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ON-SITE ROLLOVER INVESTIGATION

CASE NUMBER - IN08021
LOCATION - TEXAS
VEHICLE - 2006 MAZDA TRIBUTE DX
CRASH DATE - February 2008

Submitted:

February 25, 2009

Contract Number: DTNH22-07-C-00044

Prepared for:

U.S. Department of Transportation
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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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15. *Supplementary Notes* On-site rollover investigation involving a 2006 Mazda Tribute DX.			
16. *Abstract* This report covers an on-site rollover investigation that involved a 2006 Mazda Tribute DX, which rolled over on the roadway. The focus of this on-site investigation was the rollover. The driver and her three passengers were traveling northeast in the outside through lane of a divided highway. The driver became distracted when the two children in the back seat called for her, and the vehicle departed the left side of the roadway. The driver steered to the right and the vehicle rotated clockwise and rolled over with the left side leading an unknown number of quarter turns. During the rollover, the front right passenger's right arm was ejected through the disintegrated right front window glazing and her right hand was rolled upon by the vehicle. At final rest, her hand was entrapped between the vehicle's roof and the pavement. Passers-by tilted the vehicle to the left to free her hand and removed her through the right front window. The driver and front right passenger were transported to a hospital and admitted for treatment of fractures of the left and right arms, respectively. The two children in the second row, one who was restrained in a forward facing child safety seat, sustained minor injuries and were treated and released.			
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This crash was brought to the National Highway Traffic Safety Administration's attention in late April, 2008 by the sampling activities of the National Automotive Sampling System. This on-site investigation was assigned on May 13, 2008. The crash involved a 2006 Mazda Tribute DX that rolled over on the roadway. The focus of this on-site investigation was the rollover. The crash occurred in February, 2008, at 1459 hours in Texas and was investigated by the applicable city police department. This contractor inspected the vehicle and the crash scene on May 15 and 16, 2008. The driver interview was completed on June 3, 2008. This report is based on the police crash report, scene and vehicle inspections, an exemplar vehicle inspection, occupant medical records, occupant kinematic principles, and this contractor's evaluation of the evidence.

Figure 1: The damaged 2006 Mazda Tribute DX

CRASH CIRCUMSTANCES

Crash Environment: The trafficway on which the Mazda was traveling was a 4-lane, divided, U.S. highway, traversing in a northeast-southwest direction. The Mazda was traveling northeast. The Mazda's roadway had two through lanes and bituminous shoulders, and each lane was nominally 3.7 m (12 ft) in width. The trafficway was divided by a an approximate 9 m (29.5 ft) wide grass median with a concrete median barrier and a guardrail. The roadway pavement markings consisted of a yellow median line, broken white lane line, and a solid white outside edge line. The posted speed limit was 97 km/h (60 mph). At the time of the crash, the light condition was daylight, the atmospheric condition was clear, and the roadway pavement was dry bituminous with a positive grade estimated to be greater than 2%. Due to traffic volume and local restrictions, it was not possible to obtain measurements of the crash scene physical plant. The traffic density was light and the site of the crash was suburban commercial. See the Crash Diagram on page 10 of this report.

Pre-Crash: The Mazda was occupied by a restrained 54-year-old female driver, a restrained 91-year-old female front right passenger, a restrained 3-year-old female second row left passenger, and a restrained 2-year-old female second row right passenger. The driver was traveling northeast in the outside through lane (**Figure 2**). The driver stated in the interview that she had missed an exit, and while looking for the next exit, became distracted when the two children in the back seat called for her. As she looked into

Figure 2: Approach of Mazda to area of rollover

the back seat, the vehicle crossed the inside travel lane and departed the left side of the roadway. The driver steered to the right, reentered the roadway and the vehicle began to rotate clockwise. The driver applied the brakes in an attempt to regain control of the vehicle and the crash occurred on the roadway as the vehicle rotated clockwise.

