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CALSPAN ON-SITE ROLLOVER CRASH INVESTIGATION

SCI CASE NO.: CA12005

VEHICLE: 2012 NISSAN ROGUE

LOCATION: NORTH CAROLINA

CRASH DATE: FEBRUARY 2012

Contract No. DTNH22-07-C-00043

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The crash investigation process is an inexact science that 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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BACKGROUND

This on-site investigation focused on the rollover crash of a 2012 Nissan Rogue (**Figure 1**). The crash resulted in incapacitating injuries to the restrained 23-year-old male driver. The crash was identified by the Crash Investigations Division (CID) of the National Highway Traffic Safety Administration (NHTSA) through the review of Police Crash Reports (PARs) obtained by the National Automotive Sampling System (NASS) during the month of February 2012. The CID forwarded the PAR to the Calspan Special Crash Investigations (SCI) team on February 28, 2012, and directed the team to perform an on-site investigation of the crash. Cooperation with the salvage facility was secured on February 29, 2012 to inspect the vehicle. The on-site portion of this investigation occurred March 5-6, 2012, and involved the detailed inspection and documentation of the vehicle as well as the crash site. A telephone interview was conducted with the Nissan's driver. Although equipped with an Event Data Recorder (EDR), the vehicle's EDR could not be imaged due to limited availability of Nissan North America's proprietary tool and the short notice of the scheduled investigation.

Figure 1: Involved 2012 Nissan Rogue.

The 2012 Nissan Rogue was involved in an early morning-hour, single-vehicle crash. It was traveling north on a two-lane roadway when the driver reportedly fell asleep. The vehicle departed the right roadway edge, entered a ditch, and overturned. The vehicle completed fourteen quarter-turns, during which it struck a residential mailbox and came to rest on its roof, facing east. The crash actuated both front safety belt pretensioners and deployed the Nissan's driver frontal air bag, both front seat back-mounted side-impact air bags, and both Inflatable Curtain (IC) air bags. The IC air bags were dual-sensing, and deployed in both side impact and rollover crashes. During the rollover sequence, the driver's left arm was partially ejected from under the IC air bag. He had to be removed from the vehicle with the assistance of emergency response personnel and was transported by a ground ambulance to a local hospital. The driver received treatment for a left fibula fracture and lacerations and contusions to the left arm.

CRASH SUMMARY

Crash Site

The crash occurred on a two-lane roadway in a rural area during early-morning hours. The asphalt-surfaced roadway was oriented in a north-south direction, and delineated by a solid yellow line with a broken line that restricted passing for the northbound direction. At the time of the crash, the Nissan was traveling in the 3.1 m (10.2 ft) wide northbound lane, which was supported by a 0.7 m (2.3 ft) wide east asphalt shoulder. The roadway was straight and level for an extended period. The 3.1 m (10.2 ft) wide southbound travel lane was also supported by a 0.7 m (2.3 ft) wide west asphalt shoulder. A north-facing view of the roadway and pre-crash travel trajectory Nissan is depicted in **Figure 2**.

To the east of the roadway, the roadside transitioned down a slight negative slope into a ditch that ran essentially parallel to the travel lanes. The 0.5 m (1.5 ft) deep ditch was centered an average of 3.2 (10.5 ft) from the east roadway edge. At a convergence point for the roadside ditch with a land drainage ditch was a concrete culvert that redirected water into a sluice pipe beneath the roadway. The concrete fascia of the ditch was 2.3 m (7.5 ft) wide, centered 2.1 m (6.9 ft) from the roadway edge and 0.3-1.9 m (1-6.2 ft) below the roadway's surface. The roadside ditch extended north parallel to the roadway for 60.5 m (198.5 ft) toward a residential driveway, decreasing in depth and width. It transitioned to level ground at the edge of the gravel-surfaced driveway, which intersected the roadway in a Y-configuration. The south branch was 7.6 m (24.9 ft) wide, the center void was 10.1 m (33 ft) wide, and the north branch was 10.2 m (33.5 ft) wide. Within the center void was a residential mailbox, affixed to a non-breakaway 10x10 cm (4x4 in) wooden post that was approximately 1.1 m (3.5 ft) tall. The mailbox, which served as the Investigator's point of reference, was located precisely 73 m (239.5 ft) north of the center of the concrete sluice pipe and 2.9 m (9.5 ft) east of the roadway edge. The north branch of the driveway was bordered to its north by a slight (2.5 ft) positive embankment that transitioned to a shallow roadside drainage depression. A look back view from the vehicle's final rest position toward the residential driveway and mailbox is depicted in **Figure 3**. Speed was regulated by a posted limit of 89 km/h (55 mph). A Crash Diagram is included on page 14 of this technical report.

Figure 2: North-facing view of the Nissan's pre-crash travel trajectory.

Figure 3: South-facing look back view of the Nissan's trajectory from final rest.

