INDIANA UNIVERSITY

TRANSPORTATION RESEARCH CENTER
School of Public and Environmental Affairs
501 S. Madison Street, Suite 105
Bloomington, Indiana 47403-2452
(812) 855-3908 Fax: (812) 855-3537

ON-SITE SIDE IMPACT INFLATABLE OCCUPANT PROTECTION INVESTIGATION

CASE NUMBER - IN09025
LOCATION - NEBRASKA
VEHICLE - 2004 MAZDA TRIBUTE ES
CRASH DATE - June 2009

Submitted:

January 7, 2010

Contract Number: DTNH22-07-C-00044

Prepared for:

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

DISCLAIMERS

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no responsibility for the contents or use thereof.

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the National Highway Traffic Safety Administration.

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

1. *Report No.* IN09025	2. *Government Accession No.*	3. *Recipient's Catalog No.*	
4. *Title and Subtitle* On-Site Side Impact Inflatable Occupant Protection Investigation Vehicle - 2004 Mazda Tribute ES Location - Nebraska		5. *Report Date:* January 7, 2010 6. *Performing Organization Code*	
7. *Author(s)* Special Crash Investigations Team #2		8. *Performing Organization Report No.*	
9. *Performing Organization Name and Address* Transportation Research Center Indiana University 501 South Madison, Suite 105 Bloomington, Indiana 47403-2452		10. *Work Unit No. (TRAIS)* 11. *Contract or Grant No.* DTNH22-07-C-00044	
12. *Sponsoring Agency Name and Address* U.S. Department of Transportation (NVS-411) National Highway Traffic Safety Administration National Center for Statistics and Analysis Washington, D.C. 20590-0003		13. *Type of Report and Period Covered* Technical Report Crash Date: June 2009 14. *Sponsoring Agency Code*	
15. *Supplementary Notes* On-site Side Impact Inflatable Occupant Protection Investigation involving a 2004 Mazda Tribute ES and a 2006 Ford Escape XLT.			

16. *Abstract*

This on-site investigation focused on the seat-mounted side impact air bags, the crash dynamics, and the sources of the driver's injuries of a 2004 Mazda Tribute ES. The Mazda's restrained 28-year-old male driver was traveling south approaching a signalized, 4-leg, urban intersection. The Ford was traveling west and its front plane impacted the left fender of the Mazda (event 1) as both vehicles traveled into the intersection. The direction of force on the Mazda was within the 11 o'clock sector, and the impact force was sufficient to trigger a deployment of the driver's seat-mounted side impact air bag. The impact caused the Mazda to rotate clockwise and the Ford to rotate counterclockwise. The right quarter panel of the Ford impacted the left quarter panel of the Mazda (event 2). The Mazda departed the roadway on the southwest quadrant of the intersection and its front plane impacted a convenience store (event 3). The Mazda rolled backwards in a northerly direction across the street and its back plane impacted an iron fence (event 4) in the front yard of a residence and the vehicle came to final rest. The driver of the Mazda sustained minor injuries and was transported by ambulance to a hospital where he was treated in the emergency room and released. Both vehicles were towed from the crash scene due to damage.

17. *Key Words* Side Impact Air Bag Air Bag Deployment Motor Vehicle Traffic Crash Injury Severity		18. *Distribution Statement* General Public	
19 *Security Classif. (of this report)* Unclassified	20. *Security Classif. (of this page)* Unclassified	21. *No. of Pages* 10	22. *Price*

Form DOT 1700.7 (8-72) Reproduction of completed page authorized

TABLE OF CONTENTS IN09025

Page No.

BACKGROUND 1

CRASH CIRCUMSTANCES 1

CASE VEHICLE: 2004 MAZDA TRIBUTE ES 3
- CASE VEHICLE DAMAGE 4
- AUTOMATIC RESTRAINT SYSTEM 6
- MANUAL RESTRAINT SYSTEM 7
- CASE VEHICLE DRIVER KINEMATICS 7
- CASE VEHICLE DRIVER INJURIES 8

