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ON-SITE SIDE IMPACT INFLATABLE OCCUPANT PROTECTION INVESTIGATION

CASE NUMBER - IN-04-026
LOCATION - OKLAHOMA
VEHICLE - 2002 LEXUS IS 300
CRASH DATE - May 2004

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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 be 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 Documentation Page

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15. *Supplementary Notes* On-site air bag investigation involving a 2002 Lexus IS 300 four door sedan equipped with manual safety belts, redesigned front air bags, front seat back-mounted side impact air bags and side curtain air bags.			
16. *Abstract* This report covers an on-site investigation of an air bag deployment crash that involved a 2002 Lexus IS 300 (case vehicle), a 2004 Lexus LX 470 (1st other vehicle) and a 1990 Mazda MX-5 Miata (2nd other vehicle), which were involved in an intersection collision. This crash is of special interest because the case vehicle was equipped with multiple Advanced Occupant Protection System (AOPS) features, including front seat back-mounted side impact air bags, side curtain air bags, and the case vehicle's driver (29 year-old, female) sustained fatal injuries and her side impact and side curtain air bags deployed in this crash. The northbound case vehicle was impacted in the left front side by the eastbound LX 470 causing the case vehicle's driver air bag, side impact air bag and side curtain air bag to deploy. The case vehicle rotated clockwise, the LX 470 rotated counterclockwise and the left rear side of the case vehicle impacted the right side doors of the LX 470. Both vehicles continued to rotate, and the back of the case vehicle impacted the right rear corner of the LX 470. The LX 470 then rolled over onto its left side. The case vehicle's left front wheel separated, continued eastbound and impacted the front of the westbound Mazda. The case vehicle traveled through the median and came to final rest in the inside eastbound lane facing southeast. The LX 470 came to final rest in the east leg of the intersection across the two westbound through lanes facing southwest. The Mazda came to rest in the inside westbound through lane facing west. The impact caused the restrained case vehicle's driver to continue forward and move to the left along a path opposite the case vehicle's 300 degree direction of principal force. As the front of the LX 470 crushed the driver's door to maximum engagement and as the vehicle's rotated, the driver's head passed under her deployed side curtain air bag, through the left front window and impacted the LX 470's right fender and radio antenna base crushing the driver's skull and fracturing her neck. The driver's side curtain air bag was prevented from fully deploying as the driver's seat rotated outward (i.e., to the left) during the impact due to the crush of the driver's sill and floor pan. The space between the seat back and the "B" pillar was completely closed off, and the driver's head restraint blocked the full deployment of the driver's side curtain air bag. The driver also sustained multiple lacerations and contusions and a fractured left upper arm in this crash. The driver was fatally injured and was transported from the scene by the medical examiner.			
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BACKGROUND

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This on-site investigation was brought to NHTSA's attention in August, 2004 by NASS/GES sampling activities. This crash involved a 2002 Lexus IS 300 (case vehicle), a 2004 Lexus LX 470 (1st Other Vehicle) and a 1990 Mazda MX-5 Miata (2nd Other Vehicle). The crash occurred in May 2004, at 9:47 a.m., in Oklahoma and was investigated by the applicable city police department. This crash is of special interest because the case vehicle was equipped with multiple Advanced Occupant Protection System (AOPS) features including seat back-mounted side impact air bags and side curtain air bags, and the case vehicle's driver [29-year-old, (unknown race and ethnic origin) female] sustained a fatal injury and her front air bag, front seat back-mounted side impact air bag and side-curtain air bag deployed. This contractor inspected the case vehicle and harvested the Electronic Control Unit (ECU) on August 16, 2004, and inspected the scene and Lexus LX 470 on August 17, 2004. The Mazda was not inspected. This report is based on the police crash report, scene inspection, vehicle inspections, an interview with the insurance adjuster for the LX 470, case vehicle driver's post-mortem records, occupant kinematic principles, and this contractor's evaluation of the evidence.