Pre-Crash

According to local reports, weather conditions at the time of the early-morning hours crash included clear skies, with an ambient temperature of -2 Celsius (28.4 Fahrenheit) degrees and relative humidity of 100%. Wind speeds were calm, and the dry roadway was dark without artificial lighting.

The driver of the Nissan was returning to his residence from an evening social gathering. As estimated by the driver, the overall distance required to complete this journey took approximately 40 minutes of travel time. The driver had already completed the first 30 minutes of the journey as he was traveling north on the two lane roadway. During the SCI interview, the driver stated that he was fatigued and ultimately fell asleep while operating the vehicle.

The Nissan began to drift to the right within its travel lane. It crossed over the right lane line and departed the right roadway edge, while maintaining its northbound trajectory. The right side tires traveled over two rocks, displacing them slightly from their resting positions. These contacts, located 61.2 m (200.8 ft) and 69.2 m (227 ft) north of the initial roadside departure point, did not alter the vehicle's trajectory or result in vehicle damage or occupant injury. The Nissan continued north within the roadside swale for a total of 82 m (269 ft) as it approached the roadside ditch and the concrete culvert drainage point.

Crash

The first event occurred when the Nissan entered the 1.4 m (4.5 ft) deep drainage ditch (**Figure 4**). The initial plane of contact was the Nissan's frontal plane, at the right front bumper corner and undercarriage. This impact was of sufficient magnitude to result in the actuation of the Nissan's front safety belt retractor pretensioners and the deployment of its frontal air bag system. Due to the depth of the ditch and the roadside's negative slope, the right plane of the Nissan also impacted the east bank of the ditch. As the right front fender, right A-pillar, and right doors engaged the ground, a clockwise (CW) rotation to the Nissan was induced.

Figure 4: North-facing view of the Nissan's crash sequence trajectory.

The Nissan subsequently achieved a left-side leading orientation as it progressed north through the diminishing ditch. Its forward aspect remained within the shallow ditch as the rear aspect of the vehicle approached the east roadway edge. Frictional forces acting at the left front axle position within the ditch tripped the Nissan into a left-side leading rollover sequence (Event 2). This resulted in the deployment of the Nissan's seat back-mounted side impact and rollover-sensing Inflatable Curtain (IC air) bags. The approximate location of the trip point was 21 m (68.9 ft) north of the concrete culvert, which was 104 m (341 ft) north of the initial right roadside departure point.

Gouge marks in the soft soil of the east roadside evidenced the Nissan's rolling trajectory as it continued north. These gouge marks were centered at 78 m (255.9 ft), 114 m (374 ft), 120.7 m (396 ft), 136.8 m (448.8 ft), and 137.8 (452.1 ft) north of the initial right roadside departure point. During this sequence, the driver was partially ejected from the vehicle as his left arm shifted beneath the deployed IC air bag and protruded from the vehicle through the left front window opening. Evidenced by the driver's injuries, these kinematics occurred during the rollover sequence after the fifth quarter-turn as the Nissan maintained its trajectory toward the south branch of the residential driveway.

At a distance of 142.5-150.1 m (467.5-492.5 ft) north of the initial roadside departure point, the Nissan crossed the south branch of the driveway while maintaining its left lateral rollover. It then entered the center portion of the driveway's Y-shape, where it impacted the mailbox and non-breakaway 10x10 cm (4x4 in) wooden post (Event 3) between the eleventh and twelfth quarter-turns. This impact yielded the wooden post, but was not of sufficient magnitude to affect the Nissan's rollover dynamics. The vehicle continued on its northbound trajectory, crossing the north branch of the driveway from 160.2-170.4 m (525.6-559 ft) north of the initial departure point.

Over the duration of the vehicle's rollover sequence, the Nissan completed fourteen quarter-turns over a distance of approximately 69 m (226 ft). Ultimately, the vehicle came to final rest on its top plane, straddling the ditch and slight embankment, facing east. This position was located 172.2 m (565 ft) north of the initial right roadside departure point, and was evidenced by vehicle debris, post-crash medical refuse, and gouge marks within the soil surface. The impact and rollover sequence is depicted in the Rollover Sequence Schematic, found on page 15 at the end of this technical report.

Post-Crash

The driver of the Nissan stated to the SCI Investigator during the interview that his first recollection of the crash after having fallen asleep was awakening to the vehicle rolling multiple times. By the time he became acclimated to his surroundings, the driver stated that the crash sequence was completed and he found himself suspended from his safety belt webbing within the overturned vehicle. The driver's left upper extremity remained partially ejected from under the IC air bag at final rest. His lower extremities and waist remained restrained by the safety belt, while his upper torso was suspended through the plane of the left front window opening. His torso remained engaged against the inside surface of the deployed IC air bag.

