CRASH DATA RESEARCH CENTER

Calspan Corporation
Buffalo, NY 14225

CALSPAN ON-SITE ROLLOVER CRASH INVESTIGATION

SCI CASE NO: CA09017

VEHICLE: 2007 NISSAN ARMADA

LOCATION: VIRGINIA

CRASH DATE: FEBRUARY 2009

Contract No. DTNH22-07-C-00043

Prepared for:

U.S. Department of Transportation
National Highway Traffic Safety Administration
Washington, D.C. 20590

DISCLAIMER

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 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.

TECHNICAL REPORT STANDARD TITLE PAGE

<table>
<tr><td colspan="2">1. Report No.
CA09017</td><td>2. Government Accession No.</td><td colspan="2">3. Recipient's Catalog No.</td></tr>
<tr><td colspan="3" rowspan="2">4. Title and Subtitle
Calspan On-Site Rollover Crash Investigation
Vehicle: 2007 Nissan Armada
Location: State of Virginia</td><td colspan="2">5. Report Date:
September 2010</td></tr>
<tr><td colspan="2">6. Performing Organization Code</td></tr>
<tr><td colspan="3">7. Author(s)
Crash Data Research Center</td><td colspan="2">8. Performing Organization Report No.</td></tr>
<tr><td colspan="3" rowspan="2">9. Performing Organization Name and Address
Crash Data Research Center
Calspan Corporation
P.O. Box 400
Buffalo, New York 14225</td><td colspan="2">10. Work Unit No.</td></tr>
<tr><td colspan="2">11. Contract or Grant No.
DTNH22-07-C-00043</td></tr>
<tr><td colspan="3" rowspan="2">12. Sponsoring Agency Name and Address
U.S. Department of Transportation
National Highway Traffic Safety Administration
Washington, D.C. 20590</td><td colspan="2">13. Type of Report and Period Covered
Technical Report
Crash Date: February 2009</td></tr>
<tr><td colspan="2">14. Sponsoring Agency Code</td></tr>
<tr><td colspan="5">15. Supplementary Note
This on-site investigation focused on a rollover crash of a 2007 Nissan Armada sport utility vehicle and the occupant injury sources of the 37-year-old female driver</td></tr>
<tr><td colspan="5">16. Abstract
This on-site investigation focused on a rollover crash of a 2007 Nissan Armada sport utility vehicle and the occupant injury sources of the 37-year-old female driver. The Nissan was equipped with side impact and rollover sensing Inflatable Curtain (IC) air bags for the six outboard seating positions. In addition to the IC air bags, the Nissan Armada was equipped with a Certified Advanced 208-Compliant (CAC) frontal air bag system and an inflatable side impact protection system. The CAC system in the Nissan was comprised of dual stage frontal air bags with a front right occupant presence sensor, front seat track positioning sensors, safety belt buckle switches, and first row retractor and buckle pretensioners. The crash occurred when the eastbound Nissan Armada departed the south side of the roadway and rolled over on the right paved shoulder area. All four inflatable curtain air bags deployed in the Nissan as a result of the rollover event. The driver sustained minor severity soft tissue injuries of the left arm and was transported to a local hospital where she was treated and released. The Nissan was towed from the crash scene due to disabling damage.</td></tr>
<tr><td colspan="3">17. Key Words
Rollover Sensing Inflatable Curtain (IC) Certified Advanced 208-Compliant (CAC) frontal air bag system Electronic Stability Control (ESC) 2007 Nissan Armada Minor injuries</td><td colspan="2">18. Distribution Statement
General Public</td></tr>
<tr><td>19. Security Classif. (of this report)
Unclassified</td><td>20. Security Classif. (of this page)
Unclassified</td><td>21. No. of Pages
9</td><td colspan="2">22. Price</td></tr>
</table>

TABLE OF CONTENTS

CALSPAN ON-SITE ROLLOVER CRASH INVESTIGATION
SCI CASE NO: CA09017
VEHICLE: 2007 NISSAN ARMADA
LOCATION: VIRGINIA
CRASH DATE: FEBRUARY 2009