Figure 3: Damage to right side and top of the Mazda from the rollover; vertical scale in tenths of meter

Crash: The Mazda rolled over (**Figures 3** and **4**) with the left side leading (rollover initiation type: trip-over). During the rollover, the front right passenger's right arm was ejected through the disintegrated right front window and her right hand was rolled upon by the vehicle. There was insufficient evidence to determine the distance traversed during the rollover and the number of quarter turns. The Mazda came to final rest on its top on the inside lane heading south.

Figure 4: Damage to the top of the Mazda from the rollover, pavement scratches formed in three directions

Post-Crash: The police were notified of the crash at 1502 hours and responded to the crash scene along with other emergency responders. The front right passenger's right hand was entrapped between the vehicle's roof and the pavement. Passers-by tilted the vehicle to the left to free her hand and removed her through the right front window. All the occupants were transported by ambulance to a hospital and the vehicle was towed from the crash scene due to damage.

CASE VEHICLE

The 2006 Mazda Tribute DX was a front wheel drive, four-door, sport utility vehicle (VIN: 4F2YZ02Z76K------) that was manufactured in April 2006. It was equipped with a 2.3L, 4-cylinder engine, automatic transmission, and 4-wheel anti-lock brakes. The front row was equipped with dual stage driver and front right passenger air bags, bucket seats with adjustable head restraints, and lap-and-shoulder belts. The second row was equipped with a split bench seat with folding backs and adjustable head restraints, lap-and shoulder belts, and Lower Anchors and Tethers for Children (LATCH) in the outboard seating positions. Side impact curtain air bags and seat back-mounted side impact air bags were an option for this vehicle but it was not so equipped. The vehicle was not equipped with electronic stability control.

Exterior Damage: The rollover damage involved the Mazda's top plane and both side planes. The hood, roof, windshield, both fenders, the entire right side, left front door, left A-pillar and quarter panel were directly damaged (**Figures 3, 4,** and **5**). The width of the direct damage on the top plane was 124 cm (48.8 in). The maximum lateral and vertical crush occurred at the right roof side rail midway between the A-pillar and B-pillar (**Figure 6**). Based on the vehicle inspection and measurements from an exemplar vehicle, the maximum vertical crush was 23 cm (9.1 in) and the maximum lateral crush was 12 cm (4.7 in). The Mazda's wheelbase was unchanged. The induced damage involved the front bumper and roof.

Figure 5: Left side view of damage to the Mazda

Figure 6: Scale shows the maximum vertical and lateral crush of right roof side rail, each increment in 5 cm (2 in)

Damage Classification: The Mazda's Collision Deformation Classification was **00-TDDO-3**. The WinSMASH reconstruction program could not be used to determine the vehicle's Delta V because rollovers are out of scope for the program. The severity of the rollover damage was moderate based on the extent of crush to the top.

The manufacturer's recommended tire size was P235/70R16. The Mazda was equipped with the recommended 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	Flat	Flat	207	30	8	10	Sidewall abraded	No	Yes
LR	172	25	207	30	7	9	Sidewall abraded	No	No
RR	Flat	Flat	207	30	7	9	Sidewall punctured	No	Yes
RF	Flat	Flat	207	30	8	10	None	No	Yes

Vehicle Interior: Inspection of the Mazda's interior revealed blood smears and hair transfers on the roof and roof side rails in the front row (**Figure 7**). The blood smears were intermittent across the full width of the roof. They were probably related to the driver and front right passenger's movements following the crash. No other occupant contact evidence was found. The left front,

right front, and left rear doors remained closed and operational while the right rear door was jammed shut. All the window glazing was either closed or fixed. The windshield was in place and holed from impact forces while the left front, right front, left rear, and right rear window glazing were disintegrated due to impact forces.

Figure 7: View through left front window showing occupant contact evidence on roof and roof intrusion

The Mazda sustained numerous passenger compartment intrusions during the rollover. The most severe intrusions involved the right A-pillar, windshield header, roof, and roof side rail (**Figure 7**), all of which intruded vertically 24 centimeters (9.4 inches) into the front right sector. There was no evidence of steering rim deformation or compression of the energy absorbing steering column.