The driver stated that he was unable to exit the vehicle under his own power due to his restrained status and the vehicle's positioning. He attempted to free his body from the safety belt webbing, but was unable to adequately move his left leg due to a fractured fibula. Emergency services personnel, having been dispatched to the scene by the local emergency response system that received notification of the crash from an unknown source, assisted the driver from the vehicle through the left front window opening. He was subsequently transported by ground ambulance to a local hospital for treatment of his injuries.

The Nissan was up-righted and towed to a local yard. It was then transferred to a regional insurance vehicle salvage facility, where it was located and inspected for this SCI investigation.

2012 NISSAN ROGUE

Description

The 2012 Nissan Rogue was identified by the Vehicle Identification Number (VIN): JN8AS5MV9CWxxxxxx. An exemplar 2012 Nissan Rogue is depicted in **Figure 5** for comparison purposes. The odometer reading at the time of the crash was estimated by the driver during the SCI interview to be 1,028 km (639 mi). The all-wheel drive (AWD) Nissan was propelled by a 2.5 L, inline 4-cylinder internal combustion engine. It was equipped with a console-mounted shift lever that enabled manual selectivity for the continuously variable transmission (CVT). Based on the vehicle manufacturer's specifications and the certification label of an exemplar vehicle, the Nissan had a 269 cm (106 in) wheelbase with a Gross Vehicle Weight Rating (GVWR) of 1,968 kg (4,339 lb). The front and rear Gross Axle Weight Ratings (GAWR) were 1,039 kg (2,291 lb) and 936 kg (2,064 lb), respectively. The manufacturer's recommended tire size was P225/55R18 front and rear, with cold tire pressures of 228 kPa (33 PSI). At the time of SCI inspection, the vehicle was equipped with Dunlop SP Sport 7000 A/S tires of the recommended size. All four tires were flat and de-beaded, though no physical damage was visible. Specific tire data was as follows:

Figure 5: Front/right oblique view of an exemplar 2012 Nissan Rogue.

Position	Measured Pressure	Measured Tread Depth	Restriction	Damage
LF	Flat	7 mm (9/32 in)	Yes	None visible
LR	Flat	6 mm (8/32 in)	Yes	None visible
RR	Flat	6 mm (8/32 in)	No	None visible
RF	Flat	6 mm (8/32 in)	Yes	None visible

The Nissan was equipped with the SL trim package, which included the seating for up to five occupants. The front row featured two forward-facing, leather-surfaced bucket seats, while the second row incorporated a split forward-facing, leather-surfaced three-passenger bench seat. A center console spanned the center of the vehicle in the first row from the front instrument panel to the rear of the front row seat backs. The rear cargo area was open to the interior of the vehicle.

The Nissan was equipped with several automated safety systems, including Vehicle Dynamic Control (VDC) (*a trade name for electronic stability control*), a Traction Control System (TCS), Anti-lock disc Brakes (ABS) with Electronic Brakeforce Distribution (EBD), brake assist, and a Tire Pressure Monitoring System (TPMS).

Vehicle History

The Nissan's driver purchased the vehicle new in December 2011. He stated to the SCI Investigator during the interview that the vehicle had not yet required maintenance or service, and that it had not been involved in any prior crashes.

Exterior Damage

All planes of the Nissan exhibited damage from the multi-event, rollover crash sequence. Damage from the Event 1 ditch entry impact was located on the front, right, and undercarriage planes. This consisted of direct contact to the front bumper fascia, front undercarriage air dam, right front fender, right A-pillar, right front door, right B-pillar, and right rear door with accompanying body surface deformation and abrasions. Mud was packed into the forward aspect of both right doorframes. A portion of the silver polymer door trim on the right rear door fractured from the vehicle as it engaged the ground, and was located at the scene pierced into the east bank of the ditch. Direct contact and induced damage were overlapped by the subsequent rollover sequence, and therefore remain unknown. The Collision Deformation Classification (CDC) assigned to the Event 1 damage pattern was 12FRES9. The severity of the impact (delta-V) could not be calculated using the WinSMASH model because the parameters of the configuration were outside of the model's scope.

The Event 2 rollover sequence resulted in direct and induced damage across the entire left, top, right, and undercarriage planes, with extension to both the front and back planes. On the left side (**Figure 6**), the suspension arm of the left front axle position was fractured and the tie rod and drive axle were partially separated. The left front fender was deformed laterally. The forward and upper portions of the left front window frame were completely separated from the left front door, and the entire left rear window frame was crushed vertically. Multiple overlapping patterns of body surface abrasions in varying vertical, horizontal, and longitudinal directions were present across all portions of the left plane. Patches of embedded grass and soil were dispersed throughout.

The right plane sustained damage from the rollover that overlapped the Event 1 damage profile (**Figure 7**). This included body deformation and surface abrasions to the right front fender and both right side doors. Other damage attributable to the rollover included the vertical and lateral deformation to the upper right A-pillar, right roof side rail, upper right D-pillar, right rear fender, and fuel filler-cap door.

Figure 6: Event 2 damage pattern to the left plane of the Nissan.