BACKGROUND

This on-site investigation focused on a rollover crash of a 2007 Nissan Armada sport utility vehicle **(Figure 1)** and the occupant injury sources of the 37-year-old female driver. The Nissan was equipped with side impact and rollover sensing Inflatable Curtain (IC) air bags for the six outboard seating positions. In addition to the IC air bags, the Nissan Armada was equipped with a Certified Advanced 208-Compliant (CAC) frontal air bag system and an inflatable side impact protection system. The CAC system in the Nissan was comprised of dual stage frontal air bags with a front right occupant presence sensor, front seat track positioning sensors, safety belt buckle switches, and first row retractor and buckle pretensioners. The crash occurred when the eastbound Nissan Armada departed the south side of the roadway and rolled over on the right paved shoulder area. All four inflatable curtain air bags deployed in the Nissan as a result of the rollover event. The driver sustained minor severity soft tissue injuries of the left arm and was transported to a local hospital where she was treated and released. The Nissan was towed from the crash scene due to disabling damage.

Figure 1. Front left view of the 2007 Nissan Armada.

This crash was identified during the weekly sampling of police reported crashes conducted by the National Automotive Sampling System (NASS). The crash notification was forwarded to Calspan's Special Crash Investigation (SCI) team by the Crash Investigation Division (CID) of the National Highway Traffic Safety Administration (NHTSA) on March 13, 2009 due to the IC air bag deployment and police reported incapacitating injuries during a rollover event. A telephone interview with the driver of the Nissan was conducted on March 16, 2009. The on-site investigation, which included the inspection of the Nissan and the crash site were conducted on March 20, 2009. The Nissan's Event Data Recorder (EDR) was imaged using the Nissan Consult II scan tool at the time of the SCI inspection.

SUMMARY

Crash Site

This crash occurred during the dusk hours of February 2009, on a divided interstate roadway **(Figure 2)**. In the area of the crash site, the interstate consisted of three lanes in each direction that was physically divided by a concrete median barrier. In the vicinity of the crash site, the concrete road surface was straight and level. The conditions were clear and the environmental surfaces were dry. The eastbound travel lanes measured 3.7 m (12.1 ft) wide and were bordered by asphalt shoulders. The south side shoulder measured 3.5 m (11.5 ft) wide while the north side shoulder was 3.2 m (10.5 ft) wide. The posted speed limit was 97 km/h (60 mph). The approximate area of the rollover event was identified by surface scratches and gouge marks in the south asphalt shoulder. The Crash Schematic is included as **Figure 9** of this report.

Figure 2. Overall view of the crash site.

Vehicle Data - 2007 Nissan Armada

The 2007 Nissan Armada SE was manufactured in February 2007 and was identified by the Vehicle Identification Number (VIN): 5N1BA08A77N (production sequence deleted). The odometer reading at the time of the SCI inspection was 50,789 km (31,559 miles). The power train consisted of 5.6-liter, V-8 engine linked to a 5-speed automatic transmission with rear wheel drive. The Nissan was equipped with 4-wheel, ABS disc brakes with Electronic Brakeforce Distribution. The Nissan was also equipped with Electronic Stability Control (ESC). The Nissan was equipped with Continental Conti-Trac P265/70R18 tires mounted on OEM 5-spoke alloy wheels. The vehicle manufacturer recommended front and rear cold tire pressure was 241 kPa (35 PSI). This vehicle was also equipped with an indirect Tire Pressure Monitoring System (TPMS). The specific tire data at the time of the SCI inspection was as follows:

Tire	Measured Pressure	Tread Depth	Restricted	Damage
LF	255 kPa (37 PSI)	6 mm (8/32 in)	No	Sidewall Abrasion
LR	248 kPa (36 PSI)	5 mm (6/32 in)	No	Sidewall Abrasion
RF	255 kPa (37 PSI)	4 mm (5/32 in)	No	None
RR	193 kPa (28 PSI)	4 mm (5/32 in)	No	None

