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CALSPAN ON-SITE ROLLOVER CRASH INVESTIGATION

SCI CASE NO: CA05-034

VEHICLE: 2005 LEXUS RX330

LOCATION: MARYLAND

CRASH DATE: MAY, 2005

Contract No. DTNH22-01-C-17002

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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.

TECHNICAL REPORT STANDARD TITLE PAGE

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<i>16. Abstract</i> <p>This investigation focused on the rollover crash of a 2005 Lexus RX330 that resulted in fatal injuries to the 60 year old male front right occupant. The Lexus was struck in the rear by a 1998 Acura 2.5TL during a lane change maneuver resulting in a loss of control and subsequently a rollover crash. The Lexus was equipped with a Certified Advanced-208 Compliant (CAC) occupant protection system that included: front safety belt pretensioners, dual-stage frontal air bags, and front right occupant presence detection. Additionally, the Lexus was equipped with a driver knee bolster air bag, front seat-mounted side impact air bags, and roof rail-mounted inflatable side curtains. The vehicle was equipped with a rollover sensor utilized to deploy the side curtains in a rollover event. The Lexus was further equipped with Vehicle Stability Control (VSC), Traction Control (TRAC), and four-wheel anti-lock brakes (ABS) with Brake Assist. The front safety belt pretensioners and the inflatable side curtains in the Lexus deployed during the multiple event crash. The front right occupant of the Lexus suffered fatal head, neck, and chest injuries as a result of the crash. He was pronounced deceased at the scene. The driver of the Lexus was transported to a trauma center and held overnight for observation. She was released the day after the crash. The driver and front right passenger of the Acura were not injured in the crash and were not transported.</p>			
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SCI CASE NO: CA05-034**

**VEHICLE: 2005 LEXUS RX330
LOCATION: MARYLAND
CRASH DATE: MAY, 2005**

BACKGROUND

This investigation focused on the rollover crash of a 2005 Lexus RX330 (**Figure 1**) that resulted in fatal injuries to the 60 year old male front right occupant. The Lexus was struck in the rear by a 1998 Acura 2.5TL during a lane change maneuver resulting in a loss of control and subsequently a rollover crash. The Lexus was equipped with a Certified Advanced 208 Compliant (CAC) occupant protection system that included: front safety belt pretensioners, dual-stage frontal air bags, and front right occupant presence detection. Additionally, the Lexus was equipped with a driver knee bolster air



Figure 1: Front right view of the Lexus.

bag, front seat-mounted side impact air bags, and roof rail-mounted inflatable side curtains. The vehicle was equipped with a rollover sensor utilized to deploy the side curtains in a rollover event. The Lexus was further equipped with Vehicle Stability Control (VSC), Traction Control (TRAC), and four-wheel anti-lock brakes (ABS) with Brake Assist. The front safety belt pretensioners and the inflatable side curtains in the Lexus deployed during the multiple event crash. The front right occupant of the Lexus suffered fatal head, neck, and chest injuries as a result of the crash. He was pronounced deceased at the scene. The driver of the Lexus was transported to a trauma center and held overnight for observation. She was released the day after the crash. The driver and front right passenger of the Acura were not injured in the crash and were not transported.

This crash was identified through an internet news search conducted by the Crash Investigation Division of the National Highway Traffic Safety Administration and subsequently assigned as an on-site investigation to the Calspan Special Crash Investigations team on June 2, 2005. Calspan SCI initiated follow-up investigation and established cooperation with the investigating police department. The Lexus was located at a tow agency and available for inspection. The Acura had been released prior to SCI involvement and was not available for inspection. The on-site portion of the investigation took place June 8 and 9, 2005. It was originally reported that none of the vehicle's safety systems deployed. However, the on-site SCI investigation determined that the pretensioners actuated and the inflatable side curtains deployed during the crash.