Figure 7: Event 2 damage pattern to the right plane of the Nissan.

On the Nissan's top plane (**Figure 8**) was minor body deformation to the roof. Both roof-rack rails were fractured immediately forward of their rear mounting locations, with heavy multiple-axis abrasions. There was induced vertical deformation to the roof, with minor body surface abrasions. The forward portion of the hood had separated from its latch during the early stages of the rollover, and was subsequently deformed longitudinally. The entire hood was crushed together and folded over, which had penetrated the forward lower aspect of the center of the windshield.

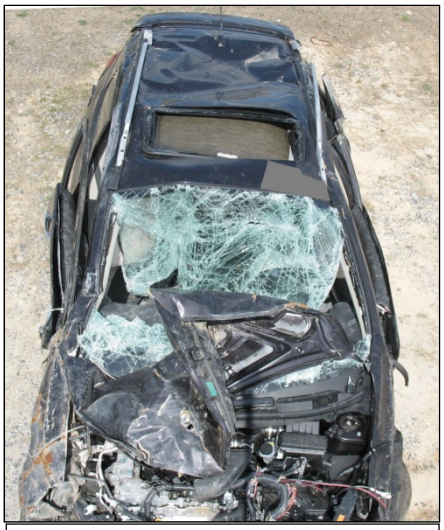


Figure 8: Event 2 damage pattern to the Nissan's top plane.

Figure 9: Overall view of the Nissan Rogue and the Events 1 and 2 overlapping damage patterns.

Damage extension to the front and back planes included direct contact damage at the bumper corner areas with induced body deformation. The front bumper fascia, grille, and other body panel components encasing the frontal plane separated from the vehicle during the rollover sequence. This exposed the front bumper beam and both frame rail ends, though there was no damage to the bumper structure. On the rear plane, direct damage was limited to body panel deformation and surface abrasions on both corner aspects, extending from the lower outboard bumper corners upward to the upper D-pillars and roof side rails. An overall view of the Nissan is depicted in **Figure 9**. The CDC assigned to the 2012 Nissan Rogue for the Event 2 damage pattern was 00TDDO3. No delta-V could be calculated for this event because the impact configuration was outside of the scope of the WinSMASH model.

Based on a combination of evidence available at the scene, a lack of damage attributable to the mailbox and non-breakaway post impact on the remaining visible planes of the vehicle, and this Investigator's knowledge of vehicle dynamics and crash reconstruction, the Event 3 impact occurred within the longitudinal passenger compartment area of the vehicle's undercarriage during the rollover sequence. However, due to the vehicle's positioning at the time of the inspection and an inability to inspect the undercarriage, specific damage relating to the Event 3 impact remains unknown. The CDC corresponding to the Event 3 impact was 00UPDN1. No delta-V could be calculated for this event because the impact configuration was outside of the scope of the WinSMASH model.

Interior Damage

Interior damage sustained by the Nissan was attributable to supplemental restraint system deployment and occupant contact. The only measureable intrusion into the passenger compartment was the penetration of the deformed hood through the lower aspect of the windshield, with a magnitude of 22 cm (8.7 in). This intrusion is depicted in **Figure 10**.

Figure 10: Penetration of the deformed hood through the base of the Nissan's windshield glazing.

Figure 11: Extrusion of the Nissan's left front door due to occupant loading.

Occupant contact within the Nissan was confined to the interior components within the driver's seating position. Identified contact damage included deformation to the left front interior door panel, the displacement of the center console fascia surrounding the transmission shift lever, and scuffs to the left lower instrument panel from the driver's knees. All of these contacts were attributed to direct occupant interaction during the rollover sequence (Event 2). The deformation to the left front door consisted of obvious bowing extrusion of at least 8 cm (3 in) as a result of occupant loading that was magnified by the response of the individual's mass to the centrifugal forces of the rollover. **Figure 11** depicts the bowing extrusion of the left front door.

Glazing damage sustained by the Nissan included the fracturing and disintegration of all glazing except the right rear door and right quarter panel glazing. This included the fracturing and holing penetration of the windshield (AS-1) by the deformed hood and the impact force disintegration of all left side (AS-2 tempered and AS-3 tempered/tinted original), the sunroof (AS-3 tempered/tinted original), the backlight (AS-3 tempered/tinted original), and the right front glazing (AS-2 tempered). It should be noted that at the time of the crash, all non-fixed glazing was fully closed due to the time of day and ambient temperature.

All doors remained closed during the crash. Both left side doors were jammed shut and could not be opened due to body/frame deformation. The right front door was open at the time of the SCI inspection and could not re-latch due to doorframe deformation. The right rear door remained closed and was operational. Although the tailgate/hatch remained closed, its operational status remains unknown due to the inoperability of the electrical latch-release mechanism.

A forward-facing view of the involved Nissan's interior is depicted in **Figure 12**. It should be noted that the Nissan's headliner was displaced during the crash sequence, and was hanging unsecured from the vehicle's roof structure. That of an exemplar is depicted in **Figure 13** for exemplar purposes.