AUTOMATIC RESTRAINT SYSTEM

The Mazda was equipped with a Certified Advanced 208-Compliant (CAC) frontal air bag system that consisted of dual stage driver and front right passenger air bags, driver seat position sensor, seat belt usage sensors, buckle-mounted pretensioners and load limiters, and a front right passenger weight sensor. The manufacturer has certified that the vehicle is compliant to the Advanced Air Bag portion of the Federal Motor Vehicle Safety Standard (FMVSS) No. 208.

The Mazda's driver air bag was located in the steering wheel hub and the front right passenger air bag was located in the middle of the right instrument panel. Neither of these air bags deployed in this crash. The frontal air bag system is not designed to deploy in a rollover crash.

MANUAL RESTRAINT SYSTEM

The Mazda was equipped with lap-and-shoulder belts for both front row seating positions and the three second row seating positions. The driver's seat 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 down position. The front right seat belt consisted of continuous loop belt webbing, a switchable ELR/Automatic Locking Retractor (ALR), sliding latch plate, and an adjustable upper anchor that was located in the full down position. The second row seat belts were similar except they were equipped with fixed upper anchors.

The inspection of the driver's seat belt assembly revealed extensive historical usage scratches on the latch plate, but there was no evidence of loading and no evidence that the pretensioner actuated. The driver stated she was restrained in this crash.

The inspection of the front right passenger's seat belt assembly revealed historical usage scratches on the latch plate, but there was no evidence of loading and no evidence that the pretensioner actuated, consistent with non-deployment of the frontal air bags. Blood stains were present on the webbing in a location that would have been inside the retractor had the belt not been in use during the crash. The driver stated that the front right passenger was restrained in this crash.

The inspection of the second row left and right passenger seat belts revealed some usage scratches on the latch plates, but no evidence of loading. The driver stated that the second row left passenger was restrained in this crash and the second row right passenger was restrained in a Child Safety Seat (CSS).

CHILD SAFETY SEAT

The Mazda's back right passenger [2-year-old, female; 84 cm and 11 kg (33 in and 25 lbs)] was seated in a forward facing CSS (**Figures 8** and **9**). The CSS was designed for children who weigh between 9 to 18 kg (20 to 40 lbs) and whose height is 109 cm (43 in) or less. The CSS was manufactured by Graco Children's Products in August 20, 2007. The model was SafeSeat-Step 2 and the model number was 8B05GLR2. The CSS was designed with a LATCH system, 5-point harness and three sets of harness strap adjustment slots. The harness straps were threaded through the bottom set of slots and a harness retainer clip was attached to the harness straps. The driver stated during the interview that the harness retainer clip was positioned above the child's armpit level, and the vehicle's lap-and-shoulder belt was used to secure the CSS in the vehicle. The seat belt was routed through the CSS's forward facing belt paths, but the driver did not pull the seat belt out of the retractor to switch it to the automatic locking function.

Figure 8: Second row right passenger's CSS, a Graco SafeSeat-Step 2

Figure 9: Back of CSS

The CSS was constructed of a one piece plastic shell and was attached to a non-removable plastic base. The shell was fitted with a padded cushion and the seat back was fitted with a styrofoam pad. There was no crash related damage to the CSS. The left harness strap was partially cut and was twisted in the harness retainer clip (**Figure 10**). The harness strap was probably cut during rescue activities. The driver stated that the harness strap was not cut prior to the crash.

