CRASH DATA RESEARCH CENTER

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CALSPAN ON-SITE ROLLOVER CRASH INVESTIGATION

SCI CASE NUMBER: CA08033

VEHICLE: 2007 FORD EXPLORER EDDIE BAUER

LOCATION: MICHIGAN

CRASH DATE: JULY 2008

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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 are 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 system.

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BACKGROUND

This on-site investigation focused on the rollover crash of a 2007 Ford Explorer Eddie Bauer **(Figure 1)**. The Ford was equipped with a Certified Advanced 208-Compliant (CAC) frontal air bag system, seatback-mounted side impact air bags, dual-purpose side impact/rollover sensing IC air bags, and Electronic Stability Control (ESC). The manufacturer of this vehicle has certified that the Ford is compliant to the advanced air bag portion of Federal Motor Vehicle Safety Standard No. 208. The Ford was involved in an intersection crash with a 2004 GMC Yukon with subsequent two-quarter turn rollover event. As a result of the crash, the IC air bag system and the right seatback-mounted side impact air bag deployed. The 41-year-old restrained female driver of the Ford was not injured. Two 17-year-old male occupants of the GMC were not injured, and were able to drive the GMC from the scene.

Figure 1: Right front oblique view of the Ford Explorer.

The Police Accident Report (PAR) was identified through the National Automotive Sampling System (NASS) and forwarded to the National Highway Traffic Safety Administration (NHTSA) for review. The PAR was subsequently provided to the Calspan Special Crash Investigations (SCI) team for follow-up. The Ford was deemed a total loss by its insurance carrier and was transferred to a regional salvage facility. The SCI team established cooperation with the insurance company to inspect the vehicle. The insurance company would not authorize the removal of the Ford's Event Data Recorder (EDR) for imaging by the manufacturer. The case was subsequently assigned for on-site investigation on August 13, 2008. The GMC had been repaired and returned to its owner prior to case assignment. The on-site investigation included the inspection of the Ford and documentation of the crash site. The driver could not be contacted for an interview.

SUMMARY

Crash Site

This crash occurred during daylight hours in July 2008 at a four-leg intersection of two-lane roadways. At the time of the crash, the visibility was clear and the asphalt road surfaces were dry. The Ford was southbound on the straight, one-percent downward sloping (-1%), two-lane undivided roadway. It was traveling in the 3.2 m (10.5 ft) wide travel lane of the 6.5 m (21 ft) wide roadway, which was supported by a 1.2 m (4 ft) wide gravel shoulder that was separated from the roadway by a solid white fog line. The travel lanes were delineated by a centerline that permitted passing for northbound traffic. The intersection was controlled by stop signs for the north and southbound traffic. Posted speed limits in all directions were 89 km/h (55 mph). **Figure 2** depicts the southbound trajectory view of the Ford on approach to the intersection.

Figure 2: Southbound trajectory view of the Ford.

The GMC was eastbound in the 3.1 m (10 ft) wide travel lane of the 6.2 m (20 ft) wide, two-and-a-half percent downward sloping (-2.5%) bituminous two-lane undivided roadway. Lane delineation consisted of a centerline that permitted passing for eastbound traffic. There was a 2.1 m (7 ft) wide gravel shoulder supporting the eastbound travel lane, separated from the roadway by a solid white fog line. The Crash Schematic is included as **Figure 13** of this report.

Vehicle Data

2007 Ford Explorer Eddie Bauer

The 2007 Ford Explorer Eddie Bauer was manufactured in August 2006 and was identified by the Vehicle Identification Number (VIN): 1FMEU74E27U (production sequence deleted). **Figure 3** provides a left front oblique view of the Ford. The electric odometer reading at the time of the SCI inspection could not be obtained due to vehicle damage. The Ford was powered by a 4.0-liter, V-6 gasoline engine linked to a 5-speed automatic transmission with on-demand four-wheel drive. The service brakes consisted of four-wheel, power-assisted discs with anti-lock (ABS). The Ford was also equipped with power steering, power windows, and power locks. The vehicle had a 289 cm (113.7 in) wheelbase with a Gross Vehicle Weight Rating (GVWR) of kg 2,807 kg (6,190 lb).