Figure 12: Forward-facing view of the Nissan's deployed IC air bags and suspended headliner.

Figure 13: Forward-facing view within an exemplar 2012 Nissan Rogue.

Manual Restraint Systems

The Nissan was equipped with manual 3-point lap and shoulder safety belts for all five seating positions. The front row safety belts incorporated continuous loop webbing with sliding latch plates, and were height-adjustable at their respective pillar-mounted D-ring anchor locations. The driver's safety belt system was equipped with an Emergency Locking Retractor (ELR) and a retractor pretensioner. The front right passenger's belt system was equipped with an ELR/Automatic Locking Retractor (ALR) and a retractor pretensioner. The second row safety belts were equipped with switchable ELR/ALR retractors and sliding latch plates with fixed D-ring anchor locations. For the second row center position, the retractor/D-ring position was mounted to the ceiling above the cargo area, behind the second row seat back.

Both the driver's and front right passenger's retractor pretensioners actuated as a result of the frontal impact (Event 1), and the driver's belt webbing was locked in a used position. Loading abrasions on the latch plate from the belt webbing were consistent with occupant loading and evidenced restraint use (**Figure 14**). At the shoulder anchor location, the driver's safety belt webbing was gathered in the forward aspect of the D-ring with a polymer transfer extending 23 cm (9 in) down the webbing towards the latch plate.

Figure 14: Loading evidence on the driver's safety belt latch plate within the Nissan.

The right front passenger's belt webbing was stretched taught against the B-pillar, signaling a lack of use prior to the actuation of the retractor pretensioner at the time of the crash. For the second row safety belt systems, all three were in "like new" condition and lacked loading evidence or historical wear.

Supplemental Restraint Systems

The Nissan Rogue was equipped with six air bags for supplemental restraint, including a Certified Advanced 208-Compliant (CAC) frontal air bag system, front seat back-mounted side impact air bags, and combination side-impact/rollover sensing roof side rail-mounted IC air bags. The frontal air bag system consisted of dual-stage air bags mounted in the steering wheel hub and top right instrument panel. It also incorporated safety belt buckle switches and a front right occupant weight sensor. The manufacturer of the Nissan Rogue has certified that vehicle's frontal air bags were compliant to the advanced air bag portion of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. Side impact protection within the Nissan incorporated IC air bags and front seat back-mounted side impact air bags. The rollover sensing IC air bags extended along both roof side rails and provided protection for all outboard seating positions (both the front and the second rows).

The driver's position steering wheel hub-mounted air bag deployed as a result of the Event 1 impact during the crash. It deployed through the H-configuration cover flaps of the module without damage. In its deflated state, the air bag was circular in shape with an overall diameter of 60 cm (23.6 in), with interior tethers stitched to the center aspect of the bag's face. There were two 6 cm (2.4 in) diameter vents on the rear of the bag, evenly spaced from the centerline, at the 10/2-o'clock positions. No contact or loading evidence from probable driver interaction was discernable.

A frontal air bag was available for the right front passenger's position, concealed within a module mounted in the top of the right instrument panel. The front right passenger's air bag did not deploy during the crash due to the unoccupied status of the front right seating position.

In its deflated state, the deployed front left seat back-mounted air bag measured 24 cm (9.4 in) wide at its upper aspect, 20 cm (7.9 in) wide at its lower aspect, and 55 cm (21.7) in overall height. The bag provided 50 cm (19.7 in) of vertical coverage from the seat bight. It deployed through 45 cm (17.7 in) of stitching on the outboard aspect of the seat. According to an alphanumeric sequence printed on the air bag, it was manufactured of semicrystalline polyamide material. There was no damage or evidence present on the front left seat back air bag to support occupant interaction.

The front right seat back-mounted air bag was of a different shape and design in comparison to the front left. It deployed through 25 cm (9.8 in) of stitching on the outboard aspect of the seat back. In its deflated state, the front right seat back air bag measured 30 cm (11.8 in) wide and 28 cm (11 in) in overall height. The bag provided 28 cm (11 in) of vertical coverage, beginning and ending 13 cm (5.1 in) and 41 cm (16.1 in) from the seat bight, respectively. It also was manufactured of semicrystalline polyamide material. There was no damage or contact evidence present on the front right seat back-mounted air bag.

The left and right rollover-sensing IC air bags deployed through the headliner along the roof side rail. In their deployed state, the IC air bags provided vertical coverage from the roof side rail to the beltline at all four outboard seating positions. Mirror images of each other, the air bags were oval in overall shape with respective length and height measurements of 176 cm (69.3 in) and 45 cm (17.7 in). The IC air bags incorporated a 25 cm (9.8 in) long A-pillar tether anchor. Vertical coverage between the A- and B-pillars measured 45 cm (17.7 in), with 40 cm (15.7 in) of vertical coverage between the B- and C-pillars. Beginning at the B-pillar and extending rearward was a trapezoidal non-fill portion, which measured 30 cm (11.8 in) wide at the top, 48 cm (18.9 in) wide at the bottom, and 30 cm (11.8 in) in height. Both bags were devoid of contact evidence or crash-related damage to support occupant interaction or intrusion.