VEHICLE DATA

2005 Lexus RX330

The 2005 Lexus RX330 was identified by the Vehicle Identification Number (VIN): 2T2HA31U55C (production sequence deleted) and was manufactured in December 2004. The digital odometer could not be read at the time of the SCI inspection to an expended battery. The RX330 was a four-door sport utility vehicle that was equipped with a 3.3-liter, V6 engine, five-speed automatic transmission, all-wheel drive, power front and rear disc brakes with anti-lock, stability and traction control, and a tire pressure monitoring system. In addition, the vehicle was equipped with and a tilt and telescoping steering wheel. The manual restraint system consisted of three-point lap and shoulder belts in all five seat positions. The front manual restraints were equipped with retractor pretensioners. The Lexus was equipped with a Certified Advanced Compliant (CAC) frontal air bag system and knee bolster air bags. The advanced frontal bags were certified by the manufacturer as compliant with the requirements of the advanced Federal Motor Vehicle Safety Standard (FMVSS) 208. The front bucket seats were equipped with thorax side impact air bags. Inflatable side curtains were mounted in the vehicle's roof rails and their deployment was controlled by the vehicle's roll sensor. The inflatable side curtains deployed in the crash. The Lexus was equipped with Michelin Energy MXV4 S8 tires, size P235/55R18 mounted on five-spoke OEM alloy wheels. The manufacturer recommended front and rear tire pressure was 207 kPa (30 PSI). The specific tire data at the time of the SCI inspection was as follows:

Tire	Measured Pressure	Tread Depth	Restricted	Damage
LF	0 kPa	7 mm (9/32 in)	No	De-beaded and debris in rim bead and between spokes
LR	276 kPa (40 PSI)	7 mm (9/32 in)	No	Debris in rim bead
RF	290 kPa (42 PSI)	7 mm (9/32 in)	No	Abrasions and debris in rim bead
RR	290 kPa (42 PSI)	7 mm (9/32 in)	No	Abrasions and debris in rim bead

The seating positions in the Lexus were configured with leather upholstered front bucket seats with height adjustable head restraints. At the time of the SCI inspection, the front left head restraint was adjusted 6 cm (2.5 in) above the seatback and the front right head restraint was adjusted to the full down position. The second row was configured with a three-passenger split (60/40) bench seat with height adjustable head restraints. The rear head restraints were adjusted 8 cm (3 in) above the seatback.

1998 Acura 2.5TL

The 1998 Acura 2.5TL was identified by the Vehicle Identification Number (VIN): JH4UA2651WC (production sequence deleted). The front-wheel drive, four-door sedan was equipped with a 2.5 liter/I5 engine linked to a four-speed automatic transmission. The vehicle was equipped with front disc/rear drum brakes with ABS. The Acura was equipped with redesigned air bags for the driver and front right passenger that deployed as a result of the crash. The vehicle was released by the police prior to SCI involvement and was not inspected.

SUMMARY
CRASH SITE

This two-vehicle/multiple event crash occurred during the daylight hours of May 2005. At the time of the crash, the weather conditions were dry and clear and were not a causal factor. The crash occurred on the westbound lanes of a three-lane divided east/west interstate highway in a rural area of the state. The asphalt road surface was straight and level in the area of the crash and had a posted 105 km/h (65 mph) speed limit.

Figure 2 is a westbound trajectory view of the roadway. At the crash site, the total width of the three westbound lanes measured 11 m (36 ft). The north (outboard) side of the travel lanes was bordered by a 3.7 m (12 ft) wide shoulder and a W-beam guardrail. The south (inboard) side of the west travel lanes was bordered by a 3.3 m (10.8 ft) wide shoulder. Three tire marks were identified on the inboard travel lane and shoulder that defined the off-road trajectory of the Lexus.



Figure 2: Westward trajectory view at the crash site.