Figure 3: Left front oblique view of the Ford.

The manufacturer had recommended the tire size of P235/65R18 with cold tire pressure of 221 kPa (32 psi) for all four positions. The tires were Michelin RF X Cross Terrain of the recommended size, with matching AP6J L7XX 2506 tire identification numbers. All four tires were mounted on OEM 6-spoke alloy wheels. Specific tire data at the time of SCI inspection was as follows:

Position	Measured Tire Pressure	Measured Tread Depth	Damage
LF	Flat	5 mm (6/32 in)	De-beaded, wheel damage (abrasions, scuffs)
LR	Flat	3 mm (4/32 in)	De-beaded, wheel damage (abrasions, scuffs)
RF	224 kPa (33 PSI)	5 mm (6/32 in)	None
RR	221 kPa (32 PSI)	2 mm (3/32 in)	None

The interior of the Ford was configured for the seating of seven occupants. The two front seating positions featured leather-surfaced bucket seats with adjustable track, seatback angle, and head restraints. The front left head restraint was adjusted 5 cm (2 in) above the seatback, while the front right was adjusted to the full-down position. The second row consisted of a fixed three-passenger bench seat with folding seatbacks, split 70/30 from right to left, while the third row consisted of a fixed two-passenger bench seat with folding seatbacks, split 50/50. All seating positions were equipped with 3-point lap and shoulder safety belts.

2004 GMC Yukon

The 2004 GMC Yukon was identified by the VIN: 1GKGK26U14R (production sequence deleted). This four door, full-size sport utility vehicle had on-demand four-wheel drive capabilities, and was powered by a 3.7-liter, V-8 gasoline engine. The GMC had a 330 cm (130 in) wheelbase and was 492 cm (194 in) in overall length, similar to the exemplar depicted in **Figure 4**. The GMC was repaired and returned to its owner prior to the assignment of this case.

Figure 4: Exemplar GMC Yukon.

Crash Sequence

Pre-Crash

The Ford was traveling southbound, driven by the 41-year-old restrained female. The driver was decelerating in the 89 km/h (55 mph) speed zone on her approach to the intersection. She stated to the investigating officer (IO) that she brought her vehicle to a controlled stop, looked in both directions, and did not see any traffic approaching the intersection. The driver accelerated into the intersection with the intention to continue her southbound travel.

The driver of the GMC was traveling eastbound approaching the same intersection. There were no traffic control devices for the GMC's direction of travel. The driver stated to the IO that he observed the Ford stop at the mouth of the intersection, then entered the intersection directly in front of his path of travel. There was no physical evidence at the crash site to support evasive actions by either driver.

Crash

The frontal plane of the GMC impacted the right side of the Ford. The resultant directions of force were 2 o'clock for the Ford and within the 11 o'clock sector for the GMC. The missing vehicle algorithm of the WinSMASH model was used to calculate the severity of the crash (delta-V) due to the repair of the GMC prior to this investigation. The total delta-V of the Ford was 22 km/h (13.7 mph). The longitudinal and lateral components were -11 km/h (-6.8 mph) and -19 km/h (-11.8 mph), respectively. The total calculated delta-V of the GMC was 16 km/h (10 mph), with a longitudinal component of -13.9 km/h (-8.6 mph) and lateral component of 8 km/h (5 mph). This algorithm serves as a borderline reconstruction for the impact event between the two vehicles. Although unconfirmed by Event Data Recorder (EDR) data, the side impact resulted in the deployment of the right seatback air bag and the IC air bags in the Ford. The PAR listed the frontal air bag system as deployed in the GMC.