Figure 15: Deployed air bag systems for the driver's seating position within the Nissan Rogue.

The deployed air bags for the driver's seating position are depicted in **Figure 15**. As detailed previously, the vehicle had been obtained new and had only been in the driver's possession for approximately three months. The driver stated that because of this fact, none of the supplemental restraint systems had required maintenance or replacement. He further stated that the supplemental inflatable restraints warning light within the instrument panel was not illuminated at any time prior to the crash.

Rollover Mitigation

The 2012 Nissan Rogue was equipped with several systems to assist the driver in maintain control of the vehicle to potentially prevent a crash from occurring. These systems included the standard equipped VDC, TCS, ABS with EBD, and TPMS as previously stated. The Vehicle Dynamic Control was a form of electronic stability control and served to maintain directional control of the vehicle despite abrupt steering maneuvers, while the Traction Control System assisted in preventing a loss of traction on varying roadway surfaces. The Nissan was also equipped with the aforementioned supplemental inflatable and manual restraint systems, which assisted in the mitigation of occupant injury in the event of a crash.

According to information published by the NHTSA, the 2012 Nissan Rogue AWD had a 4-star Rollover Rating.[1] The calculated rollover risk reported was 17.9%. It had achieved 5-star ratings for the driver and rear passenger for both the side barrier and side pole crash tests. For frontal barrier crash tests, it was awarded a 4-star rating. At the time of the subject crash, there were no current safety recalls, investigations, complaints, or service bulletins for the 2012 Nissan Rogue AWD sport utility vehicle.

2012 NISSAN ROGUE OCCUPANTS

Driver Demographics

Age / Sex:	23 years / Male
Height:	170 cm (67 in)
Weight:	130 kg (286 lb)
Eyewear:	None
Seat Type:	Bucket
Seat Track Position:	Rear-most
Manual Restraint Usage:	3-point lap and shoulder safety belt
Usage Source:	Vehicle inspection
Air Bag(s):	CAC frontal air bag, IC air bag, seat back air bag
Alcohol/Drug Data:	None
Egress from Vehicle:	Assisted by emergency response personnel through left front glazing opening
Transport from Scene:	Ground ambulance to a local hospital
Medical Treatment:	Treated in emergency department and released

Driver Injuries

Injury No.	Injury	AIS 2005/08	Injury Source	Confidence Level
1	Left fibula fracture, proximal aspect of the middle one-third, comminuted, non-displaced	854471.2,2	Lower left instrument panel	Probable
2	Multiple lacerations to the left forearm, including a 6 cm posterior lateral mid-shaft laceration and a pair of 2 cm dorsal mid-shaft lacerations	710602.1,2	Ground	Certain
3	Contusions to the lower left arm, NFS	710402.1,2	Ground	Certain
4	Abrasion to the anterior aspect of the right thigh	810202.1,1	Steering wheel	Certain

Source: Medical Records; Interview (Same person)

Driver Kinematics

The 23-year-old male driver of the Nissan was seated in the forward facing bucket seat. He had adjusted the seat to a full-rear track position, with the seat back slightly reclined. The driver was restrained by the manual 3-point lap and shoulder safety belt. Restraint usage was determined from the post-crash condition of the safety belt system during the SCI inspection.

The driver initiated a forward trajectory in response to the initial frontal impact. His body loaded the safety belt webbing, but his movement was restricted by the actuation of the retractor pretensioner. His upper torso and face probably contacted the deployed frontal air bag, but no injuries attributable to this contact were sustained.

As the vehicle's right plane engaged the embankment of the ditch and began to rotate CW, the driver remained restrained by the safety belt system. His body then initiated a left lateral trajectory in response to the vehicle's left side-leading orientation and subsequent trip-over. The driver's left flank contacted the seat back-mounted and inflatable curtain air bags immediately following their deployment as the vehicle began its left side-leading rollover.

As the vehicle rolled about its longitudinal axis, the driver maintained a left lateral trajectory. The centrifugal force of the driver's mass created by the vehicle's rotation resulted in prolonged loading by the driver on the webbing of the safety belt system. This force exceeded the static force load capability of the retractor, and webbing began to slowly spool from the retractor as the driver's mass maintained a left lateral trajectory. This resulted in a 23 cm (9 in) polymer transfer from the D-ring onto the webbing extending toward the latch plate as the webbing gathered in the forward aspect of the D-ring. Despite the loosening of the safety belt system with respect to the seating position, the driver remained restrained.

