year-old, male; 81 cm (32 in) and 13 kg (28 lbs)] was seated in the FSS. The passenger was asleep at the time of the crash.

The initial impact on the right side plane of the Ford displaced the second row right passenger forward and right within the FSS opposite the 1 o'clock direction of force. The passenger was redirected to the left and toward the roof within the FSS as the vehicle rolled over left side leading. There was no discernable evidence that the passenger contacted the right rear door or right IC air bag. He remained restrained in the FSS thoughout the crash sequence and was removed from the vehicle by the driver.

CASE VEHICLE SECOND ROW RIGHT PASSENGER INJURIES

The Ford's second row right passenger was examined at the crash scene by emergency medical responders and determined to be uninjured. The driver took the passenger to a pediatrician approximately one week after the crash for a routine examination and no crash related injuries were diagnosed.

OTHER VEHICLE

The 2003 Mazda 6 was a front wheel drive, 4-door, sedan (VIN: 1YVFP80D735-------) equipped with a 3.0L, V6 engine, manual transmission, and redesigned driver and front right passenger frontal air bags.

Exterior Damage: The impact with the Ford involved the front plane of the Mazda. The front bumper, grille, hood, and both headlamp/turn signal assemblies were directly damaged (**Figure 10**). The direct damage began at the front left bumper corner and extended across the full width of the front plane. The crush measurements were measured on the bumper bar and the residual maximum crush was 20 cm (7.9 in) occurring at C_6 (**Figure 11**). The table below shows the front crush profile.

Units	Event	Direct Damage		Field L	C_1	C_2	C_3	C_4	C_5	C_6	Direct	Field L
		Width CDC	Max Crush								±D	±D
cm	1	135	20	106	6	12	15	19	19	20	0	0
in		53.2	7.9	41.7	2.4	4.7	5.9	7.5	7.5	7.9	0.0	0.0

