

CRASH DATA RESEARCH CENTER

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**CALSPAN ON-SITE ROLLOVER CRASH INVESTIGATION
SCI CASE NO.: CA09050**

VEHICLE: 2008 FORD ESCAPE XLT

LOCATION: NORTH CAROLINA

CRASH DATE: JULY 2009

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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 systems.

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CALSPAN ON-SITE ROLLOVER CRASH INVESTIGATION
SCI CASE NO.: CA09050
VEHICLE: 2008 FORD ESCAPE XLT
LOCATION: NORTH CAROLINA
CRASH DATE: JULY 2009

BACKGROUND

This on-site investigation focused on an off-road rollover crash of a 2008 Ford Escape XLT (**Figure 1**). The vehicle was equipped with four-wheel anti-lock brakes, Electronic Stability Control (ESC), a Certified Advanced 208-Compliant (CAC) frontal air bag system, side impact air bags and Inflatable Curtain (IC) air bags with rollover sensing. The CAC system included dual-stage frontal air bags for the driver and right front passenger positions, seat track



Figure 1: 2008 Ford Escape case vehicle.

positioning sensors, retractor pretensioners, safety belt buckle switches, and a front right occupant presence sensor. The Ford departed the roadway to the right and the front right area impacted a concrete culvert. The Ford then rotated clockwise on the road edge and initiated a rollover event to the left. Both IC's deployed. The 20-year-old female driver sustained moderate severity injuries. The driver was transported by ambulance to a regional trauma center where she was treated in the emergency department and released.

The crash was identified by NHTSA's Crash Investigation Division on July 27, 2009. Due to the rollover of the Ford and the deployment of the IC air bags, this case was assigned for an on-site investigation on the same day. The on-site investigation was initiated on July 29, 2009 and involved the inspection of the Ford, a detailed interview with the driver and documentation of the crash scene.

SUMMARY

Crash Site

This crash occurred during the evening hours of July 2009 on the north roadside of an east/west roadway. The conditions at the time of the crash were clear, dry and dark. The roadway consisted of two travel lanes that were 3.1 m (10.2 ft) in width and bordered by narrow asphalt shoulders that were 0.5 m (1.6 ft) in width. Located outboard of the asphalt shoulder on the north roadside was a 1 m (3.3 ft) grass shoulder. Parallel to the shoulder was a ditch that was 3.2 m (10.5 ft) in width and 0.8 m (2.6 ft) in depth at the

lowest point. This ditch was surfaced with grass. The posted speed limit for the area was 72 km/h (45 mph). Extending north and south from the roadway were multiple private driveways. The driveway at this crash scene was 4.4 m (14.4 ft) in width and surfaced with gravel. There was a 50 cm (20 in) diameter concrete culvert that extended under the private driveway. The driver of the Ford lived nearby and was familiar with the area of the crash. The Crash Schematic is included as **Figure 12** of this report.

Vehicle Data - 2008 Ford Escape

The case vehicle was a 2008 Ford Escape XLT. The Ford was manufactured in February 2007 and was identified by the Vehicle Identification Number (VIN): 1FMCU03198K (production sequence deleted). The vehicle was purchased used at the end of the summer in 2008 by the current owner. The vehicle’s odometer reading at the time of the crash was approximately 56,315 km (35,000 mi).

The front-wheel drive Ford was powered by a 3.0-liter V-6 engine linked to a 4-speed automatic transmission. The braking system consisted of a front disc/rear drum system with four-wheel antilock and electronic brakeforce distribution. The Ford was also equipped with Electronic Stability Control (ESC) and an indirect Tire Pressure Monitoring System (TPMS). The driver stated during the interview that the TPMS warning light was not illuminated prior to the crash and she had not disengaged the ESC. The left side windows were closed at the time of the crash. The front right window was partially open prior to the crash, and the right rear door window was fully opened prior to the crash. The Escape was equipped with four Continental Contitrac tires, size P235/70R16 that were the manufacturer recommended tire size. The tires were mounted on OEM five-spoke alloy wheels. The manufacturer recommended cold tire pressure was 221 kPa (32 PSI) for the front and rear. The specific tire data at the time of the SCI inspection was as follows:

Position	Measured Tire Pressure	Measured Tread Depth	Damage
Left Front	186 kPa (27 PSI)	6 mm (7/32 in)	None
Left Rear	193 kPa (28 PSI)	7 mm (9/32 in)	None
Right Front	Tire flat	7 mm (9/32 in)	Rim cracked, sidewall cut, tire de-beaded
Right Rear	172 kPa (25 PSI)	6 mm (7/32 in)	None

The interior of the Ford was configured with cloth-surfaced five-passenger seating. The front bucket seats were separated by a center console and equipped with adjustable head restraints. Both front head restraints were in the full-down position. The front left seat

track was in the full-rear position. At the time of the SCI inspection, the front right seat track was 3 cm (1.2 in) forward of the full-rear position. The location of the seat track at the time of the crash was unknown for the short-stature driver. The front left seatback angle was measured at 24 degrees aft of vertical, with the front right seatback measuring 22 degrees aft of vertical. The second row seat consisted of a 60/40 split bench with separate folding backs. The three second row seats had adjustable head restraints. The rear right was 4 cm (1.6 in) above the full-down position, the rear center head restraint was 2 cm (0.8 in) above the full-down position and the rear left head restraint was 5 cm (2 in) above the full-down position. The second row seat tracks were not adjustable.

The interior occupant safety systems consisted of 3-point lap and shoulder belt systems for the five designated seating positions, front seat safety belt retractor pretensioners, dual-stage frontal air bags, front seatback-mounted side impact air bags and IC air bags that provide protection for the four outboard seating positions. The Ford was equipped with rollover sensing for the IC air bags.

Crash Sequence

Pre-Crash

The restrained 20-year-old female driver of the Ford was en route to her residence and was traveling westbound on the two-lane roadway (**Figure 2**). She accelerated from an intersection that was located approximately 150 m (492 ft) east of the crash site to a driver-estimated speed of 64 km/h (40 mph). The police-estimated speed of the Ford was 89 km/h (55 mph). For an unknown reason, the driver relinquished directional control of the Ford and the right tires of the Ford departed the roadway. She initiated a slight steering input to the left; however, the Ford entered the ditch. The driver did not apply the brakes.



Figure 2: Westbound approach to the crash scene.

Crash

The front right area of the Ford impacted the concrete culvert on the north roadside. The impact with the culvert damaged the front bumper beam and extended rearward to the right front wheel. The right front wheel was separated from the axle and was displaced rearward. The right front wheel fractured and the tire was cut. The direction of force to the Ford was within the 12 o'clock sector. The Damage Algorithm of the WinSMASH

program was used to calculate a total delta-V of 21 km/h (13 mph) with a longitudinal delta-V of -21 km/h (-13 mph) and a lateral component of 0 km/h. **Figure 3** is a view of the initial impact location with the culvert.



Figure 3: Westward view of the area of initial impact with the culvert.

The offset right impact induced a clockwise yaw to the Ford as its center of gravity continued in a westerly direction as it traversed the driveway. The Ford traveled in the left side leading yaw for approximately 9 m (14.5 ft) evidenced by a left rear yaw mark that was 3.5 m (11.5 ft) in length. The yaw mark began near the north fog line of the roadway and extended off the roadway into the grass. The Ford rotated approximately 95 degrees clockwise before initiating a rollover event to the left. The left side tires tripped as the vehicle traveled on the grass down slope of the ditch. The Ford rolled two-quarter turns to the left over a distance of 7 m (23 ft). The rollover was not an interrupted event. **Figure 4** is a view of the trip point for the rollover of the Ford. The Ford came to rest on its roof facing in a northeasterly direction on the north roadside.