During the first five quarter-turns of the rollover sequence, the left side glazing panels were disintegrated by the impact forces and the window frames were deformed. The driver maintained a left lateral trajectory due to the rollover forces, and his body loaded against and deformed the interior aspect of the left front door. Subsequently, his lower left arm slid underneath the IC air bag between the upper portion of the left front door and the lower portion of the IC air bag. Due to the already disintegrated status of the left front glazing, this resulted in the partial ejection of the driver's lower left arm. Over the course of the remaining rollover sequence, the driver's lower left arm contacted the ground in unison with the vehicle's left plane, resulting in lacerations and contusions.

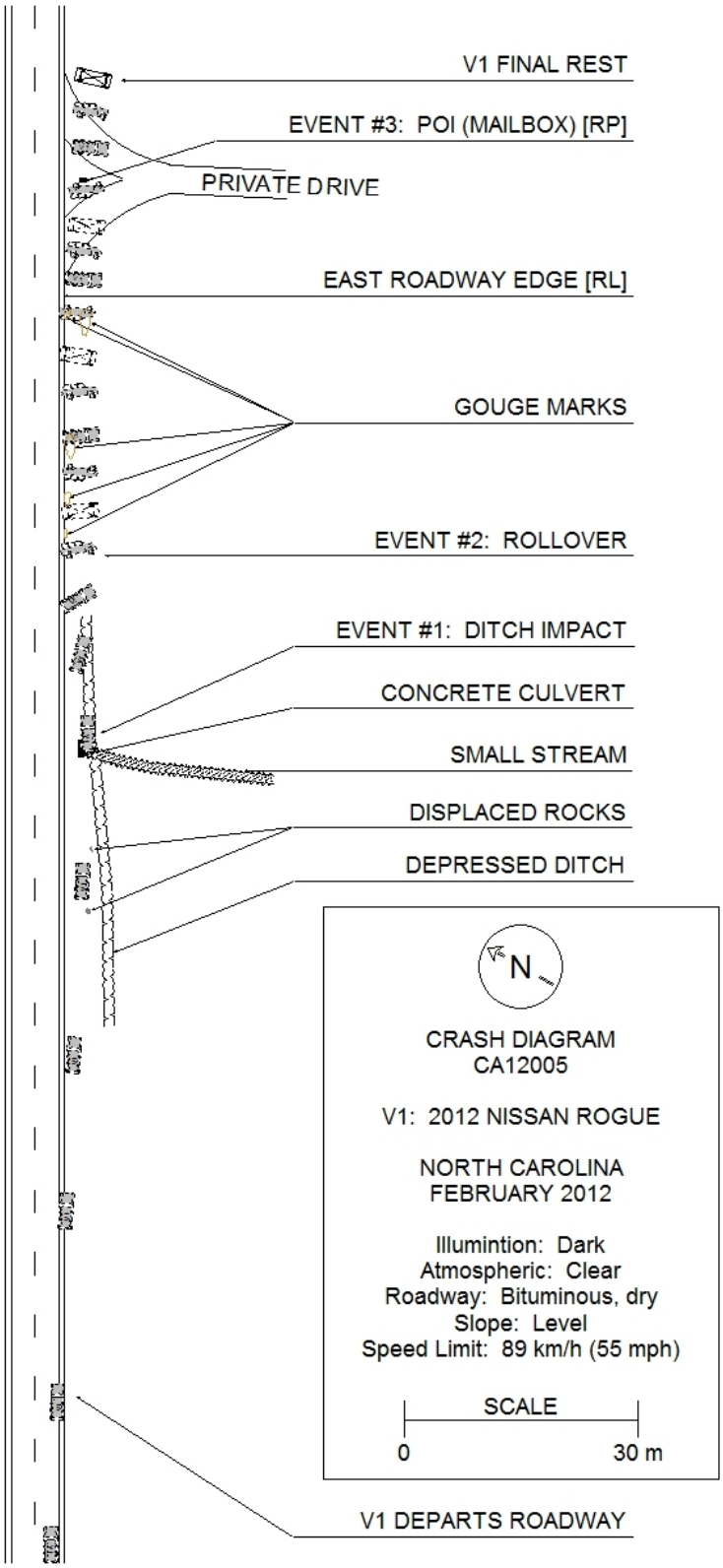
Impact forces associated with the third event were not of sufficient magnitude to affect the driver's kinematics, nor did it result in exterior occupant interaction despite the driver's partially ejected status.

Coupled with the driver's left lateral trajectory in response to the rollover sequence, his respective movement away from the longitudinal axis of the vehicle's center of mass also resulted in the interaction of his lower extremities with the left lower instrument panel and toe pan. As the vehicle completed the final quarter-turn of the rollover sequence, the driver's mass and displaced positioning responded to the force of gravity and directed the driver downward. This sharply increased the driver's force load against the lower instrument panel on his lower left leg, fracturing his left fibula.