A 9 m (30 ft) wide depressed grass median separated the east and west travel lanes. A W-beam guardrail system was located within the median 3 m (6 ft) south of the inboard westbound shoulder. The Lexus impacted and tripped over the guardrail during the course of the crash. **Figure 3** is a view looking east along the guardrail. The guardrail system was mounted to 10 cm x 15 cm (4 in x 6 in) I-beams spaced 2 m (6.5 ft) apart. The W-beam was mounted on 19 cm (7.5 in) block-outs and spanned the height 46 cm to 76 cm (18 in to 30 in) above the ground. The Lexus' impact to the guardrail deformed the rail 0.4 m (1.4 ft) to the south. The vehicle's direct contact to the guardrail measured 8 m (26.4 ft). **Figure 4** is a view of the vehicle's roadside departure and the direct contact to the guardrail.



Figure 3: Eastward lookback view along the guardrail.



Figure 4: Westward view of the roadside departure and guardrail impact.

CRASH SEQUENCE

Pre-Crash

The 2005 Lexus RX330 was traveling east in the outboard lane of the interstate and was driven by a 58 year old female. The front right position of the Lexus was occupied by a 60 year old male. Both occupants of the Lexus were restrained by the vehicle's manual restraint systems. The 1998 Acura 2.5TL was in the center eastbound lane driven by a 42 year old female. A 40 year old female was the Acura's front right occupant. The crash sequence was initiated when the Lexus attempted a lane change maneuver to the left. In the process of the maneuver, the Lexus cut off a 1998 Acura 2.5TL. Reportedly, the Acura swerved in a left avoidance maneuver in an attempt to avoid the encroaching vehicle and then overcorrected back to the right.

Crash

During the process of these steering maneuvers, the right front of the Acura impacted the left rear corner of the Lexus. The impact resulted in both vehicles losing directional control. The force of the impact caused the Lexus to rotate counterclockwise as evidenced by the three tire marks through the inboard traffic lane and inboard shoulder. The tire marks measured 9.8 m (32 ft) in length and were attributed to the left front, right front, and right rear tires of the Lexus. The right side wheel rims were abraded. The Lexus rotated approximately 160 degrees counterclockwise and struck the inboard guardrail with the right front fender. The force of the impact with the guardrail coupled with the vehicle's momentum resulted in a tripped right side leading rollover over the guardrail. The vehicle's pretensioners actuated and the inflatable side curtains deployed in response to the roll event. The Lexus rolled six-quarter turns and came to rest on its roof within the center median 46.3 m (152 ft) from its impact with the guardrail. The vehicle's roll trajectory was evidenced by three distinct ground contacts on the south side of the guardrail.

The Acura separated from its frontal impact with the Lexus with a northwest trajectory. The Acura traveled through the outboard lane and shoulder and impacted the north guardrail. The impact initiated a clockwise rotation to the vehicle and the Acura slid to rest facing east-northeast in the outboard westbound lane. A schematic of the crash is included at the end of this narrative report as **Figure 12**.

Post-Crash

The police, fire and ambulance personnel responded to the crash site. Reportedly, the crash resulted in a four hour back-up of traffic on the interstate. The front right passenger in the Lexus sustained fatal injuries during the crash event and was pronounced deceased at the scene. The driver of the Lexus was transported with minor injuries and hospitalized overnight for observation. The Lexus sustained disabling damage and was towed from the scene. The driver and front passenger in the Acura were not injured.

2005 Lexus RX440

Exterior Damage

The Lexus sustained minor damage as a result of the rear impact from the Acura and severe exterior damage as a result of the impact to the guardrail and the six-quarter turn rollover. The direct damage to the rear plane began 58 cm (23 in) left of center immediately outboard of the rear bumper reinforcement. The width of the direct contact measured 23 cm (9 in) and extended to the left rear corner. The width of the undeformed rear plane measured 163 cm (64 in). The maximum deformation of the sheet metal within the rear quarterpanel measured 5 cm (1.8 in) longitudinally and 6 cm (2.2 in) laterally. The length of the contact extended forward 51 cm (20 in) from the rear bumper (**Figure 5**). The nature of the physical damage was indicative of an underride impact consistent with the interaction with the Acura. The Collision Deformation Classification of the impact was 06-BLEE-3.