OTHER VEHICLE: 2006 FORD ESCAPE XLT 8

CRASH DIAGRAM 10

This on-site investigation focused on the seat-mounted side impact air bags, the crash dynamics, and the sources of the driver's injuries of a 2004 Mazda Tribute ES (**Figure 1**). This crash was brought to our attention by the National Highway Traffic Safety Administration (NHTSA) on July 24, 2009 through the sampling activities of the National Automotive Sampling System-General Estimates System (NASS-GES). This investigation was assigned on August 6, 2009. The crash involved the Mazda and a 2006 Ford Escape XLT. The crash occurred in June 2009, at 0001 hours, in Nebraska and was investigated by the city police department. The Mazda and the crash scene were inspected on August 6-7, 2009. The interview with the driver of the Mazda was conducted on August 18, 2009. The Ford was not inspected since it could not be located. This report is based on the police crash report, scene and vehicle inspections, driver interview, medical records, occupant kinematic principles, and evaluation of the evidence.

Figure 1: The damaged 2004 Mazda Tribute ES

CRASH CIRCUMSTANCES

Crash Environment: The trafficway that the Mazda was traveling on was a 2-lane, undivided, city street, traversing in a north-south direction. On the northern leg of the intersection, the roadway had one through lane in each direction. Each travel lane was 3.2 m (10.5 ft) in width and parking was allowed on each side of the street. The roadway pavement markings consisted of solid double yellow center lines, a solid white stop bar, and a designated pedestrian crossing. The trafficway that the Ford was traveling on was a 3-lane, undivided, city street, traversing in an east-west direction. On the eastern leg of the intersection, the roadway had one through lane in the westbound direction and two through lanes in the eastbound direction. Each lane was 3.1 m (10.2 ft) in width and parking was allowed on each side of the street. The roadway pavement markings consisted of solid double yellow center lines, a solid white stop bar, and a designated pedestrian crossing. The intersection was controlled by 3-phase traffic signals. The speed limit was 56 km/h (35 mph) for both vehicles. At the time of the crash, the light condition was dark with artificial lighting, the atmospheric condition was clear, and the roadway pavement was dry bituminous. The Mazda's roadway had a positive 3.3% grade. The Ford's roadway had a negative 8.3% grade. The speed limit for both vehicles was 56 km/h (35 mph). There was no other traffic at the time of the crash, and the site of the crash was suburban commercial. The Crash Diagram is on page 10 of this report.

Pre-Crash: The Mazda's restrained 28-year-old male driver was traveling south (**Figure 2**) and intended to continue south through the intersection. The Ford's restrained 26-year-old male driver was traveling west (**Figure 3**) and intended to continue west through the intersection. The police report indicated that the Ford's driver was under the influence of alcohol and his blood alcohol

concentration was reported as 0.132 mg/dl. The driver of the Mazda took no actions to avoid the crash.

Crash: The front plane of the Ford impacted the Mazda's left fender (**Figure 4**, event 1). The direction of force on the Mazda was within the 11 o'clock sector, and the impact force was sufficient to trigger a deployment of the driver's seat-mounted side impact air bag. The impact caused the Mazda to rotate clockwise and the Ford rotated counterclockwise. The right quarter panel of the Ford impacted the left quarter panel of the Mazda (**Figure 5**, event 2). Both vehicles were redirected to the southwest (**Figure 6**) and entered a convenience store lot where the front of the Mazda (**Figure 7**) impacted the north wall of the convenience store (**Figure 6**, event 3). The Mazda's direction of force was within the 12 o'clock sector and the impact force was not sufficient to trigger deployment of the driver's frontal air bag. The Mazda rolled backward in a northerly direction across the street (**Figure 8**) and its back plane (**Figure 9**) impacted a metal fence (event 4) where the vehicle came to final rest heading southeast. The Ford came to final rest in the convenience store lot heading southwest.

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

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

Figure 4: Damage on the left fender of the Mazda from impact with the front of the Ford

Figure 5: Damage on the left quarter panel of the Mazda from impact with the right quarter panel of the Ford

Figure 6: Post-impact travel of the Mazda and Ford southwest toward the convenience store lot; arrow shows location of Mazda's front impact on the north wall of the convenience store

Figure 7: Damage to the Mazda's front plane from the impact with the was of the convenience store

Figure 8: View south at Mazda's travel path from the impact location on the convenience store to impact with a metal fence (arrow)

Figure 9: Arrow shows damage location on Mazda's back bumper from impact with the metal fence

Post-Crash: The police and emergency medical personnel responded to the scene. The Mazda's driver and the Ford's second row left passenger were transported by ambulance to a hospital. The Ford's driver and second row right passenger were not injured. The Ford's front right passenger sustained a C (possible) injury, but was not transported. Both vehicles were towed from the crash scene due to damage.