Figure 4: Westward view of the location of the rollover.

Post-Crash

The residents of the home at the crash site called the 9-1-1 emergency response system to report the crash. The residents approached the Escape and assisted with opening the left front door for the driver to exit the vehicle. Police, emergency medical and tow personnel responded to the crash site. The driver of the Ford was transported to a regional trauma center where she was treated in the emergency department for soft tissue injuries to her right leg, left shoulder and abdomen, and evaluated for a possible head injury due to a scalp contusion. Following treatment in the emergency department, the driver was released. The Escape was towed from the scene due to disabling damage to a local tow yard where it remained until it was transferred to a regional vehicle salvage facility for auction, where it was inspected for this investigation.

2008 Ford Escape

Exterior Damage

The Ford sustained moderate severity damage to the front, left and top planes as a result of this multiple event crash. The right front area of the Ford sustained damage from the initial impact (**Figure 5**). The direct contact damage began 47 cm (18.5 in) right of the centerline and extended 24 cm (9.4 in) to the front right bumper corner. The combined direct and induced damage (Field L) was 113 cm (44.5 in) and extended from bumper corner-to-bumper corner. The crush profile was documented along the full length of the bumper beam and was as follows: C1 = 0 cm, C2 = 1 cm (0.4 in), C3 = 2 cm (0.8 in), C4 = 5 cm (2 in), C5 = 8 cm (3.1 in), C6 = 13 cm (5.1 in).



Figure 5: Initial impact damage to the Ford.

As the vehicle continued forward, the right front tire and wheel engaged the culvert. The impact punctured the sidewall and fractured the alloy wheel. The impact also fractured the drive axle inboard of the steering upright. As a result of the tire/wheel contact, the tire and wheel were displaced rearward resulting in a reduction of the right wheelbase of 59 cm (23 in). The Collision Deformation Classification (CDC) assigned for the initial impact was 12FREE4.

As a result of the rollover event, the Ford sustained moderate severity damage to the left and top planes. The direct contact damage to the roof extended laterally 108 cm (42.5 in) from roof side rail-to-roof side rail. The longitudinal direct contact damage measured 374 cm (147.2 in) and extended from the front left corner of the hood rearward to the backlight header. The maximum vertical and lateral crush was located at the same position on the right roof side rail, 5 cm (2 in) rearward of the windshield header. The maximum vertical crush measured 10 cm (3.9 in). The maximum lateral crush was 6 cm (2.4 in). **Figures 6 and 7** depict the rollover damage sustained by the Ford. The CDC assigned for the rollover was 00TDDO3.

The windshield glazing was fractured but remained intact after the crash. After the Ford was transferred to the salvage facility, the windshield laminate separated due to heat related sag along the header and both A-pillars. The left front, left rear, right front, right rear, right rear quarter glazing and the backlight remained intact post-crash. The left rear quarter glazing was disintegrated by the impact. The right front window was partially

open and the right rear door window was fully open prior to the crash. The left side windows were closed prior to the crash. All four doors remained closed during the crash. The right front and left rear doors were jammed closed post-crash while the left front and right rear doors and the tailgate remained closed and operational post-crash.



Figure 6: Rollover damage from above, right front.



Figure 7: Rollover damage from left side.

Interior Damage

The Ford sustained moderate severity interior damage that was attributed to passenger compartment intrusion and occupant contact. There was a scuff mark on the left roof side rail located 26-40 cm (10.2-15.7 in) rearward of the A-pillar that was attributed to the driver’s head.

The intrusion to the Ford is listed on the following table.