The Ford initiated a left lateral translation due to the force of the impact on its right side. As the Ford transitioned from a tracking profile to a left side leading translation, an instability was created due to the lateral drag-force load on the left side tires with respect to the Ford's higher center of gravity. The left side tires de-beaded and the alloy wheels gouged the asphalt road surface. This tripped the Ford into a left side-leading rollover event within the intersection. The Ford contacted the asphalt road surface with its left side and top planes as it completed two-quarter turns. This sequence ended as the vehicle slid to rest at the southwest quadrant of the intersection on its top plane. The rollover was classified as a tripped rollover and was not an interrupted event.

Subsequently, the GMC initiated a slight clockwise (CW) rotation and came to rest at the southwest edge of the intersection.

Although equipped with ESC, the Ford was tracking as it accelerated from the stop sign to impact with the GMC, therefore the ESC did not engage. The impact induced lateral displacement of the Ford exceeded the capabilities of the ESC. The IC air bag system presumably deployed at the initial impact event. The dual-purpose IC system maintains inflation for an extended time frame (approximately 6 seconds); therefore the IC air bags should have provided protection during the rollover event.

Post-Crash

The emergency response system was notified of the crash and subsequently dispatched local police, fire department, and ambulance personnel, who responded to the scene. All three

occupants were uninjured and refused emergency medical assistance or transport. The Ford had sustained disabling damage from the collision and was towed from the scene to a local tow yard, where it was subsequently deemed a total loss by its insurance carrier. The GMC remained operable and was driven from the crash scene.

Vehicle Damage - 2007 Ford Explorer Eddie Bauer

Exterior

The exterior of the Ford sustained damage to its right, left, and top planes as a result of the side-impact and subsequent rollover sequence. The initial right side damage included the lateral crush and inward buckling of both passenger doors, extruded buckling of the rear aspect of the rear passenger door, lateral crush of the rear aspect of the right front fender aft of the axle, disintegration of the right front glazing, and displacement of the right rear glazing. This damage is depicted in **Figure 5**.

Figure 5: Side impact damage to the Ford.

The direct contact damage began 50 cm (19.6 in) aft of the right front axle and extended 156 cm (61 in) rearward. The combined direct and induced damage (Field L) began 15 cm (6 in) aft of the right front axle and extended 250 cm (98.5 in) rearward to the C-pillar. The residual crush measured along the right side at mid-door level was as follows: C1 = 0 cm [-14 cm (-8.5 in)], C2 = 8 cm (3 in), C3 = 17 cm (7 in), C4 = 22 cm (8.5 in), C5 = 13 cm (5 in), and C6 = 0 cm. Maximum crush was 24 cm (9.5 in), located at the edge of the right front door at the B-pillar. The right front door was opened post-crash and would not re-latch due to body distortion. The right rear door latch released during the crash. Due to the post-crash condition of the doors, the door-sill differential was 0 cm. The Collision Deformation Classification (CDC) associated with this damage pattern was 02RYEW3.

The rollover damage was located across the entire left and top planes of the Ford. The left front door and left front fender were crushed laterally, the left front glazing was disintegrated, and the windshield was shattered. Abrasions and scratches were located across the body surfaces on the left side, with isolated dents to the doors and left front fender. The non-horizontal impact forces sustained during the rollover sequence had crushed the windshield header downward, which displaced both A-pillars rearward at their intersection points with the roof side rail (**Figure 6**). This induced the downward buckling of the

Figure 6: Rollover damage to the Ford's roof.

roof at the forward aspect of the passenger greenhouse, however, the roof glazing located in this area was not damaged. There were abrasions and scratches located on the rails of the roof rack. The maximum roof crush was 13 cm (5 in) located at the right roof area between the roof glazing and the right A-pillar/side rail juncture. There was no lateral displacement of the roof structure. The CDC corresponding to the rollover damage was determined to be 00TDDO3.

