

CRASH DATA RESEARCH CENTER

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**CALSPAN ON-SITE ROLLOVER CRASH INVESTIGATION
SCI CASE NO.: CA10035**

VEHICLE: 2010 NISSAN SENTRA

LOCATION: NORTH CAROLINA

CRASH DATE: AUGUST 2010

Contract No. DTNH22-07-C-00043

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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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<i>16. Abstract</i> <p>This on-site investigation focused on the rollover crash of a 2010 Nissan Sentra and the source of occupant injury for this roadside departure crash. The Nissan was equipped with a Certified Advanced 208-Compliant (CAC) frontal air bag system, side impact Inflatable Curtain (IC) air bags, and side impact air bags located in the front seat backs. The manufacturer of the Nissan certified that the vehicle was compliant with the advanced air bag portion of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The CAC system includes dual-stage frontal air bags for the driver and front right passenger positions, seat track positioning sensors, retractor pretensioners, and a front right occupant presence sensor. The vehicle was traveling on a two-lane roadway and traveled left of the center line prior to initiating a steering –induced clockwise (CW) yaw on the roadway. The Nissan departed the roadway to the right and tripped into a left side leading rollover. The driver’s frontal air bag, left IC and left side air bag deployed during the crash sequence. The restrained 62-year-old female driver of the Nissan was transported to a regional trauma center via air ambulance. She was treated for minor soft tissue injuries and released.</p>			
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BACKGROUND

This on-site investigation focused on the rollover crash of a 2010 Nissan Sentra (**Figure 1**) and the source of occupant injury for this roadside departure crash. The Nissan was equipped with a Certified Advanced 208-Compliant (CAC) frontal air bag system, side impact Inflatable Curtain (IC) air bags, and side impact air bags located in the front seat backs. The manufacturer of the Nissan certified that the vehicle was compliant with the advanced air bag portion of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The CAC system includes dual-stage frontal air bags for the driver



Figure 1: Front left oblique view of the 2010 Nissan Sentra.

and front right passenger positions, seat track positioning sensors, retractor pretensioners, and a front right occupant presence sensor. The vehicle was traveling on a two-lane roadway and traveled left of the center line prior to initiating a steering-induced clockwise (CW) yaw on the roadway. The Nissan departed the roadway to the right and tripped into a left side leading rollover. The driver's frontal air bag, left IC and left side air bag deployed during the crash sequence. The restrained 62-year-old female driver of the Nissan was transported to a regional trauma center via air ambulance. She was treated for minor soft tissue injuries and released.

The crash was identified through an online search of a regional vehicle salvage facility on September 22, 2010. Based on the rollover of the late model year vehicle and the injury status of the driver, this case was assigned by the Crash Investigation Division (CID) of the National Highway Traffic Safety Administration (NHTSA) to the Calspan Special Crash Investigations team (SCI) on September 23, 2010. The on-site portion of this investigation was initiated on September 24, 2010. This investigation involved the inspection and documentation of the Nissan and the crash site, and a detailed interview with the owner/driver of the vehicle. The Event Data Recorder (EDR) in the Nissan Sentra was imaged via the use of a proprietary scan tool supplied by Nissan North America.

SUMMARY

Vehicle Data

2010 Nissan Sentra

The 2010 Nissan Sentra was manufactured in October, 2009 and was identified by the Vehicle Identification Number (VIN): 3N1AB6AP6AL (production sequence deleted). The vehicle had been purchased new by the driver approximately five months prior to the crash. At the time of the SCI inspection, the odometer read 7,343 km (4,563 mi). The front-wheel drive Nissan was powered by a 2.0-liter inline four-cylinder engine linked to an Xtronic Continuously Variable Transmission (CVT). The braking system consisted of power-assisted front disc and rear drum brakes with four-wheel antilock and Electronic Brakeforce Distribution (EBD). The 2010 Nissan was also equipped with a direct Tire Pressure Monitoring System (TPMS) and Electronic Stability Control (ESC). The case vehicle was equipped with four Bridgestone Turanza EL400 tires in size P205/60R15. This matched the manufacturers recommended tire size. The tires were mounted on OEM steel wheels with plastic wheel covers. The vehicle manufacturer recommended cold tire pressure was 228 kPa (33 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	Tire/Wheel Damage
Left Front	Tire Flat	7 mm (9/32 in)	De-beaded, wheel rim deformed
Left Rear	Tire Flat	7 mm (9/32 in)	De-beaded
Right Front	193 kPa (28 PSI)	7 mm (9/32 in)	None
Right Rear	200 kPa (29 PSI)	7 mm (9/32 in)	None