Position	Component	Direction	Magnitude
Row 1 Center	Windshield header	Vertical	4 cm (1.6 in)
Row 1 Center	Roof	Vertical	4 cm (1.6 in)
Row 1 Right	Windshield header	Vertical	6 cm (2.4 in)
Row 1 Right	Roof	Vertical	7 cm (2.8 in)
Row 1 Right	Roof side rail	Vertical	7 cm (2.8 in)
Row 1 Right	Door sill	Lateral	13 cm (5.1 in)
Row 1 Right	A-pillar (lower)	Lateral	12 cm (4.7 in)
Row 1 Right	Side panel forward of the A-pillar	Lateral	17 cm (6.7 in)
Row 1 Right	Right front door (FLQ)	Lateral	12 cm (4.7 in)
Row 1 Right	Toe pan	Longitudinal	15 cm (5.9 in)
Row 2 Right	Roof	Vertical	4 cm (1.6 in)
Row 2 Right	Roof side rail	Vertical	5 cm (2.1 in)
Row 2 Center	Roof	Vertical	2 cm (0.8 in)

Manual Restraint Systems

The Ford was equipped with 3-point lap and shoulder belts for the five seating positions. All belt systems utilized continuous loop webbing. The front left belt system utilized a sliding latch plate and retractor and buckle-mounted pretensioners, which actuated during the crash. The front left upper D-ring was height adjustable and found in the full-down position. The driver's belt retracted onto an Emergency Locking Retractor (ELR). The driver used the safety belt at the time of the crash, which was supported by liquid stains on the belt webbing between the latch plate and the upper D-ring. Specifically, the stain was located 115-140 cm (45.3-55.1 in) above the lower seat anchor. The stain was consistent with a partially filled soda cup the driver had in a cup holder prior to the crash. A disposable soda cup was found in the rear of the vehicle at the time of the SCI inspection. The retractor pretensioner did not lock the webbing post-crash.

The front right and second row safety belt systems utilized a switchable ELR/Automatic Locking Retractor (ALR) and a sliding latch plate. In addition, the front right belt system utilized buckle-mounted pretensioners. The retractor mounted pretensioner actuated during the crash, pulling the belt webbing taut against the B-pillar. The buckle pretensioner did not actuate as the seat was unoccupied.

Frontal Air Bag System

The Ford Escape was equipped with the CAC frontal air bag system. The manufacturer of the Ford certified that the vehicle was compliant to the advanced air bag requirements of Federal Motor Vehicle Safety Standard No. 208. The driver's frontal air bag deployed during the crash. The frontal air bag was concealed within the center hub of the four-spoke steering wheel by two cover flaps. The flaps were symmetrical and were 7 cm (2.8 in) in width and 12 cm (4.7 in) in height with a vertical tear seam. There was a Ford medallion attached to the left cover flap that extended into the right cover flap. The air bag (**Figure 8**) was 60 cm (23.6 in) in diameter in its deflated state. The air bag was vented by two vent ports at the 11 and 1 o'clock positions at the rear aspect of the air bag. The air bag was tethered by two tethers at the 12 and 6 o'clock positions.



Figure 8: Deployed driver's frontal air bag.

There were no occupant contact points on the air bag; however, the right side of the face of the air bag was covered by small drops of soda consistent with soda carried in the vehicle that also stained both front seats, the left IC air bag and the front left safety belt.

The front right air bag was mounted within the top aspect of the right instrument panel. The front right seat was not occupied during the crash; therefore the CAC system suppressed the deployment of the air bag, as designed.

Side Impact/Rollover Air Bag System

The Ford was equipped with front seatback-mounted side impact air bags and roof side rail-mounted IC air bags. Both IC's and the left side impact air bag deployed in this multiple impact crash sequence. The right side impact air bag did not deploy. The Ford was equipped with rollover sensing for the IC air bags. The roll sensor commanded the deployment of the IC's when thresholds of the vehicle's roll angle and/or roll rate were exceeded during a crash event.