Interior

The interior damage to the Ford consisted of deployment of the vehicle's air bag and pretensioner systems, integrity loss due to disintegrated glazing, and horizontal and vertical intrusions of the right side and top interior components. The following table provides a listing of the Ford's intrusions as documented by the SCI team during inspection:

SEAT POSITION	COMPONENT	INTRUSION	DIRECTION
Row 1, Left	Windshield header	9 cm (3.5 in)	Vertical
Row 1, Left	Leading edge of roof glazing	10 cm (4 in)	Vertical
Row 1, Right	Windshield header	10 cm (4 in)	Vertical
Row 1, Right	Leading edge of roof glazing	13 cm (5 in)	Vertical
Row 1, Right	Door panel	13 cm (5 in)	Lateral
Row 1, Right	Mid B-pillar	10 cm (4 in)	Lateral
Row 2, Left	Roof	5 cm (2 in)	Vertical
Row 2, Center	Roof	10 cm (3.75 in)	Vertical
Row 2, Right	Door panel	8 cm (3 in)	Lateral
Row 2, Right	Lower B-pillar	11 cm (4.5 in)	Lateral
Row 2, Right	Roof	5 cm (2 in)	Vertical

The roof crush and the IC air bag deployment partially separated the headliner from the roof. There were no occupant contacts within the interior or on the deployed air bags.

Manual Safety Restraint Systems

The front row of the Ford was equipped with manual 3-point, continuous loop lap and shoulder safety belt systems. The driver's safety belt system was equipped with a sliding latch plate, an Emergency Locking Retractor (ELR), and a buckle pretensioner. The front right belt system was equipped with a sliding latch plate, an ELR/Automatic Locking Retractor (ALR), and a buckle pretensioner. Both belts were adjustable at the sliding, B-pillar-mounted D-ring anchor point.

The remaining five seating positions within the second and third rows were equipped with 3-point, continuous loop lap and shoulder safety belt systems, all incorporating sliding latch plates and switchable ELR/ALR retractors. The D-rings for the four outboard seating positions of the second and third rows were fixed to their respective pillars. The shoulder belt and retractor of the second row center position was integrated into the seatback.

At the time of SCI inspection, the compression of the buckle stalks of both front seat safety belt systems evidenced the that both of the buckle pretensioners had actuated as a result of the crash. The SCI team measured the vertical distance between the top of the buckle and the top of the center console armrest to 5 cm (2 in) on the left and 8 cm (3 in) on the right. This discrepancy supported the utilization of the manual safety belt restraint system by the driver. Both front seat D-rings were adjusted to the full-up positions, and although there were indications of historical wear, no loading evidence was found on the latch plates or webbing of either front seat safety belt system.

Air Bag Systems

The Ford was equipped with the CAC frontal, seatback-mounted side impact, and side impact/rollover sensing IC air bag systems.

Frontal

The CAC frontal air bag system consisted of dual-stage air bags mounted in the steering wheel hub and the right mid-instrument panel. It also incorporated seat track positioning sensors with safety belt buckle switches and a front right occupant weight sensor. The frontal air bags did not deploy in this crash.

Figure 7: Right front seatback-mounted air bag.

Side Impact/Rollover Sensing

The side impact air bag system consisted of front seatback-mounted air bags and the roof rail-mounted IC air bags. The IC air bags were commanded to deploy through side impact crash sensing and rollover sensing. This crash resulted in the deployment of the right seatback-mounted air bag **(Figure 7)** and both IC air bags. This air bag was constructed of Automotive Safety Components International (ASCI) recognized PA 6.6 nylon material and had deployed through 43 cm (17 in) of the outboard seam stitching. The foam padding of the seatback was spilt over a vertical height of 24 cm (9.5 in). The interior cover flap of the side impact air bag module measured 20 cm (8 in) vertically and 6 cm (2.5 in) laterally.