Figure 5: Left rear damage to the Lexus.

The Lexus impacted the guardrail with its right front fender area (**Figure 6**) consistent with the vehicle rotation during the roadside departure. The direct contact damage to the fender measured 102 cm (40 in) in length and began in the area of the right headlamp. The fender deformed rearward and downward. The inner fender collapsed around the right front tire. The elevation of the fender damage measured 75 cm (29.5 in) above the ground. This guardrail interaction tripped the vehicle into a right side leading roll. It should be noted that there was no impact damage to the front bumper system from the guardrail impact. The front bumper system was not involved. The front fascia separated in the rollover.



Figure 6: Impact damage to the right front fender.

The rollover damage to the vehicle was consistent with a multiple turn rollover event. Both side planes and the top plane exhibited direct damage that consisted of bi-directional scratches, abrasions, and buckling of the body panels. **Figures 7 through 9** are the front, right side, and left side views of the Lexus, respectively. The right roof rail deformed 28 cm (11 in) inboard from ground contact. The compromised structure of the roof buckled into a V-pattern and was deformed downward to the level of the seat backs. The windshield was fractured and separated. The backlight and all side windows disintegrated. The rear tailgate remained latched and was buckled outward 10 cm (4 in) at the belt line. The left front fender was buckled down. Dirt and debris were embedded in the body panel, undercarriage, and the left front wheel from ground

contact. The left front tire was deboned. The right and left wheelbase dimensions were reduced 7 cm (2.7 in) and 6 cm (2.2 in), respectively. The overall length of the vehicle was unchanged. The doors remained closed during the crash and were operational upon inspection. However, the doors could not be relatched due to the body deformation. The Collision Deformation Classification of the rollover was 00-TDDO-4.



Figure 7: Front view of the Lexus.



Figure 8: Right side view.



Figure 9: Left side view.

Interior Damage

The interior damage to the Lexus was attributed to the severe intrusion of the roof, the deployment of the inflatable side curtains and the occupant interior contacts as a consequence of the rollover crash. The deformed roof was in contact with the head restraint of the front right seat and compressed the restraint approximately 5 cm (2 in). The documented intrusions are listed in the table below:

<i>Position</i>	<i>Component</i>	<i>Magnitude and Direction</i>
Row 1 Left	A-pillar	33 cm (13 in) Vertical
Row 1 Left	Left roof side rail	18 cm (7 in) Vertical
Row 1 Center	Header	19 cm (7.5 in) Vertical
Row 1 Right	Header	32 cm (12.5 in) Vertical
Row 1 Right	Roof (above seat)	27 cm (10.5 in) Vertical
Row 1 Right	Right roof side rail	24 cm (9.5 in) Vertical
Row 1 Right	Right roof side rail	29 cm (11.5 in) Lateral
Row 2 Right	Right roof Side Rail	23 cm (9 in) Lateral
Row 2 Right	Roof (above seat)	15 cm (6 in) Vertical

The driver seat was adjusted to a rear third track position that measured 8 cm (3 in) forward of full rear. The total seat track travel measured 24 cm (9.5 in). The seat back was reclined 22 degrees aft of vertical. The horizontal distance from the seat back to the center hub of the steering wheel measured 53 cm (20.8 in). There were no identified contacts to the knee bolster. The left door panel arm rest was contacted by the driver's left flank during the roll sequence. This contact was located 18 cm (7 in) forward of the aft edge of the door and resulted in 1.3 in of compression. The top aspect of the door panel was also deformed; consistent with occupant contact. An area of post-crash dried blood was noted to the central aspect of the sun-roof cover.