The interior was configured with 8-passenger seating with front bucket seats and folding split-bench seats for the second and third rows. The Nissan was equipped with adjustable head restraints in the front seating positions, the three second row positions, and the third row outboard positions. The manual restraint systems consisted of 3-point lap and shoulder safety belts in all eight seating positions. The front safety belts were equipped

with load-force limiting retractors with dual retractor and buckle pretensioners. The Nissan was equipped with the CAC frontal air bag system, front seat back-mounted side impact air bags and the IC air bags with rollover sensing for the six outboard positions. The vehicle manufacturer has certified that the frontal air bags in the Nissan were compliant with the advanced air bag requirements of the Federal Motor Vehicle Safety Standard No. 208.

Crash Sequence

Pre-Crash

The Nissan Armada was traveling eastbound in the right outboard lane driven by the 37-year-old restrained female. The Nissan was traveling at an EDR recorded speed of 103-106 km/h (64-66 mph) at the -7 to -4 seconds prior to IC deployment. Based on driver interview statements, she was en route to her residence following the completion of her work shift. While traveling westbound, the driver stated that she allowed the vehicle to drift left into the center lane. She detected a non-contact vehicle in the center lane and initiated a right steering input with brake application. The EDR data recorded a rapid right-left-right steering inputs by the driver -4 to -1 seconds before deployment. The steering angles were 106 degrees right at -4 seconds, followed by -128 degrees back to the left at -3 seconds, followed by 266 degrees to the right at the -2 second interval before deployment. The Nissan subsequently initiated a clockwise (CW) yaw as it reentered the outboard travel lane. The steering inputs redirected the vehicle's center of gravity (CG) in a southeasterly direction. There was no physical evidence remaining at the crash site to support the extent or distance of the pre-crash yaw.

Crash

As the Nissan yawed in a CW direction, the roll moment at the CG exceeded the lateral forces exerted on the left side tires and caused the high-CG vehicle to initiate a lateral rollover to the left. There were no air outs of the left side tires and no gouging of the alloy wheels **(Figure 3)** into the concrete road surface or asphalt shoulder. Therefore, the rollover was classified as an untripped, turn-over event. The EDR recorded a roll angle of -20 degrees at time zero. This was the deployment command for the IC air bags and the actuation of the buckle and retractor pretensioners. The roll angle continued to -88 degrees at the 1-2 second interval post-deployment. The roll rate was recorded at 47 degrees/second to the right at the -1 second interval, followed by -100 degrees/second to the left at time zero (deployment). The Nissan rolled onto its left side and slid for a distance of approximately 8 m (26 ft) before coming to final rest straddling the south edge line. At rest, the vehicle was facing in a southerly direction.

Figure 3. Left front tire and wheel of the Nissan.

Post-Crash

Local police and ambulance personnel responded to the crash site. The driver of the Nissan complained of injury to her left arm and was transported by ground ambulance to a local hospital where she was treated and released. The Nissan sustained disabling damage and was towed from the crash scene. The Nissan was subsequently deemed as total loss by the insurance provider and was transferred to a regional vehicle salvage facility where it was inspected for this investigation.

Vehicle Damage

Exterior

The exterior of the Nissan sustained damage that was distributed vertically and longitudinally on the left side as a result of the rollover sequence. The damage consisted of abrasions that were vertically oriented with superficial dents of the sheet metal and lateral displacement of the left A- and C-pillars. The direct contact damage measured 489 cm (192.5 in) in length and extended from the left front bumper corner to the left rear bumper corner. The vertical aspect of the direct damage extended from the sill to the roof side rail area and included the exposed portion of the alloy wheels. The left upper A-pillar was displaced 3.8 cm (1.5 in) laterally that resulted in fracturing of the left aspect of the windshield. The lateral displacement of the upper A-pillar resulted in 3 cm (1.2 in) of induced vertical deformation to the windshield header/A-pillar juncture **(Figure 4)**. The left upper B-pillar was displaced 3.8 cm (1.5 in) laterally with equal displacement of the left roof side rail at the area of the pillar **(Figure 5)**. All four doors remained closed and were found to be operational at the time of the SCI inspection. The left front door glazing, left rear quarter window glazing and sunroof glazing were all disintegrated from impact forces. The Collision Deformation Classification for this left side rollover event was 00LDAO3.