CASE VEHICLE

The 2004 Mazda Tribute ES was a 4-wheel drive, 4-door sport utility vehicle (VIN: 4F2CZ96124K------), equipped with a 3.0-liter, V6 engine, automatic transmission, and 4-wheel anti-lock brakes. The front row was equipped with bucket seats, adjustable head restraints, lap-and-shoulder safety belts, redesigned driver and front right passenger frontal air bags, and seat-mounted side impact air bags. The second row was equipped with a split bench seat with folding backs, lap-and-shoulder safety belts in the outboard seating positions, and a lap belt in the center seating position. The second row was also equipped with adjustable head restraints

and Lower Anchors and Tethers for Children (LATCH) in the outboard seating positions. The vehicle's mileage was 91,853 miles (147,819 miles) and the specified wheelbase was 262 cm (103.1 in).

CASE VEHICLE DAMAGE

Exterior Damage: The initial impact with the Ford involved the left side plane of the Mazda. The left fender, corner of the front bumper, and the left front wheel were directly damaged. The direct damage began 32 cm (12.6 in) rear of the left front axle and extended 112 cm (44.1 in) along the fender. The crush measurements were taken at the upper fender level and the residual maximum crush was 34 cm (13.4 in) occurring at C_4 (**Figure 10**). The induced damage involved the left front door and the left side wheelbase was reduced 3 cm (1.2 in). The table below shows the vehicle's left side crush profile.

Figure 10: Top view of the crush on the left fender of the Mazda

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	112	34	124	0	8	20	34	28	26	154	149
in		44.1	13.4	48.8	0.0	3.2	7.9	13.4	11.0	10.2	60.6	58.7

The second impact with the Ford also involved the left side plane of the Mazda. The left quarter panel and the side portion of the back bumper fascia were directly damaged. The direct damage began 34 cm (13.4 in) forward of the left rear axle and extended 116 cm (45.7 in) rearward along the quarter panel. The crush measurements were taken at the middle quarter panel level and the residual maximum crush was 12 cm (4.7 in) occurring 6 cm (2.4 in) forward of C_3 (**Figure 11**). The induced damage involved the left rear door. The table below shows the crush profile on the left quarter panel.

Figure 11: Top view of the crush on the left quarter panel of the Mazda

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	2	116	12	116	0	9	12	11	5	0	-146	-146
in		45.7	4.7	45.7	0.0	3.5	4.7	4.3	2.0	0.0	-57.5	-57.5

The Mazda's impact with the convenience store involved the front plane and the front bumper was directly damaged. The direct damage began 22 cm (8.7 in) left of the front right bumper corner and extended 100 cm (39.4 in) across the bumper. The front bumper sustained no residual crush due to this impact. The induced damage involved the bumper fascia.

The Mazda's impact with the fence involved the back plane and the back bumper was directly damaged. The direct damage began 51 cm (20.1 in) left of the back right bumper corner and extended 31 cm (12.2 in) across the bumper. The back bumper sustained no residual crush due to this impact. The induced damage involved the bumper fascia.

Damage Classification: The Collision Deformation Classifications (CDC) were **11-LFEW-3** (**330** degrees) for the left fender impact with the front plane of the Ford (event 1) and **09-LZEW-2** (**270** degrees) for the left quarter panel impact with the right quarter panel of the Ford (event 2). The CDC for the front plane impact with the convenience store (event 3) was **12-FDLW-1** (**0** degrees), and **06-BZLN-1** (**180** degrees) for the back plane impact with the metal fence (event 4).

The Missing Vehicle algorithm of the WinSMASH program calculated the Mazda's total Delta V for the left fender impact with the front plane of the Ford (event 1) as 17 km/h (11 mph). The longitudinal and lateral velocity changes were -15 km/h (-9 mph) and 8 km/h (5 mph), respectively. The Missing Vehicle algorithm calculated the total Delta V for the left quarter panel impact with the Ford (event 2) as 7 km/h (4 mph). The longitudinal and lateral velocity changes were 0 km/h and 7 km/h (4 mph), respectively. The results appeared to be reasonable. The WinSMASH program was not used for the front and back plane impacts (events 3 and 4) since the vehicle sustained no residual crush for either impact and both impacted objects yielded.