The front right passenger seat was located in a full rear track position. The seat back was reclined 18 degrees. The horizontal distance from the seat back to the vertical face of the instrument panel measured 80 cm (31.3 in). There were no contacts to the glove box door. The front right passenger's head contacted the right roof rail at the rear aspect of the grab handle, **Figure 10**. There was a large associated area of blood evidence throughout the region and on the inflatable side curtain. The passenger's head likely pocketed and remained in this area due to the buckling and deformation of the roof.



Figure 10: Front right passenger head contact at the right grab handle.

Manual Restraint System

The manual restraint system in the 2005 Lexus RX330 consisted of three-point lap and shoulder belts in all five seat positions. The driver's safety belt consisted of a continuous loop webbing, a sliding latch plate, an adjustable D-ring and an Emergency Locking Retractor (ELR) located in the base of the B-pillar. The ELR retractor was equipped with a pretensioner that actuated during the impact sequence. Upon inspection, the driver's webbing was extended from the retractor and the retractor was locked due to the pretensioner actuation. The length of the exposed webbing measured 146 cm (57.5 in). The latch plate revealed evidence of historical use. A frictional abrasion was observed on the latch plate hardware. The D-ring was adjusted to a mid-position. No physical evidence was observed on the D-ring surface. The observations of the SCI inspection determined the driver was restrained at the time of the crash.

The front right safety belt consisted of a continuous loop webbing, a sliding latch plate, an adjustable D-ring, and a switchable Automatic Locking Retractor/Emergency Locking Retractor (ALR/ELR). The restraint was equipped with a retractor pretensioner that actuated as a result of the crash. The webbing of the front passenger restraint was extended and locked upon initial inspection. The length of the exposed webbing measured 180 cm (71 in). Blood evidence was observed along the length of the webbing. Examination of the latch plate revealed historical use indicators and an abrasion was observed to hardware indicative of occupant loading. The D-ring was adjusted to the full down position. The post-crash condition of the restraint indicated the front right passenger was restrained at the time of the crash.

Air Bag System

The Lexus was equipped with a Certified Advanced-208 Compliant (CAC) occupant protection system that included: front safety belt pretensioners, advanced dual-stage frontal air bags, and front right occupant presence detection. Additional passive protection was provided by a driver knee bolster air bag, front seat-mounted side impact thorax air bags, and roof rail-mounted inflatable side curtains. The vehicle was equipped with a rollover sensor utilized to deploy the side curtains in a rollover event. The system was controlled and monitored by a control module located under the center console. The inflatable side curtain air bags deployed in the rollover crash. The frontal air bags, knee bolster air bag and seat mounted side impact air bags did not deploy.

The inflatable side curtains deployed vertically downward from the respective roof-rails during the initial stages of the rollover. The side curtains were rectangular in shape and provided coverage from the A- to C-pillar. The gross dimensions of the membrane measured 165 cm by 33 cm (65 in by 13 in), length by height. A 25 cm (10 in) triangular sail panel designed for ejection mitigation was located between the forward aspect of the inflatable curtain and the A-pillar anchor point. Inspection of the left curtain was unremarkable for driver contact. The right curtain was heavily blood stained over a 71 cm (28 in) length forward of the right B-pillar from contact with the injured front right occupant. Refer to **Figure 11**.



Figure 11: Lateral view of the right side curtain.

OCCUPANT DEMOGRAPHICS

	<i>Driver</i>	<i>Rear Left Passenger</i>
Age / Sex:	58 year old / Female	60 year old/Female
Height:	Unknown	183 cm (72 in)
Weight:	Unknown	78 kg (171 lb)
Seat Track Position:	Rear-third track	Full-rear track
Restraint Use:	Three-point lap and shoulder	Three-point lap and shoulder
Usage Source:	SCI inspection, PAR	SCI inspection, PAR
Medical Treatment:	Treated and released the day following the crash	None, fatally injured

DRIVER INJURIES

The 58 year old driver sustained police reported minor injuries. She was transported to a local hospital for overnight observation and released. Medical records were not available.