Figure 4. Lateral displacement of the left upper A-pillar with vertical displacement of the windshield header.

Figure 5. Lateral displacement of the left upper C-pillar and adjacent side rail.

Interior

The interior damage to the Nissan was limited to the deployment of the vehicle's IC air bags, actuation of the pretensioner systems, one possible occupant contact, and intrusions of the left outboard occupant positions. The intrusions of the Nissan are listed in the following table:

Position	Component	Intrusion	Direction
Front Left	Left A-pillar	4 cm (1.5 in)	Lateral
Front Left	Windshield Header	3 cm **(**1.25 in)	Vertical
Second Row Left	Upper C-pillar	3 cm (1 in)	Lateral
Second Row Left	Roof side rail	3 cm (1.0 in)	Lateral
Third Row Left	Roof side rail	3 cm (1.0 in)	Lateral

The possible occupant contact point involved a 4 cm (1.6 in.) scuff mark with displacement of the roof-mounted maplight console. There was no contact evidence on the deployed IC air bags.

Manual Restraint Systems

The driver's manual restraint was a 3-point lap and shoulder safety belt that consisted of continuous loop webbing, a sliding latch plate, an adjustable D-ring and an Emergency Locking Retractor (ELR). The D-ring was adjusted to the full-down position. Both the retractor and belt buckle were equipped with pretensioners that actuated as a result of the crash. At initial examination, the retractor was locked with belt webbing gathered in the D-ring. The length of the exposed belt webbing was 193 cm (76 in), measured from the lower anchor. The latch plate tab revealed historical evidence of routine usage. The plastic surface of the latch plate exhibited frictional abrasions to its full width that resulted from loading by the driver. There was no related loading evidence on the belt webbing. The belt buckle was engaged against the plastic trim panels due to the actuation of the of the buckle pretensioner **(Figure 6)**.

Figure 6. Actuation of the front left buckle pretensioner of the Nissan.

The remaining safety belt systems utilized switchable ELR and Automatic Locking Retractors and sliding latch plates. The driver was the only occupant; therefore none of the other belt systems were used; however, the front right retractor and buckle pretensioners also actuated.

Frontal Air Bag System

The Nissan was equipped with the CAC frontal air bag system that consisted of dual-stage frontal air bags, seat track positioning sensors, safety belt buckle switches, and an occupant presence sensor for the front right position. The driver's air bag was

conventionally mounted in the center of the steering wheel hub while the front right air bag was mounted in the top of the right instrument panel. The CAC system did not deploy in this rollover crash.

Side Impact/Rollover Air Bag Systems

The Nissan was equipped with dual-mode side impact/rollover sensing IC air bags mounted in the roof side rails and front seat back mounted side impact air bags. The IC air bags consisted of one curtain that provided coverage for the first two rows and a separate curtain, connected by a tether that provided protection to the third row. The IC air bags deployed as a result of the rollover crash. The forward IC air bags measured 166 cm x 50 cm (65.4 in x 19.7 in) length x height in overall dimensions and provided coverage from the upper aspect of the A-pillar to the C-pillar area. A 33 cm (13 in) long, triangular shaped sail-panel tether extended from the A-pillar and was sewn to the forward aspect of the air bag. The forward tether did not provide full coverage in the area of the A-pillar. The vertical coverage of this curtain extended 1 cm (0.4 in) below the beltline in both the front and second seating rows.

The rearward, third row IC air bags measured 63 cm x 53 cm (24.8 in x 20.9 in) length x height in overall dimensions and provided coverage from the rear aspect of the C-pillar to the forward aspect of the D-pillar area. The vertical coverage of this curtain extended 4 cm (1.6 in) below the beltline in the third seating row. A center tether measuring 22 cm (8.7 in) connected the forward air bag to its rear counterpart. There was no evidence of occupant contact on the deployed IC air bags. The front seat back mounted side impact air bags did not deploy in this rollover crash.