The IC air bags deployed from their respective roof side rails at the on-set of the rollover. The air bags measured 148 cm (58.3 in) in length. At the front and rear left seating positions, the IC was 48 cm (18.9 in) in height. The air bag was tethered to the A-pillar by a 40 cm (15.7 in) tether strap and to the C-pillar by a 10 cm (3.9 in) strap. The IC provided complete longitudinal coverage across the rear side glazing, and coverage across the front side glazing with the exception of an open area at the A-pillar area, at the front of the curtain. This void measured 16 cm (6.3 in) in width and 14 cm (5.5 in) and 8 cm (3.1 in) at the rear and front of the opening, respectively. Vertically, the IC air bag extended below the belt line at each outboard position. **Figures 9 and 10** depict the IC air bags.

The front inboard aspect of the left IC was covered with numerous small droplets of a beverage, but was free of occupant contact.



Figure 9: Left curtain air bag.



Figure 10: Right curtain air bag.

The left side impact air bag deployed from a panel in the upper outboard aspect of the left seat back. The air bag measured 28 cm (11 in) in width and 20 cm (7.9 in) in height. It contained one vent port at the forward seam and was not tethered. There was smeared body fluid on the entire outboard aspect of the membrane. There was no damage to the air bag or contact evidence on the inboard side. **Figure 11** depicts the front left side air bag.



Figure 11: Left side impact air bag.

Driver Demographics/Data

Driver Age/Sex: 20-year-old / Female
 Height: 152 cm (60 in)
 Weight: 68 kg (150 lb)
 Eyewear: None
 Seat Track Position: Full-rear
 Manual Safety Belt Use: Lap and shoulder belt
 Usage Source: Vehicle inspection
 Egress from Vehicle: Exited with assistance
 Mode of Transport
 From Scene: Ground ambulance
 Type of Medical Treatment: Treated in emergency department and released

Driver Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
8 cm (3 in) contusion of the forehead over right eye (w/ imprint of stitching)	Minor (290402.1,7)	Driver's frontal air bag
Cervical strain	Minor (640278.1,6)	Impact force
5 cm (2 in) wide contusion across chest, left to right	Minor (490402.1,4)	Safety belt
5 cm (2 in) wide contusion across lower abdomen	Minor (590402.1,4)	Safety belt
Close head injury w/o LOC	Minor (160402.1,0)	Left roof side rail

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
Contusion 15 cm (6 in) high and 8 cm (3 in) wide on front outside corner of the right knee	Minor (890402.1,1)	Knee bolster
Abrasion over the right knee	Minor (890202.1,1)	Knee bolster

Source of injury data: Emergency Room Report and Driver interview

Driver Kinematics

The 20-year old female driver was seated in a full-rear track position and was restrained by the manual 3-point lap and shoulder belt system. At impact with the culvert, the driver's CAC air bag deployed as the driver initiated a forward trajectory within the front left seating position. The driver loaded the lap and shoulder belt resulting in the contusions across the abdomen and diagonally across the chest. Her right knee impacted the left knee bolster resulting in a contusion and abrasion to the knee. Her head continued forward as her torso was restrained by the safety belt. The driver's face loaded the CAC frontal air bag near the centerline resulting in a forehead contusion with an imprint of the stitching from contact with the tether seam.

As the vehicle began to roll to the left, the IC air bags and the left seat back mounted side air bag deployed. The driver's left shoulder and her left upper arm loaded the deployed left IC. Her left flank area loaded the deployed left seatback-mounted air bag. As the Ford rolled onto its roof, the driver initiated an upward trajectory within the front left seating position. Her head contacted and scuffed the left roof side rail resulting in an unspecified closed head injury without loss of consciousness.

The Ford came to rest on its roof. The driver was hanging inverted by the front left safety belt. A local resident came to render aid and opened the left front door. The driver released the safety belt buckle and was assisted from the vehicle. She was transported by ground ambulance to a local hospital where she was treated in the emergency department and released.