The seatback-mounted air bag, in its deflated state, measured 24 cm (9.5 in) vertically by 22 cm (8.5 in) horizontally. It was vented by a 3 cm (1 in) vent port that was centered 5 cm (2 in) from its leading edge. The side impact air bag was not tethered. Maximum lateral excursion of the air bag measured 8 cm (3 in). There was no evidence of occupant contact on the air bag at the time of SCI inspection.

The side impact/rollover IC air bags were mounted to the roof side rails between the A- and C-pillars. A single curtain provided coverage for the first two rows over the full-height of the side glazing. The IC air bags measured 145 cm x 64 cm (57 in x 25 in) length x height in overall dimensions and were connected by a tether at the A- and C-pillars. A 30 cm (12 in) long by 43

cm (17 in) tall, triangular shaped, sail-panel filled the void at the A-pillar location. The sail panel was sewn to the forward aspect of the IC and did not inflate. The vertical coverage of this curtain extended 11 cm (4.5 in) below the beltline at the B-pillar.

The rear tether of the IC was mounted to a metal guide within a vertically oriented track that was attached to the C-pillar. This guide was designed to slide vertically downward as the bag deployed, maintaining rear coverage of the IC during system deployment. The SCI team noted a discrepancy in the deployment of this system when comparing the left and right. The right side IC deployed full height, while the left IC guide snagged within the track. This had result in partial coverage of the left rear door glazing, as seen in the comparison of **Figure 8** to **Figure 9**.

Figure 8: Right inflatable curtain air bag.

Figure 9: Left inflatable curtain air bag.

The rear tether of the left IC had snagged on a metal bracket that was affixed to the C-pillar, which had prevented the full deployment of the rear aspect of the IC. This is depicted in **Figures 10** and **11**, which depict the properly deployed right tether and the snagged left tether, respectively (*note the location of the tethers and their corresponding track locations*).

The metal bracket was stamped with the numeric 6690, and was part of the mounting bracket for the upper aspect of the tether track. The SCI team measured a protrusion of 1.4 cm (9/16 in) of the bracket past the centerline of the track, shown in **Figure 12**.

Figure 10: Right IC rear tether track.

Figure 11: Left IC rear tether track.

Figure 12: Rear tether of left IC snagged on metal bracket.

2004 GMC Yukon

Exterior Damage

The GMC sustained frontal damage as a result of the impact with the Ford. Given the repaired status of the GMC prior to the assignment of this case to the SCI team, and subsequent lack of inspection, the exact damage is unknown.

Occupant Data

Driver Demographics

Age / Sex:	41-year-old / Female
Height:	Unknown
Weight:	Unknown
Seat Track:	Mid-to-rear track position
Safety Belt Usage:	3-point lap and shoulder safety belt
Usage Source:	SCI vehicle inspection
Egress from Vehicle:	Exited vehicle without assistance
Type of Medical Treatment:	Not injured, refused medical treatment

Driver Kinematics

The 41-year-old female driver of the Ford was seated in a mid-to-rear track position with the seatback reclined to a measured angle of 20 degrees. She was restrained by the 3-point lap and shoulder safety belt system. Upon the initial impact with the GMC, the driver of the Ford initiated a right lateral trajectory in response to the associated direction of force as the right side impact and IC air bags deployed. The driver loaded the safety belt webbing as the inertia retractor engaged and the buckle pretensioner actuated.

As the Ford initiated the lateral, left side-leading, two-quarter turn rollover event, the driver remained within her seat position by the lap and shoulder safety belt. When the Ford's left side-plane contacted the asphalt surface, the driver responded to the non-horizontal impact forces by initiating a downward vertical trajectory toward the left side interior components and the deployed IC air bag. The Ford continued the rollover sequence one-quarter turn before sliding to rest on its roof within the southwest quadrant of the intersection.

The driver's reported method of egress from the vehicle was without assistance. She denied injury at the scene and refused emergency medical assistance and transport. There was no discernable contact evidence within the vehicle or to the deployed air bags of the Ford attributable to the driver's kinematics.