The interior of the Nissan was configured with cloth-surfaced, five-passenger seating. The front bucket seats were separated by a center console. The front head restraints were both in the full-down position at the time of the SCI inspection. The driver's seat track was operational post-crash and was in a mid-track position located 13 cm (5.1 in) forward of full-rear. The driver's seat back angle was 20 degrees rear of vertical. The front right seat was in the full-rear track position and the seat back angle 24 degrees rear of vertical. The rear seat consisted of a single bench seat with split folding backs that provided access to the trunk area of the Nissan. The rear outboard seats were equipped with adjustable head restraints, both of which were in the full-down position.

The Nissan's occupant safety systems consisted of 3-point lap and shoulder belts for all five designated seating positions, front seat safety belt retractor pretensioners, CAC dual-stage frontal air bags, side impact air bags in the outboard aspect of the front seat backs, and roof side rail-mounted side impact IC air bags that provide protection for the four outboard seating positions.

Crash Site

This crash occurred during daylight hours on a two-lane rural roadway. **Figure 2** depicts the southerly approach to the area of the crash site. The roadway extended northwest/southeast, was straight and had a level grade throughout the area in which the crash occurred. The travel lanes measured 3.2 m (10.5 ft) in width and were bordered on the outboard sides by narrow asphalt shoulders 40 cm (15.7 in) in width. Outboard of these shoulders were grass roadsides with a negative grade of 1.5 percent. On the west roadside, the grass shoulder measured 2 m (6.6 ft) in width prior to transitioning to a drainage ditch 2.7 m (8.8 ft) wide and 50 cm (19.7 in) deep. Beyond the drainage ditch was an agricultural field. The speed limit on this section of road was 89 km/h (55 mph). A Crash Schematic is included as **Figure 8** at the end of this report.



Figure 2: Southerly approach to the crash

Crash Sequence

Pre-crash

The restrained 62-year-old female driver of the Nissan was operating the vehicle in a southeasterly direction on the two-lane roadway. She was traveling at a driver-estimated speed of 89 km/h (55 mph). The EDR-reported speed of the Nissan was 129 km/h (80 mph) 4 seconds prior to the crash. For an unknown reason, the driver allowed the vehicle to drift left of center into the oncoming traffic lane. When she realized her position on the roadway, the driver initiated a sudden steering input to the right. The Nissan entered a CW yaw near the center line of the roadway. As it yawed, the Nissan followed a curving trajectory to the southwest. Yaw marks 29.2 m (95.8 ft) and 15.5 m (50.9 ft) long were deposited on the roadway by the left front and left rear tires, respectively. The Nissan departed the right roadside having yawed approximately 130 degrees CW. The left tires of the Nissan furrowed into the soft soil of the grass roadside.

Crash

The Nissan tripped into a left side leading rollover. The left side of the vehicle contacted the negative slope of the ditch wall as the Nissan rolled, increasing the speed of the rotation. Over a distance of 15 m (49.2 ft) the vehicle rolled five-quarter turns, coming to rest on its left side. The rollover was evidenced by disturbed soil in the roadside and ditch.

Post-Crash

The driver of the Nissan was conscious post-crash but could not exit the vehicle due to the Nissan resting on its left side, and the right door being out of her vertical reach. The driver called the 9-1-1 emergency response system with her cellular phone. Police, emergency medical and tow personnel responded to the crash site. Air ambulance responded to the scene due to the rollover and potential for serious injury. EMS personnel cut the windshield out of the Nissan and used hydraulic spreaders to reposition the steering column to the right. This allowed the driver to be removed from the vehicle. She sustained soft tissue injuries to her left shoulder and was transported by air ambulance to a regional trauma center where she was admitted for treatment further diagnosis. The Nissan was towed from the scene due to disabling damage. The vehicle was then transferred from the local tow yard to a regional vehicle-salvage facility, where it was inspected.