The vehicle manufacturer's recommended tire size was P235/70R16. The Mazda 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	207	30	6	8	None	No	No
LR	221	32	207	30	8	10	None	No	No

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			
RR	207	30	207	30	8	10	None	No	No
RF	207	30	207	30	6	8	None	No	No

Vehicle Interior: The inspection of the Mazda's interior (**Figure 12**) revealed a possible skin transfer near the top of the driver's seat-mounted side impact air bag. The source of the transfer was possibly the left side of the driver's face. There was no other discernable occupant contact evidence and no steering rim deformation or compression of the energy absorbing steering column.

Figure 12: The front row of the Mazda

All the vehicle's doors remained closed and operational. The pre-crash status of all the window glazings was either closed or fixed. The left front window glazing was disintegrated due to impact forces and the windshield was in place and cracked from impact forces. The remaining window glazings were undamaged. The vehicle sustained no passenger compartment intrusions.

AUTOMATIC RESTRAINT SYSTEM

The Mazda was equipped with driver and front right passenger redesigned frontal air bags and front seat-mounted side impact air bags. The vehicle's side impact sensors were located within the lower B-pillars. The driver's seat-mounted side impact air bag deployed in this crash. No other air bags deployed.

The driver's seat-mounted side impact air bag was located in the outboard side of the driver's seat back and deployed through a tear seam (**Figure 13**). The deployed air bag (**Figure 14**) was 23 cm (9.1 in) in width and 65 cm (25.6 in) in height. There was one vent port located at

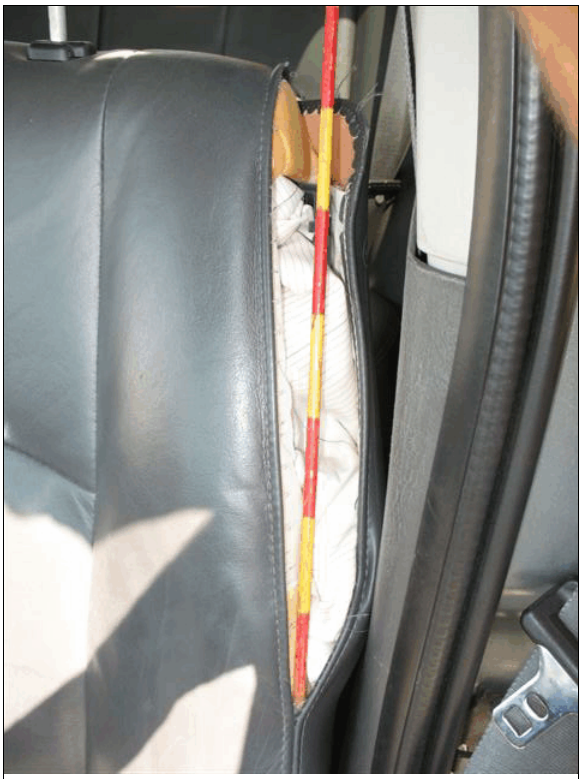


Figure 13: The location of the left front seat-mounted side impact air bag and post-deployment condition of the seat

the bottom of the air bag. Inspection of the air bag revealed a possible skin transfer located 10 cm (4 in) from the top and 23 cm (9.1 in) from the front edge of the air bag. The transfer was possibly due to contact by the left side of the driver's face. There were no other discernable occupant contacts on the air bag and no damage.

Figure 14: The deployed left front seat back-mounted side impact air bag

MANUAL RESTRAINT SYSTEM

The Mazda was equipped with lap-and-shoulder safety belts for the front and second row outboard seating positions and a lap belt for the second row center seating position. The driver's safety belt consisted of continuous loop belt webbing, an Emergency Locking Retractor (ELR), sliding latch plate, and an adjustable upper anchor that was in the full-up position. The front right safety belt was similarly equipped, but had an ELR/Automatic Locking Retractor (ALR). The front row safety belts were equipped with buckle-mounted pretensioners, which did not actuate in this crash. The second row lap-and-shoulder belts were equipped the same as the front right, but had fixed upper anchors and no pretensioners. The second row center lap belt was equipped with a locking latch plate.