Figure 7. Overall view of the deployed left IC air bags in the Nissan.

Figure 8. Deployed IC air bag in the driver's position of the Nissan.

Event Data Recorder

The air bag systems in the Nissan were controlled by an Air bag Control Module (ACM) that was located under the rear aspect of the center console. The ACM module was equipped with Event Data Recording (EDR) capabilities and controlled the diagnostic, sensing and deployment command functions of the air bag systems. The EDR was imaged utilizing the diagnostic link connector with a Nissan proprietary Consult II scan tool. The Nissan's EDR recorded a complete, single deployment event that was related to the left side rollover. The imaged data indicated that the driver safety belt was buckled; however, the right front passenger safety belt was not buckled at the time of the recorded

event. The EDR recorded 7 seconds of pre-crash data and 6 seconds of post-crash data for the multiple vehicle parameters, which are listed in the following tables.

Parameter	-7 Seconds	-6 Seconds	-5 Seconds	-4 Seconds	-3 Seconds	-2 Seconds	-1 Seconds
Vehicle Speed km/h	103	105	106	105	92	72	62
Engine Speed rpm	1956	1988	2000	1988	1456	1194	1128
Percent Throttle	23	22	12	0	0	0	13
Brake Switch Circuit Status	Off	Off	Off	On	On	On	On
Steering Angle in Degrees	-3	1	5	106	-128	266	246
Roll Angle in Degrees	0	0	0	0	0	0	0
Roll Rate in Degrees	0	0	0	0	0	0	47

Parameter	0 Seconds	1 Seconds	2 Seconds	3 Seconds	4 Seconds	5 Seconds	6 Seconds
Roll Angle in Degrees	-20	-88	-88	Not reported	Not reported	Not reported	Not reported
Roll Rate in Degrees	-100	29	0	Not reported	Not reported	Not reported	Not reported

Driver Demographics/Data

Age/Sex:	37-year-old/Female
Height:	173 cm (68 in)
Weight:	96.6 kg (213 lbs)
Seat Track Position:	Rear track position
Safety Belt Usage:	3-point lap and shoulder
Usage Source:	SCI vehicle inspection
Egress from Vehicle:	Assisted from vehicle by a passing motorist
Type of Medical Treatment:	Transported to a local hospital where she was treated and released

Driver Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
Left forearm contusion	Minor (790402.1,2)	Left front door panel forward upper quadrant
Left forearm abrasion	Minor (790202.1,2)	Left front door panel forward upper quadrant
Left hand contusion	Minor (790402.1,2)	Left front door panel forward upper quadrant
Left hand abrasion	Minor (790202.1,2)	Left front door panel forward upper quadrant

Source: Hospital Emergency Room Records

Driver Kinematics

The 37-year-old female driver of the Nissan was seated in a rear track position and was restrained by the manual 3-point lap and shoulder safety belt system with the seat back reclined 10 degrees aft of vertical. The driver's head restraint was removed prior to the SCI inspection. The 3-spoke tilt steering wheel was located in the full-up position.

As the Nissan began to roll onto its left side, the rollover sensing system actuated the buckle and retractor pretensioners and deployed the IC air bags. The actuated pretensioners removed slack from the belt system and tightened the webbing around the driver. The combination of pretensioner actuation and driver loading produced frictional abrasions to the latch plate and gathered the belt webbing in the D-ring. When the Nissan's left side-plane contacted the asphalt surface, the driver responded to the non-horizontal impact forces by initiating a lateral left trajectory with respect to the vehicle and contacted the left door panel and the deployed left IC air bag. No discernable contact evidence was present to the deployed IC air bags. The driver sustained abrasions and contusions of the left hand and forearm from probable contact with the left door panel. There was no contact evidence on the door panel or associated components. The rollover sensing deployment of the IC air bags probably prevented the driver from a partial ejection through the disintegrated glazing opening of the left front door.

The center front mounted map light was scuffed and was displaced from the headliner mount. This possibly resulted from contact by the driver during the early phase of the rollover event, or post-crash as she exited the vehicle.