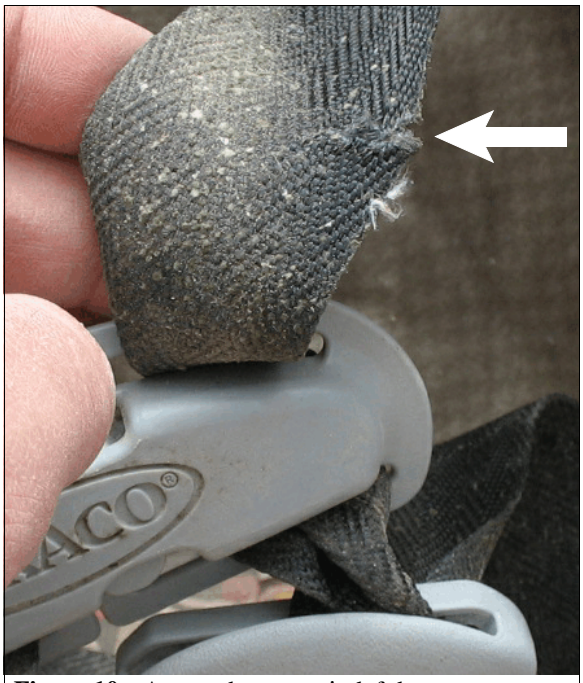

Figure 10: Arrow shows cut in left harness strap

CASE VEHICLE DRIVER KINEMATICS

The Mazda's driver [54-year-old, female; 163 cm and 77 kg (64 in and 170 lbs)] was seated upright with both hands on the steering wheel, and she turned to the right to look into the second seat row just prior to the crash sequence. The seat track was adjusted to between the middle and full forward position and the seat back was slightly reclined. The tilt steering column was located in the full down position. The driver was restrained by the lap-and–shoulder belt and was wearing glasses.

Based on occupant kinematic principles, as the vehicle rolled over with the left side leading, the driver was displaced to the left and toward the roof within the seat belt. During the rollover the driver sustained a fractured and displaced left olecranon. While there was no occupant contact evidence, occupant kinematics principles indicated that her left elbow probably loaded the left front door. She remained restrained throughout the rollover and exited the vehicle without assistance through the left front window.

CASE VEHICLE DRIVER INJURIES

The driver was hospitalized for two days and received physical therapy following her release from the hospital. The table below shows 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	Fracture, oblique, with displacement left olecranon	serious 753204.3,2	Left front door panel, rear upper quadrant	Probable	Hospitalization records
2	Contusion over left humerus, not further specified	minor 790402.1,2	Left front door panel, rear upper quadrant	Probable	Emergency room records

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source	Source Confidence	Source of Injury Data
3	Abrasion at proximal left elbow over olecranon and left wrist, not further specified	minor 790202.1,2	Left front door panel, rear upper quadrant	Probable	Emergency room records

CASE VEHICLE FRONT RIGHT PASSENGER KINEMATICS

The front right passenger [91-year-old, female; 157 cm and 64 kg (62 in and 140 lbs)] was seated in an upright posture with her back against the seat back, feet on the floor, and hands on her lap. The seat track was adjusted to the full rear position and the seat back was slightly reclined. She was restrained by the lap-and-shoulder belt and was wearing glasses.

As the vehicle rolled over, the front right passenger was displaced to the left and toward the roof within the seat belt. When the vehicle landed on the right portion of the roof and right roof side rail, she was redirected to the right and the right front window disintegrated. The passenger's right arm was ejected through the right front window opening during the rollover and loaded the pavement. Her right hand also became entrapped between the roof and the pavement as the vehicle came to final rest. As a result, the passenger sustained a comminuted fracture with displacement of the neck of the right humerus, a comminuted fracture of the distal radius, fractures of the right 2nd metacarpal, 2nd through 4th phalanges, and a lacerated tendon on the right hand. The passenger also sustained a fracture of the right 1st rib, which probably resulted from compression of the rib due to the loading of the right humerus on the ground.