The inspection of the driver's safety belt assembly revealed historical usage scratches on the latch plate. The safety belt assembly was otherwise unremarkable. The driver stated during the SCI interview that he was restrained by the lap-and-shoulder safety belt at the time of the crash.

CASE VEHICLE DRIVER KINEMATICS

Based on the SCI interview, the driver of the Mazda [28-year-old, male; 173 cm (68 in) and 73 kg (162 lbs)] was seated in an upright posture with his back against the seat back and both hands on the steering wheel at the 10 and 2 o'clock positions. The driver's seat track was adjusted to between the middle and rear positions, which was measured as 14 cm (5.5 in) rear of the full-forward. The seat back was slightly reclined and the adjustable head restraint was located in the full-up position. The distance from the top of the seat back to the top of the head restraint was 31 cm (12.2 in). The tilt steering column was located between the center and full-up position. The driver was not wearing glasses.

The initial impact on the left fender of the Mazda displaced the driver forward and left opposite the 11 o'clock direction of force. The driver's head and upper torso loaded the deployed seat-mounted side impact air bag. The driver sustained a laceration on the left lateral supra-orbital area and several small lacerations above the left eyelid from flying glass from the disintegrated left

front window glazing. The driver remained restrained in his seat position throughout the crash sequence. He exited the vehicle through the left front door and laid on the ground until emergency responders arrived.

CASE VEHICLE DRIVER INJURIES

The driver of the Mazda was transported by ambulance to a hospital where he was treated in the emergency room and released. During the SCI interview, the driver reported that he sustained a dislocated left jaw. He also stated that he developed numbness in the right foot and had on-going lower back and neck pain. The driver's medical records indicated that the cervical region and mouth were examined. A CT scan of the cervical region was also performed. No injuries to jaw, neck, or lower back were diagnosed. The driver sought follow-up treatment from a chiropractor and a podiatrist. He missed two work days as a result of the crash. 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	Laceration to left lateral supra-orbital area of face (temple)	minor 290602.1,2	Noncontact injury: flying glass, left front glazing	Certain	Emergency room records
2	Lacerations above left eyelid, not further specified	minor 290602.1,7	Noncontact injury: flying glass, left front glazing	Certain	Emergency room records