2010 Nissan Sentra

Exterior Damage

The 2010 Nissan's left, top and right planes sustained moderate damage as a result of this rollover (**Figure 3**). On the top plane, the direct contact damage began at the leading edge of the hood and extended rearward 423 cm (166.5 in) to the trailing edge of the trunk lid. Laterally, the direct damage extended across the full width of the Nissan, from the left roof side rail to the right roof side rail. The greatest vertical deformation was located on the roof over the rear left seating position, 46 cm (18.1 in) aft of the leading edge of the left rear door and 13 cm (5.1 in) inboard of the left roof side rail rubber trim strip. The residual vertical deformation measured 5 cm (2 in). The greatest lateral deformation was located on the left roof side rail adjacent to the rear left seating position 56 cm (22 in) aft of the leading edge of the left rear door. The residual lateral deformation measured 5 cm (2 in). The Collision Deformation Classification (CDC) assigned for the rollover event was 00TDDO2.



Figure 3: Rollover damage to the top plane of the Nissan.

All four doors remained closed throughout the rollover. The left front door was jammed shut post-crash. The left rear and right side doors were operational post crash. The AS-2 left front window and backlight disintegrated during the rollover. The AS-2 left rear, left rear quarter glass and all right side windows were intact post-crash. The AS-1 windshield was completely fractured but held in place by the laminate post-crash. It was cut from the vehicle post-crash to facilitate the removal of the driver.

Interior Damage

The Nissan sustained moderate severity interior damage that was attributed to passenger compartment intrusion, occupant contact and air bag deployment. There was a scuff mark that included body fluid and hair that measured 10 cm (3.9 in) wide and 8 cm (3.1 in) high on the left roof side rail. The contact scuff was located 17 cm (6.7 in) forward of the B-pillar. This contact was attributed to the left side of the driver's head. There was a scuff mark that included a small amount of body fluid on the upper rear quadrant of the left door panel, below the left IC and forward of the side impact air bag. This scuff mark measured 12 cm (4.7 in) in width and 11 cm (4.3 in) in height and was located 19 cm (7.5 in) forward of the rear edge of the door panel and 9 cm (3.5 in) below the window sill. This contact was attributed to the driver's left elbow. **Figure 4** depicts the occupant contact evidence observed during the SCI inspection. The passenger compartment intrusion is listed on the following table:



Figure 4: Left side occupant contact evidence in the Nissan.

Position	Component	Direction	Magnitude
Row 1 Left	Roof side rail	Lateral	5 cm (2.0 in)
Row 1 Left	B-pillar	Lateral	4 cm (1.6 in)
Row 2 Left	Roof	Vertical	4 cm (1.6 in)
Row 2 Left	Roof side rail	Lateral	5 cm (2.0 in)
Row 2 Center	Roof	Vertical	4 cm (1.6 in)

Manual Restraint Systems

The Nissan was equipped with 3-point lap and shoulder belts for all five designated seating positions. All belt systems utilized a continuous loop of webbing and a sliding latch plate. The upper D-rings for the front seats were height adjustable and were both located in the full-down position. The driver's belt retracted onto an Emergency Locking Retractor (ELR). All other belts retracted onto switchable ELR/Automatic Locking Retractors (ALR). Both front safety belts utilized retractor pretensioners which actuated during the rollover sequence. The front left safety belt was in use at the time of the crash, based on evidence found on the belt webbing and the extended post-crash position of the belt. The front right seat was not occupied and the front right belt was not in use at the time of the crash. The front right belt webbing was pulled taut against the right B-pillar and the webbing had gathered in the upper D-ring.

The front left belt webbing contained a frictional abrasion attributed to the upper D-ring. This abrasion was located 180 cm (70.8 in) above the lower floor anchor and measured 4 cm (1.6 in) in height. The front left belt webbing had a total of 189 cm (74.4 in) spooled out and locked by the actuation of the retractor pretensioner.

Frontal Air Bag System

The Nissan 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, seat track positioning sensors, front seat retractor pretensioners, safety belt buckle switches and a front right passenger seat weight sensor. The manufacturer of the Nissan certified that this vehicle was compliant with the advanced air bag portion of the Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The driver's frontal air bag deployed during this rollover sequence. The front right passenger's frontal air bag did not deploy.