CASE VEHICLE FRONT RIGHT PASSENGER INJURIES

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source	Source Confidence	Source of Injury Data
1	Fracture, closed, proximal right 1st rib	minor 450212.1,1	Ground {Indirect injury}	Certain	Hospitalization records
2	Fracture, comminuted, neck of right humerus with 9 mm (0.35 in) displacement	serious 752604.3,1	Ground	Certain	Hospitalization records
3	Fracture, comminuted, right distal radius with 2 mm (0.08 in) displacement	serious 752804.3,1	Ground	Certain	Hospitalization records
4	Fracture, comminuted, right 2nd metacarpal neck	moderate 752002.2,1	Ground	Certain	Hospitalization records

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source	Source Confidence	Source of Injury Data
5	Fractures, open, right 2nd through 4th phalanges (i.e., Tuft fractures[1]) with maceration of fingers and hand	minor 752404.1,1	Ground	Certain	Hospitalization records
6	Laceration tendon right hand, not further specified	minor 740200.1,1	Ground	Certain	Hospitalization records
7	Contusion orbital tissues, not further specified	minor 297402.1,9	Roof, right front side rail	Certain	Hospitalization records
8	Laceration center forehead	minor 290602.1,7	Roof, right front side rail	Probable	Hospitalization records
9	Contusion upper right chest, not further specified[2]	minor 490402.1,1	Ground {Indirect injury}	Probable	Interviewee (same person)
10	Abrasion right elbow just proximal to right medial epicondyle	minor 790202.1,1	Ground	Certain	Hospitalization records
11	Laceration, 0.5 cm (0.2 in) right elbow, not further specified	minor 790602.1,1	Ground	Certain	Hospitalization records

CASE VEHICLE SECOND ROW LEFT PASSENGER KINEMATICS

The second row left passenger [3-year-old-year-old, female; 102 cm and 20 kg (40 in and 45 lbs)] was seated in an upright posture with her back against the seat back, feet dangling off the front of the seat and her hands on her lap. The driver stated during the interview that this passenger was restrained by the lap-and-shoulder belt. The lap belt was snug and low across the passenger's hips, but the driver was unsure as to the position of the shoulder belt.

As the vehicle rolled over, the back left passenger was displaced to the left and toward the roof within the seat belt. There was no evidence of contact to the left rear door, but based on occupant kinematic principles the left side of her body probably contacted the door during the rollover. The passenger sustained an abrasion on the chin, but the source of this injury was unknown. She remained restrained in her seat during the crash and exited the vehicle with assistance from the driver and passers-by.

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[1] The following terms are defined in Dorland's Illustrated Medical Dictionary as follows:
fracture (frak′cher): 1. the breaking of a part, especially a bone. 2. a break or rupture in a bone.
bursting fracture: a comminuted fracture of the distal phalanx; called also tuft f.
tuft fracture: *bursting f.*
macerate (mas′er-at): to soften by wetting or soaking.

[2] This lesion was latent during this occupant's emergency room visit and subsequent hospitalization; this contractor believes that the lesion resulted from the underlying fracture.

The back left passenger was examined in the emergency room of a children's hospital and released. The table below shows the passenger's injury.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source	Source Confidence	Source of Injury Data
1	Abrasion, small, on chin	minor 290202.1,8	Unknown contact source	Unknown	Emergency room records