Figure 10: Damage on the front plane of the Mazda from the impact with the Ford

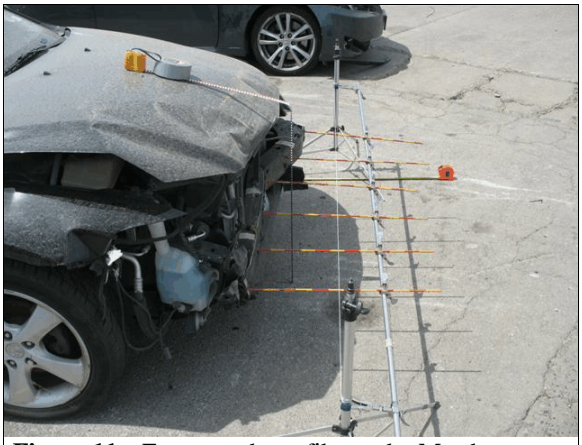


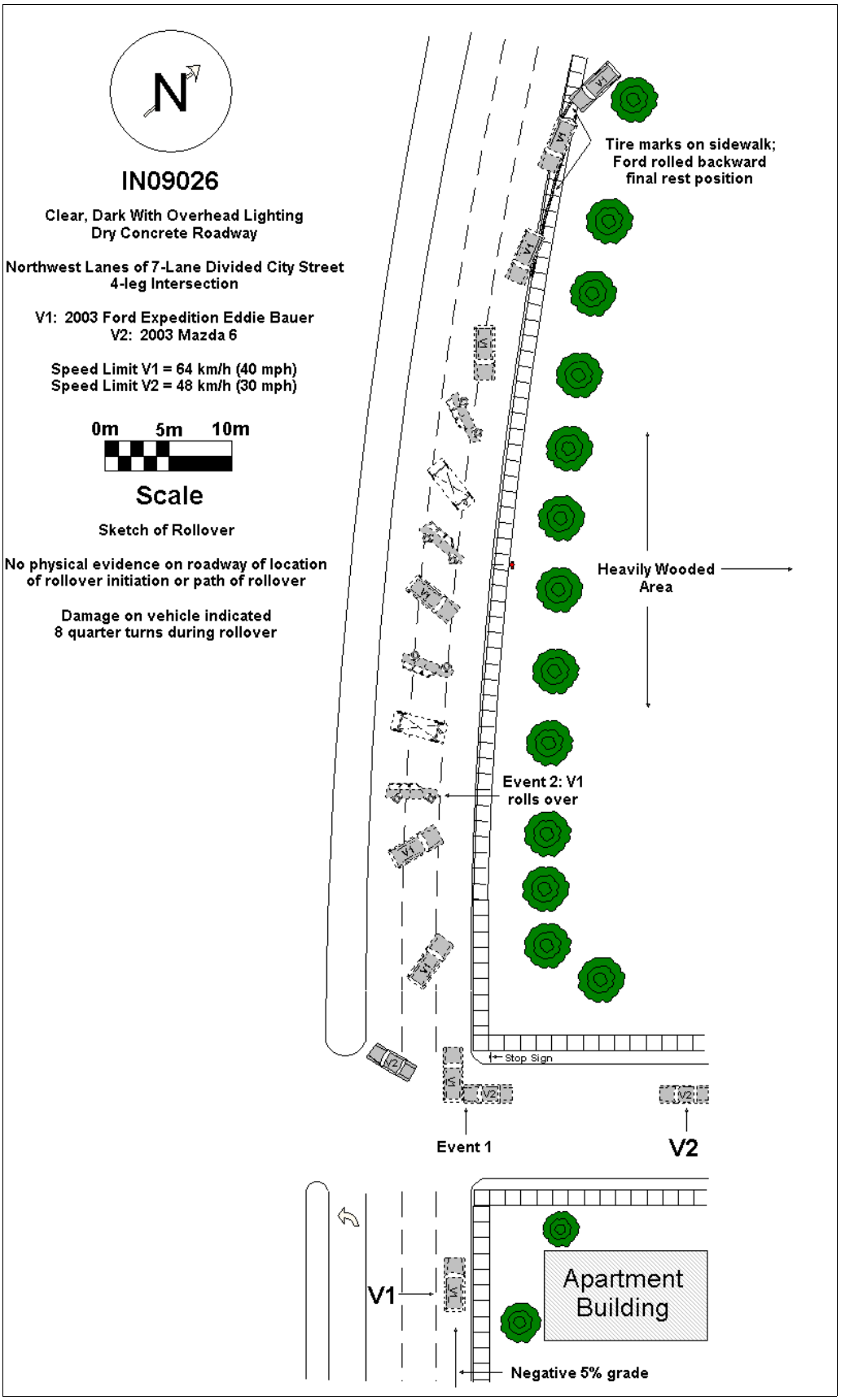
Figure 11: Front crush profile on the Mazda

Damage Classification: The CDC for the front impact with the Ford was **10-FDEW-1** (**300** degrees). The Damage Algorithm of the WinSMASH program calculated the Mazda's total Delta-V for the front impact as 14 km/h (8.7 mph). The longitudinal and lateral velocity changes were –7 km/h (-4.3 mph) and 12.1 km/h (7.5 mph), respectively. The results appeared low for the reasons indicated under the Ford's vehicle exterior section on page 3 above.

The vehicle manufacturer's recommended tire size was P205/60R16. The Mazda was equipped with P215/50R17 size tires. The vehicle's tire data are shown in the table below.

Tire	*Measured Pressure*		*Vehicle Manufacturer's Recommended Cold Tire Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kPa	psi	kPa	psi	milli-meters	32nd of an inch			
LF	138	20	221	32	7	9	None	No	No
LR	179	26	221	32	7	9	None	No	No
RR	Flat	Flat	221	32	6	8	None	No	Yes
RF	193	28	221	32	7	9	None	No	No

Other Vehicle's Driver: The police crash report indicated that the Mazda's driver (22-year-old, male) and front right passenger (21-year-old, male) were both restrained by the lap-and-shoulder belts and both frontal air bags deployed. The driver and passenger both sustained a police reported C-injury and were treated at the crash scene by emergency medical responders and released.


N
IN09026
Clear, Dark With Overhead Lighting
Dry Concrete Roadway
Northwest Lanes of 7-Lane Divided City Street
4-leg Intersection
V1: 2003 Ford Expedition Eddie Bauer
V2: 2003 Mazda 6
Speed Limit V1 = 64 km/h (40 mph)
Speed Limit V2 = 48 km/h (30 mph)
0m 5m 10m
Scale
Sketch of Rollover
No physical evidence on roadway of location of rollover initiation or path of rollover
Damage on vehicle indicated
8 quarter turns during rollover
Tire marks on sidewalk; Ford rolled backward final rest position
Heavily Wooded Area
Event 2: V1 rolls over
Stop Sign
Event 1
V2
V1
Apartment Building
Negative 5% grade