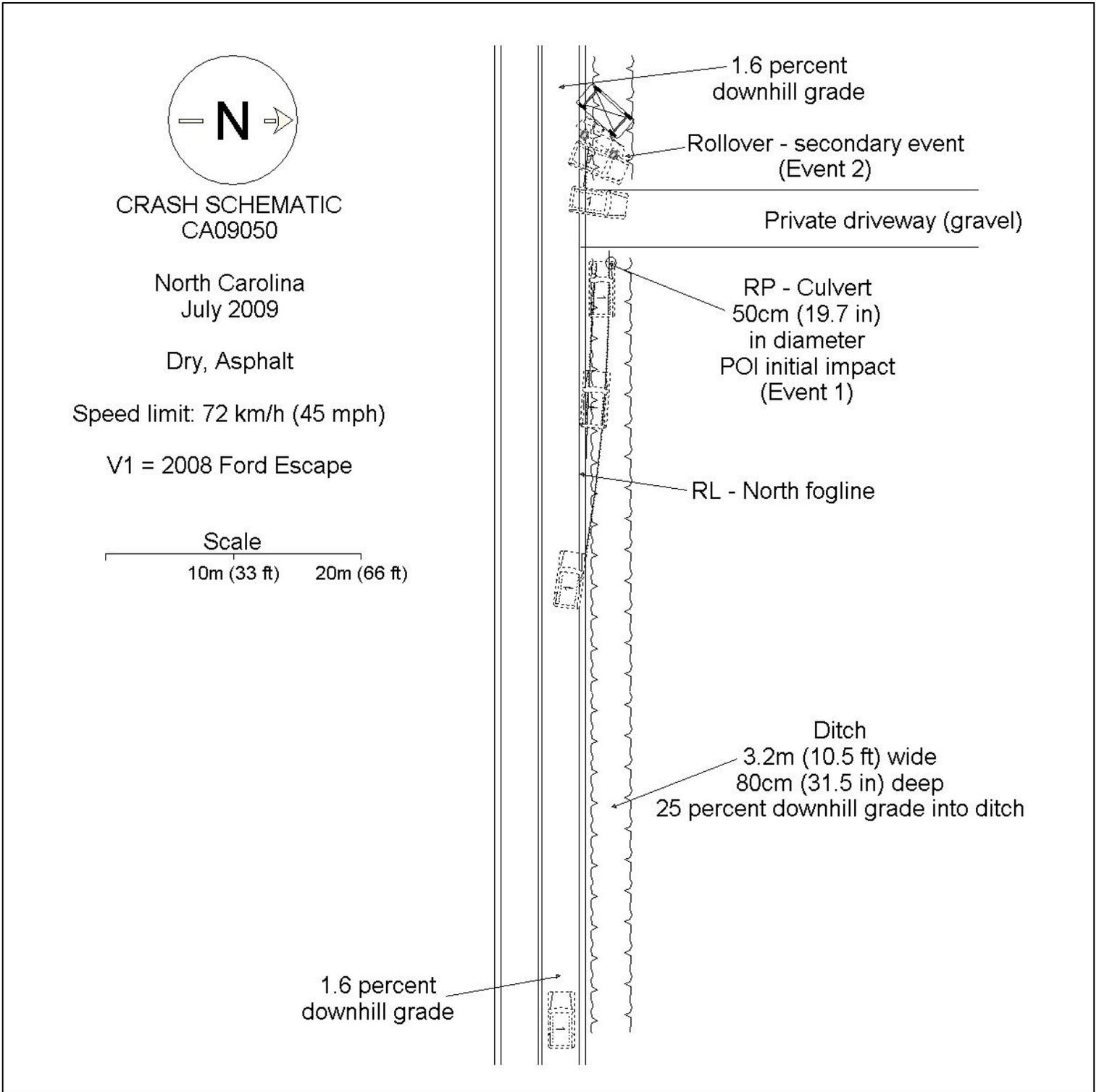


Figure 12: Crash Schematic