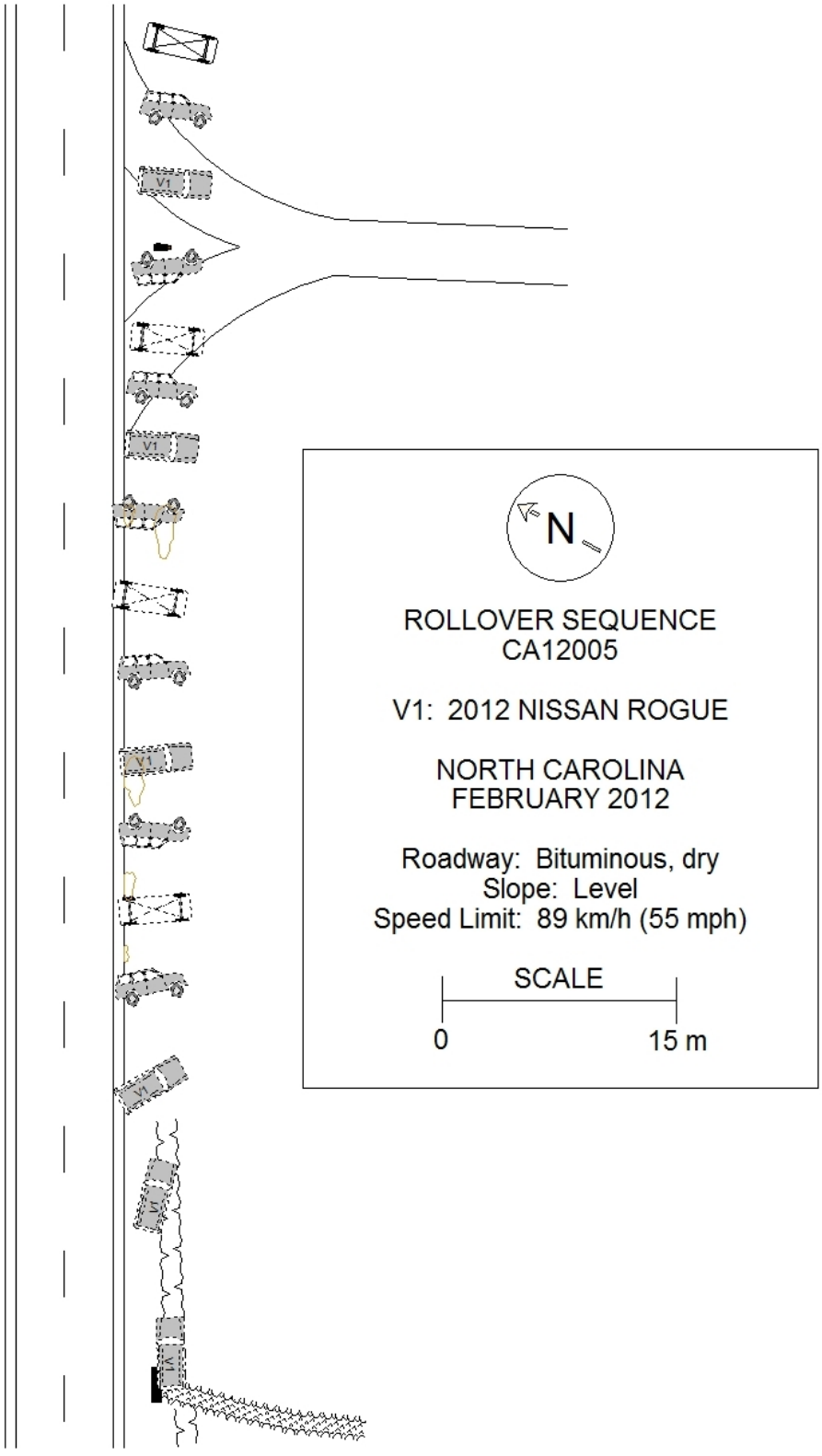
The driver came to rest in a suspended position within the overturned vehicle. He was unable to disengage the safety belt system's latch plate from the buckle due to the static force load of his mass, and instead attempted to maneuver his body out of the safety belt webbing. Due to his suspended positioning and injury status, however, the driver was unable to free himself from the safety belt system and exit the vehicle. He was subsequently assisted from the vehicle upon the arrival of emergency response personnel.

The driver was transported from the scene via a ground ambulance to a local hospital, where he was evaluated and treated for his injuries. At the time of the SCI interview one month post-crash, the driver continued to receive follow-up medical care.

CRASH DIAGRAM



ROLLOVER SEQUENCE SCHEMATIC



APPENDIX A
References

1. NHTSA. “2012 Nissan Rogue SUV AWD.” *5-Star Safety Ratings / 2011-Newer Vehicles.* United States Department of Transportation, 2011. Web. March 2012. <https://safercar.gov/Vehicle+Shoppers/5-Star+Safety+Ratings/2011-Newer+Vehicles/Vehicle-Detail?vehicleId=6556>