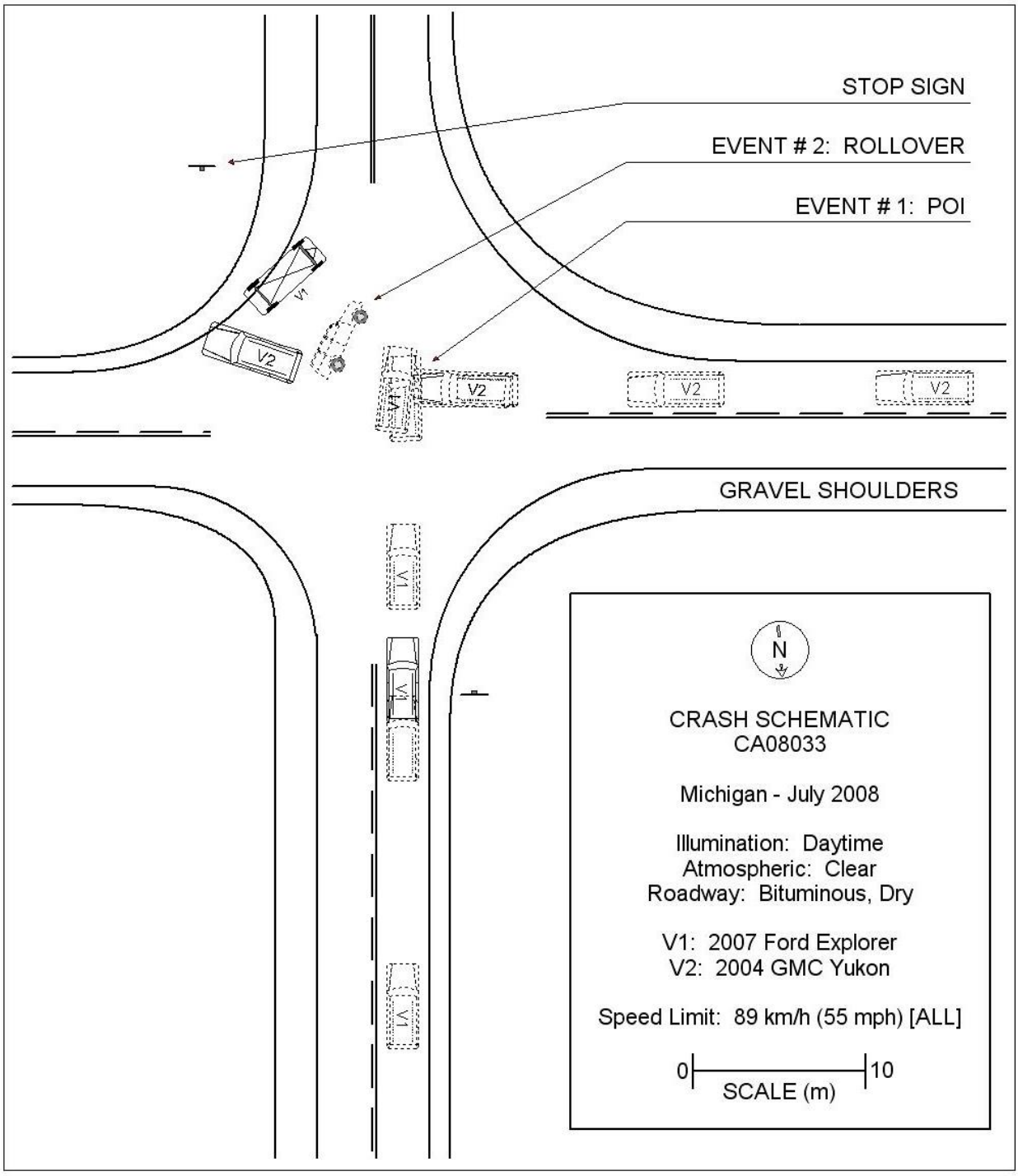

Figure 13: Crash Schematic