The driver's air bag was concealed within the center hub of the four-spoke steering wheel by a tri-flap design. The upper flaps were triangular in shape and measured 7 cm (2.8 in) in width and 4 cm (1.6 in) in height. The lower flap was 14 cm (5.5 in) in width at the upper tear seam, 9 cm (3.5 in) in width at the lower aspect and 9 cm (3.5 in) in height. The driver's air bag measured 60 cm (23.6 in) in diameter and was vented by two vent ports located on the back side of the air bag at the 10 and 2 o'clock positions. The air bag was not tethered. There were droplets of post-crash body fluid on the face of the air bag in the upper and lower left quadrants of the air bag. The driver's air bag was cut by the EMS during the windshield removal. The series of small cuts extended from the upper right quadrant near the 1 o'clock position to the left side of the air bag, near the 9 o'clock position. The face of the driver's air bag is depicted in **Figure 5**.

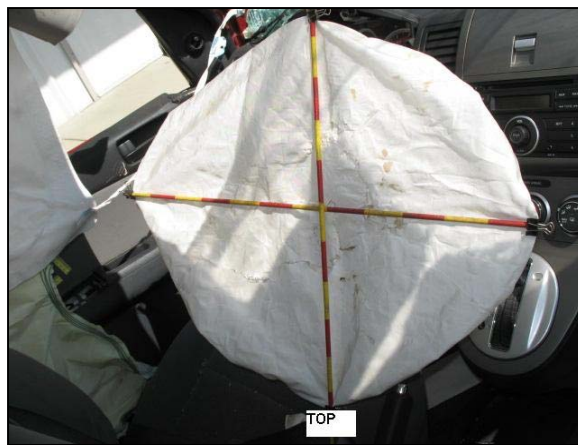


Figure 5: Face of the driver's air bag.

The passenger side frontal air bag was concealed within the middle aspect of the right instrument panel. The passenger air bag was suppressed by the CAC air bag system due to the fact that the Nissan's front right seat was unoccupied. This air bag did not deploy during the crash.

Side Impact Air Bag System

The Nissan was equipped with front seat-mounted side impact air bags and side impact roof side rail-mounted IC air bags. The vehicle was not equipped with a rollover sensor. The left side

impact air bag and left IC air bag deployed during the first quarter turn of the rollover event. The right side impact air bag and IC air bag did not deploy.

The side impact air bag deployed from a 34 cm (13.4 in) long seam in the outboard aspect of the front left seat back. The air bag measured 52 cm (20.5 in) in height and was “kidney-shaped”. The forward edge of the air bag had a double curve and measured 20 cm (7.9 in) forward of the seat back at the upper and lower aspects and 16 cm (6.3 in) forward at the center. The left side air bag (**Figure 6**) was free from contact evidence or damage.

The left IC air bag deployed from the left roof side rail. The IC measured 138 cm (54.3 in) in length. It was 42 cm (16.5 in) in height at the front and rear seating positions. Vertically, the curtain air bags extended below the belt line at each outboard position. The left IC provided protection from the upper aspect of the A-pillar to the C-pillar area. The open triangular area located forward of the IC measured 29 cm (11.4 in) high and 43 cm (16.9 in) in length along the window sill. The left IC was tethered to the left A- and C-pillars by straps 55 cm (21.7 in) and 10 cm (3.9 in) in length, respectively. The left IC is depicted in **Figure 7**.

There was a scuff mark on the inboard side of the left IC attributed to the driver’s left shoulder, and a corresponding abrasion on the outboard side of the left IC from contact with the ground. These marks were 18 cm (7.1 in) in length and 19 cm (7.5 in) in height and were located 20 cm (7.9 in) aft of the forward edge of the IC and 9 cm (3.5 in) above the lower edge of the air bag. This contact resulted in the contusion to the driver’s left upper arm.



Figure 6: Inboard aspect of left side air bag.



Figure 7: View of the left IC air bag.

Event Data Recorder

The air bag systems in the Nissan Sentra were controlled by an Air bag Control Module (ACM) that was mounted under the center console aft of the transmission selector. The ACM had Event Data Recording (EDR) capabilities.

The proprietary scan tool obtained from Nissan North America was used to communicate with the EDR and image the stored data. The scan tool was connected to the Diagnostic Link Connector located under the left instrument panel. The software-driven scan tool was powered via the Nissan’s electrical system and communicated to the ACM directly across the vehicle’s communication bus. The following data was imaged during the SCI inspection.