DRIVER KINEMATICS

The restrained 58 year old female driver of the 2005 Lexus RX330 was seated in a rear-third track position in a presumed upright posture. The initial impact to the left rear area from the Acura was minor and resulted in minimal displacement of the driver. Due to the left rear impact, the Lexus initiated a counterclockwise rotation and departed the left roadside. Once off road, the right front area of the Lexus impacted the W-beam guardrail. The vehicle consequently rolled over the guardrail right side leading.

As a result of the predicted rollover, the front seat belt pretensioners actuated and the left and right inflatable side curtain air bags deployed. The actuated pretensioner tightened the three-point restraint about the driver. During the roll over event, the restrained driver remained within the front left area of the vehicle. The left side of the Lexus impacted the ground during rollover evidenced by the physical damage to the left plane and the soil and debris embedded in the body panels. The driver responded to this impact by contacting the left front door panel with her left flank. The driver's left hip contacted the door panel which was evidenced by the 3 cm (1.25") localized compression to the door panel. The Lexus continued to roll a total of six quarter turns and came to rest on its roof. The driver came to rest within the front left of the vehicle.

FRONT RIGHT PASSENGER INJURIES

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
100 ml upper mediastinum hemorrhage with pulmonary parenchyma exuding moderate amounts of bloody fluid	Serious (442202.3,3)	Shoulder belt loading
Hemorrhage of the inferior surface of the cerebellum and around the pons and medulla	Serious (140466.3,6)	Right roof side rail

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
Subarachnoid hemorrhage to the upper surfaces of both cerebral hemispheres	Serious (140684.3,1) (140684.3,2)	Right roof side rail
Atlanto-occipital dislocation with subarachnoid hemorrhage	Moderate (650208.2,6)	Indirect, caused by the body loading the cervical spine beyond its anatomical limits
3 cm (1”) laceration over upper right aspect of the forehead	Minor (290602.1,7)	Right roof side rail
Abrasions on the superior surface of the back left shoulder	Minor (690202.1,2)	Roof
Petechiae of the face and eyes	Not coded under AIS rules	Positional asphyxia

Note: the above injuries were identified in the front right passenger’s record of autopsy.

FRONT RIGHT PASSENGER KINEMATICS

The 60 year-old male front right passenger of the Lexus was seated in a full rear track position in a presumed upright posture and was restrained by the manual safety belt system. The minor impact with the Acura resulted minimal movement by the passenger. On impact with the guardrail and impending rollover, front seat belt pretensioners actuated and the left and right curtain air bags deployed. As the vehicle rolled inverted, the front right passenger was displaced within the front right area and loaded the locked manual restraint system with his torso. Upon ground impact the passenger’s head contacted the inflatable side curtain and the intruding right roof and side rail. The roof buckled and deformed and the passenger’s head became pocketed at the roof rail. The loading of the safety belt resulted in the upper mediastinum hemorrhage with pulmonary parenchyma. The right roof side rail contact resulted in the hemorrhage of the inferior surface of the cerebellum and around the pons and medulla, subarachnoid hemorrhage to the upper surfaces of both cerebral hemispheres, and the 3 cm (1”) laceration over upper right aspect of the forehead. The atlanto-occipital dislocation with subarachnoid hemorrhage was an indirect injury as a consequence of the front right passenger’s body loading the cervical spine beyond its anatomical limits while the head was pocketed in the roof. Additionally, the passenger contacted the intruding right roof with the superior surface of the back left shoulder during the roll sequence resulting in the abrasions to the area. The male passenger was pronounced deceased at the scene. The passenger’s autopsy record attributed his cause of death as multiple injuries and positional asphyxia.