The driver was transported by ground ambulance to a local hospital where she was treated for her soft tissue injuries and released.

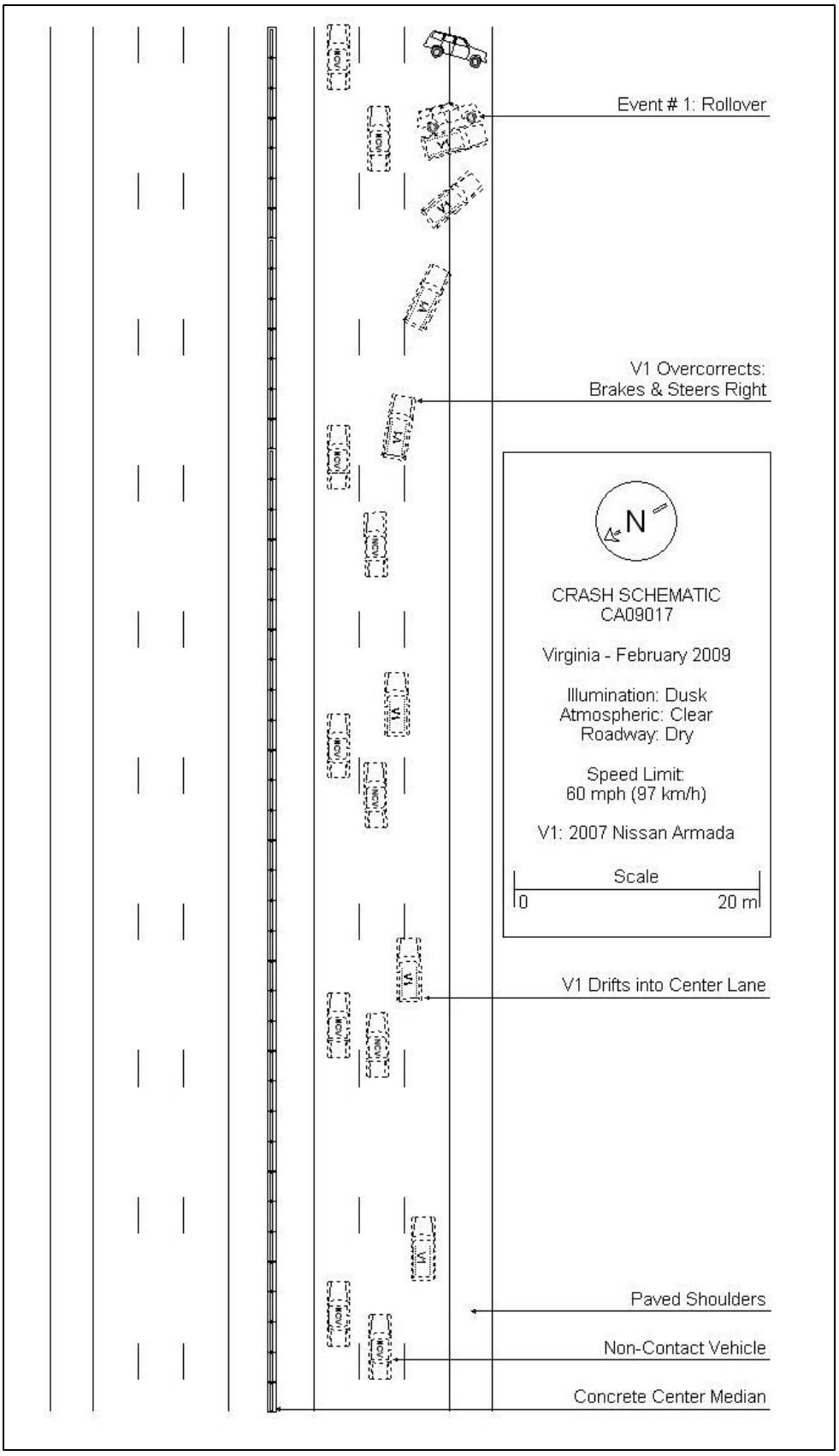

Figure 9. Crash Schematic