The current diagnostic record indicated that the EDR recorded a Frontal collision and a Side collision. This data field also reported the deployed state of the driver air bag module, the driver seat-mounted side air bag, the left IC module and the actuation of both pretensioners. There were no historical Diagnostic Trouble Codes (DTC) present prior to the crash. This was an indicator that the Air Bag light in the instrument cluster was “OFF” prior to the crash and the air bag system was operational. The Ignition Cycles at the time of the event and at the time of the data imaging were reported as “FE”. The data field reporting the state of the EDR Recording indicated the recording was a “Success”; i.e. the data was completely written.

The EDR recorded fourteen seconds (14 sec) of vehicle speed data (7 sec pre-crash/6 sec post-crash). Time “Zero” (0 sec) was assumed to indicate the impact/deployment event. The speed data imaged from the EDR is listed in the following table:

Time (sec)	Speed
-7	129 km/h (80 mph)
-6	129 km/h (80 mph)
-5	129 km/h (80 mph)
-4	128 km/h (80 mph)
-3	125 km/h (78 mph)
-2	124 km/h (77 mph)
-1	117 km/h (73 mph)
0	95 km/h (59 mph)
1	18 km/h (11 mph)
2	3 km/h (2 mph)
3	18 km/h (11 mph)
4	28 km/h (17 mph)
5	32 km/h (20 mph)
6	32 km/h (20 mph)

The EDR also recorded 400 milliseconds of bi-directional longitudinal and lateral acceleration data. The data was bracketed into 100 milliseconds of pre-crash data and 300 milliseconds of post-crash data. The vehicle’s longitudinal and lateral delta V’s were also reported. The maximum longitudinal acceleration was -4.39 g at 2.0 milliseconds. The maximum lateral

acceleration was 4.69g at 3.5 milliseconds. The entire longitudinal delta-V data field was reported as FF (the value FF was unwritten default data). The maximum reported lateral delta-V was -5 km/h (-3 mph) at 130 milliseconds.

Driver Demographics/Data

Driver Age/Sex: 62-year-old/Female
 Height: 165 cm (65 in)
 Weight: 91 kg (200 lb)
 Eyewear: Prescription glasses
 Seat Track Position: Mid-track, 13 cm (5.1 in) fwd of full-rear
 Manual Safety Belt Use: Lap and shoulder
 Usage Source: SCI vehicle inspection
 Egress from Vehicle: Removed from vehicle due to perceived serious injuries
 Mode of Transport from Scene: Air ambulance
 Type of Medical Treatment: Treated and released

Driver Injuries

Injury	Injury Severity (AIS 2005/08)	Injury Source
Lower abdominal contusion (1)	Minor (410402.1,8)	Safety belt
Left arm contusion, shoulder to forearm (1)	Minor (710402.1,2)	Left door panel rear upper quadrant
Complaint of pain to left arm and shoulder (2)	Not codeable under AIS rules	N/A

Source of injury data: (1) - Emergency Room records and (2) – Driver Interview

Driver Kinematics

The 62-year-old female driver of the Nissan was seated in a mid-track position and reportedly was leaning forward slightly as she operated the vehicle southbound on the two-lane roadway. She had both hands on the steering wheel. She departed the travel lane for an unknown reason, crossed the centerline and partially entered the oncoming lane. When she realized that she had entered the oncoming lane, the driver initiated a sudden steering input to the right in an attempt to re-enter the right travel lane. The driver over-corrected and the Nissan entered a CW yaw. The vehicle traveled off the roadway to the right. When the Nissan departed the roadway and the left tires furrowed into the soft soil of the grass roadside, it tripped into a left side leading 5-quarter turn rollover.

The left side ground impact of the Nissan actuated the front retractor pretensioners and deployed the driver’s frontal, side and IC air bags. As the vehicle rolled left around the driver, she loaded

the safety belt with her chest and abdomen. Her left flank and arm impacted the left door panel depositing a scuff mark and body fluid. Her left shoulder loaded the inboard side of the deployed left IC air bag during ground contact depositing a scuff mark and resulting in a contusion to her left shoulder. Her head impacted the left roof side rail, depositing a scuff mark and hair. The head contact did not result in an injury.