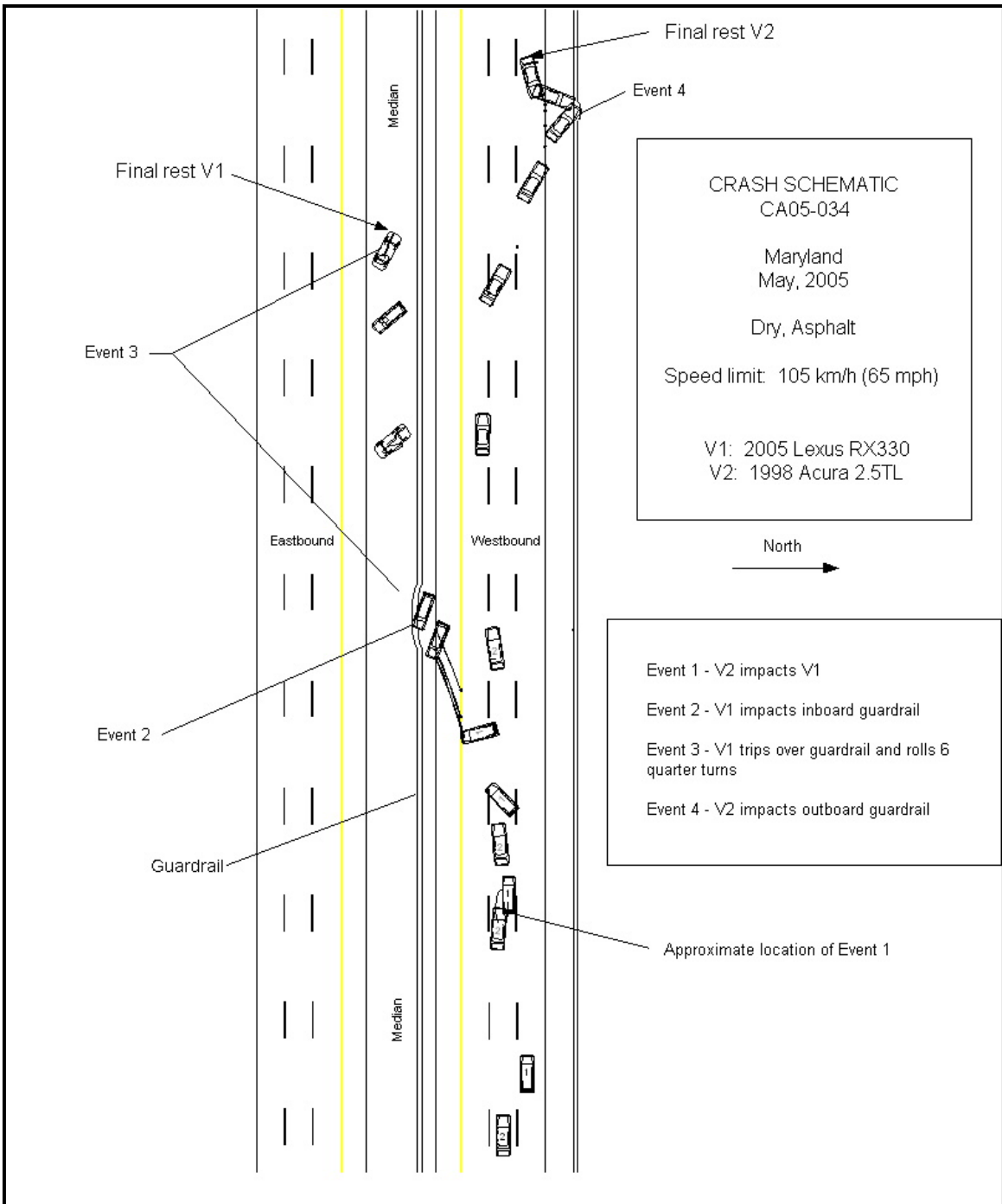


Figure 12: Crash Schematic.