OTHER VEHICLE

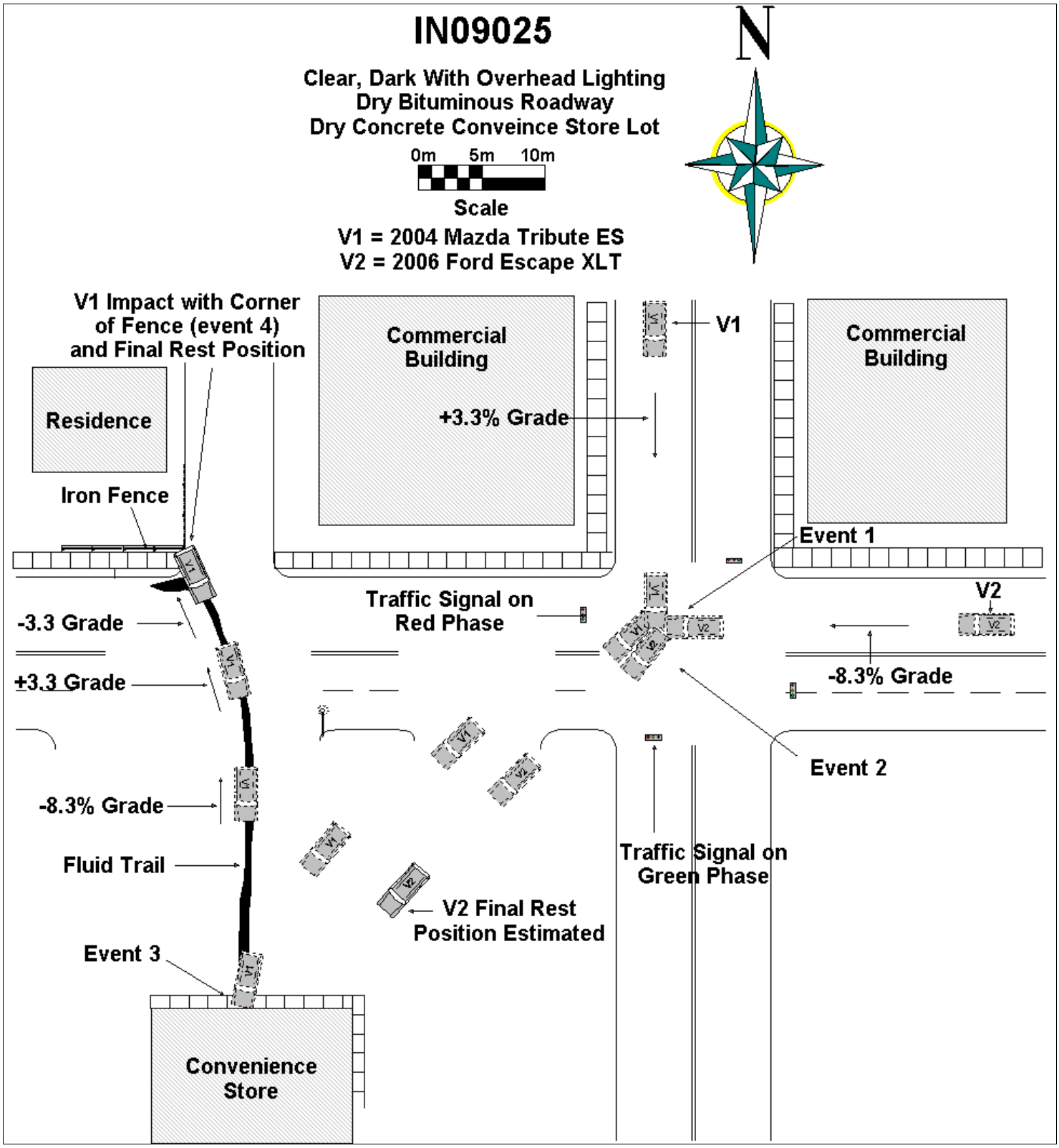
The 2006 Ford Escape XLT was a 4-wheel drive, 4-door sport utility vehicle (VIN: 1FMYU93106K-------) equipped with a 3.0L, V6 engine, 4-wheel anti-lock disc brakes, and dual stage driver and front right passenger frontal air bags. The Ford's frontal air bag system was certified by the manufacturer to be compliant to the Advanced Air Bag portion of Federal Motor Vehicle Safety Standard (FMVSS) No. 208.

Exterior Damage: The Ford was not inspected since it could not be located. There were no photographs of the vehicle available and a CDC could not be estimated.

The Missing Vehicle algorithm of the WinSMASH program calculated the Ford's total Delta V for the front plane impact with the Mazda's left fender (event 1) as 16 km/h (10 mph). The longitudinal and lateral velocity changes were –8 km/h (-5 mph) and -14 km/h (-9 mph), respectively. The WinSMASH program calculated the total Delta V for the right side plane impact with the Mazda's left quarter panel (event 2) as 6 km/h (4 mph). The longitudinal and lateral velocity changes were -1 km/h (-1 mph) and -6 km/h (4 mph), respectively. The results were based only on the Mazda's crush profile and should be considered as a borderline reconstruction of the Ford's Delta V.

Ford's Driver: The police crash report indicated that the driver of the Ford (26-year-old, male) and second row right passenger (unknown age and gender) were restrained by the lap-and-shoulder safety belts. Neither occupant was transported by ambulance to a hospital and they did not sustain any police-reported injuries.

The Ford's front passenger (22-year-old, female) and second row left passenger 23-year-old, female) were also restrained by their lap-and-shoulder safety belts. Both occupants sustained a C (possible) injury, but only the second row left passenger was transported for medical treatment.


IN09025
N
Clear, Dark With Overhead Lighting
Dry Bituminous Roadway
Dry Concrete Conveince Store Lot
0m 5m 10m
Scale
V1 = 2004 Mazda Tribute ES
V2 = 2006 Ford Escape XLT
V1 Impact with Corner of Fence (event 4) and Final Rest Position
Residence
Iron Fence
Commercial Building
+3.3% Grade
V1
Commercial Building
Event 1
V2
-3.3 Grade
+3.3 Grade
Traffic Signal on Red Phase
-8.3% Grade
Event 2
-8.3% Grade
Fluid Trail
Traffic Signal on Green Phase
V2 Final Rest Position Estimated
Event 3
Convenience Store