CASE VEHICLE SECOND ROW RIGHT PASSENGER KINEMATICS

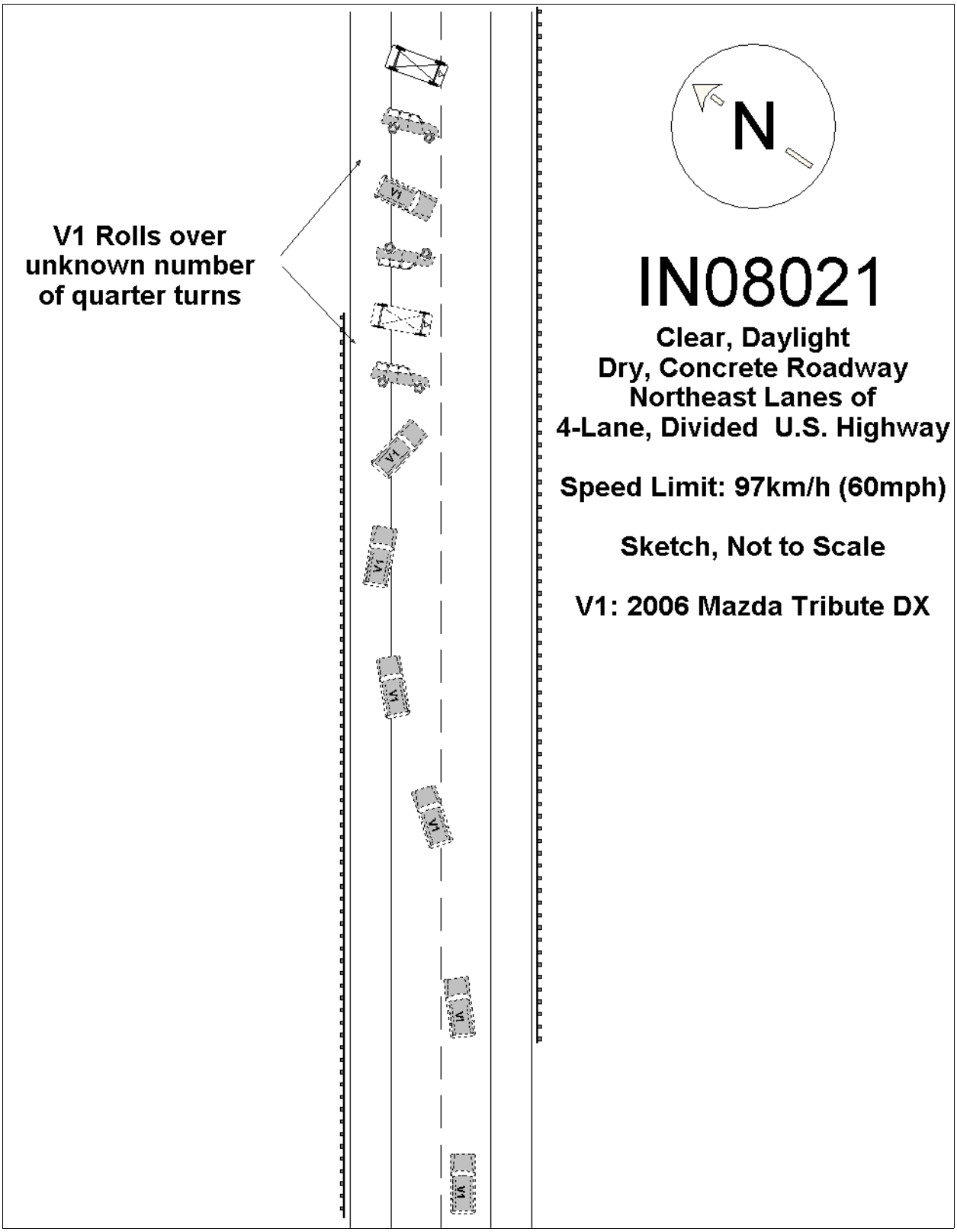
The back right passenger [2-year-old, female; 84 cm and 11 kg (33 in and 25 lbs)] was seated in and upright position in a forward facing CSS. Her legs were dangling off the edge of the seat and her arms were in an unknown position. She was restrained in the CSS by the 5-point harness.

The back right passenger remained restrained in the CSS throughout the rollover and the CSS remained secured to the vehicle. She sustained an abrasion on the chin, but the source of this injury was unknown. She exited the vehicle with assistance from the driver and passers-by.

CASE VEHICLE SECOND ROW RIGHT PASSENGER INJURIES

The back right passenger was examined in the emergency room of a children's hospital and released. The table below shows the passenger's injury.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source	Source Confidence	Source of Injury Data
1	Abrasion on chin	minor 290202.1,8	Unknown contact source	Unknown	Emergency room records


V1 Rolls over unknown number of quarter turns
N
IN08021
Clear, Daylight
Dry, Concrete Roadway
Northeast Lanes of
4-Lane, Divided U.S. Highway
Speed Limit: 97km/h (60mph)
Sketch, Not to Scale
V1: 2006 Mazda Tribute DX