The driver came to rest in the front left seating position, restrained by the safety belt but laying on the left door as a result of the final rest position of the vehicle. She was unable to exit the seat due to the position of the steering wheel and could not open the right door above her. EMS removed the driver from the vehicle and she was transported to a regional trauma center where she was treated for soft tissue injuries and released the day of the crash.

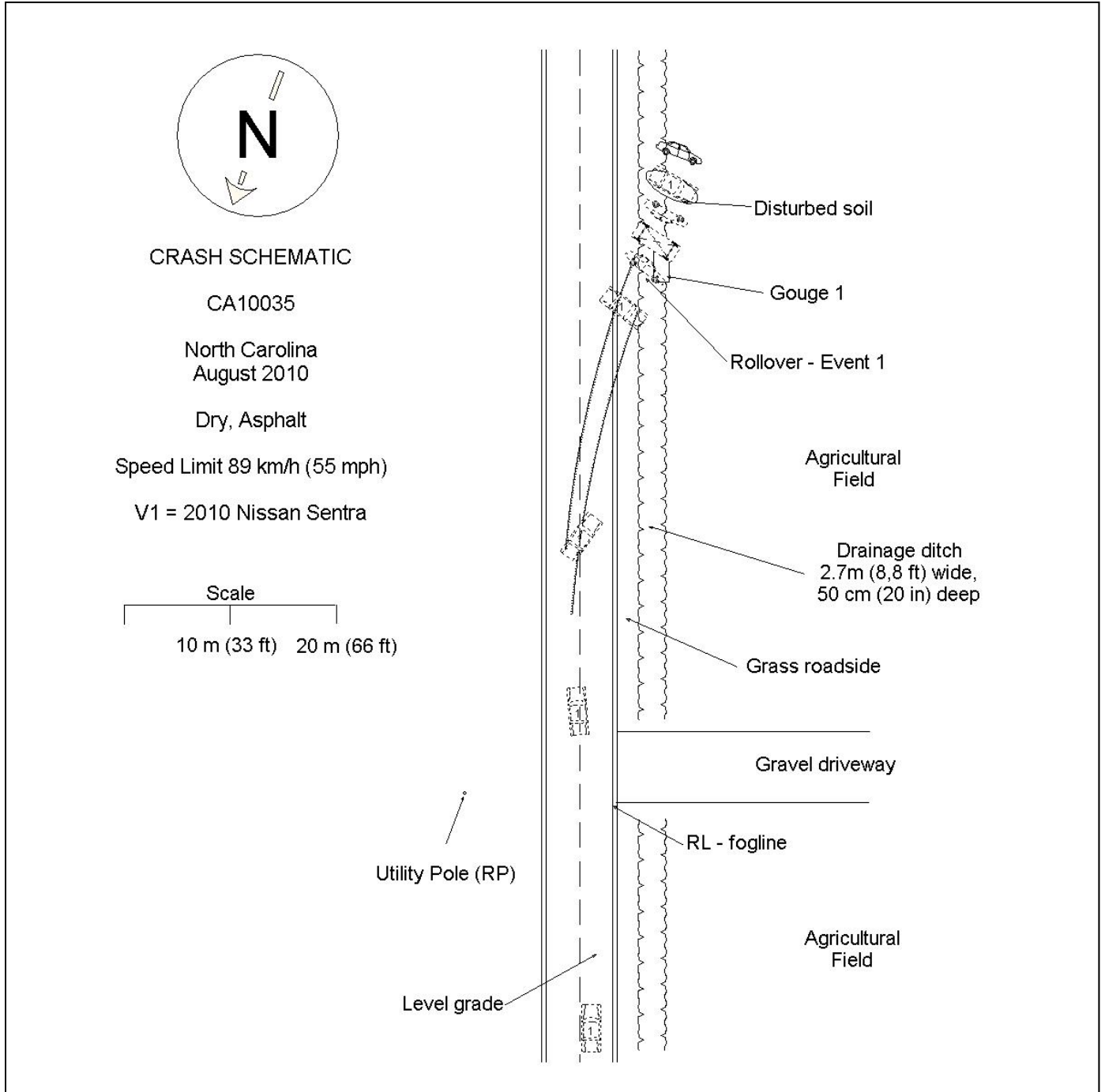


Figure 8: Crash Schematic