SUMMARY

The case vehicle was traveling northbound on a two lane city street approaching a four leg intersection. The LX 470 was traveling eastbound and the Mazda was traveling westbound on a multi-lane, divided city street approaching the same intersection. The case vehicle and the LX 470 entered the intersection, and the front of the LX 470 impacted the left side of the case vehicle (event 1) causing the case vehicle driver's front air bag, side curtain air bag and seat back-mounted side impact air bag to deploy. In addition, the front right passenger's air bag deployed. As a result of the impact, the LX 470 rotated counterclockwise and the case vehicle rotated clockwise. The case vehicle's left quarter panel impacted the LX 470's right rear and right front doors (event 2). The two vehicles continued to rotate and the right portion of the case vehicle's back bumper and trunk lid impacted the LX 470's right rear corner (event 3). The LX 470 continued to rotate counterclockwise and rolled over onto its left side (event 4). The left front wheel separated from the case vehicle, traveled northeast and impacted the front of the westbound Mazda (event 5). The case vehicle traveled southeast across the median and came to rest in the east leg of the intersection in the inside eastbound lane facing southeast. The LX 470 came to rest in the east leg of the intersection in the middle of the two westbound through lanes facing southwest. The Mazda came to rest in the inside westbound lane facing west. At the time of the crash the light condition was daylight, the atmospheric condition clear and the roadway was dry, level bituminous.

The CDCs for the case vehicle were determined to be: **10-LYAW-3** (**300** degrees) for the impact with the front of the LX 470 (event 1), **09-LZAW-3** (**270** degrees) for the impact with the right rear and right front doors of LX 470 (event 2) and, **00-BZEW-1** for the non-horizontal impact with the right rear corner of the LX 470 (event 3). The WinSMASH reconstruction program, damage algorithm, was used to reconstruct the case vehicle's highest severity impact (event 1). The Total, Longitudinal, and Lateral Delta Vs are, respectively: 41 km.p.h. (25.5 m.p.h.), -20.5 km.p.h. (-12.7 m.p.h.), and 35.5 km.p.h. (22.1 m.p.h.). The collision fits the reconstruction model, but the results appear to be low. The WinSMASH reconstruction program, damage only algorithm, was also used to reconstruct the case vehicle's second highest severity

impact (event 2). The Total, Longitudinal, and Lateral Delta Vs are, respectively: 10.0 km.p.h. (6.2 m.p.h.), 0.0 km.p.h. (0.0 m.p.h.), and 10.0 km.p.h. (6.2 m.p.h.). The results of the WinSMASH reconstruction appear to be low for this impact as well.

The CDCs for the LX 470 were determined to be: **01-FDEW-2** (**20** degrees) for the impact with the left side of the case vehicle (event 1), **03-RPEW-2** (**90** degrees) for the impact with the left quarter panel of the case vehicle (event 2), **00 RBHE-2** for the non horizontal impact with the back bumper and trunk lid of the case vehicle (event 3), and **00-LDAO-2** for the rollover (event 4). The WinSMASH reconstruction program, damage algorithm, was used to reconstruct the LX 470's highest severity impact (event 1). The Total, Longitudinal, and Lateral Delta Vs are, respectively: 24.0 km.p.h. (14.9 m.p.h.), -22.6 km.p.h. (-14.0 m.p.h.), and -8.2 km.p.h. (-5.1 m.p.h.). The collision fits the reconstruction model, but the results appear to be very low. The LX 470's EDR recorded a maximum longitudinal Delta V of -44.7 km.p.h. (-27.8 m.p.h.). The WinSMASH reconstruction program, damage algorithm, was also used to reconstruct the LX 470's side slap impact with the case vehicle (event 2). The Total, Longitudinal, and Lateral Delta Vs are, respectively: 6.0 km.p.h. (3.7 m.p.h.), 0.0 km.p.h. (0.0 m.p.h.), and -6.0 km.p.h. (-3.7 m.p.h.). The results of the WinSMASH reconstruction appear to be low for this impact as well.

Immediately prior to the crash, the case vehicle's driver was most likely seated in an upright driving position. The location of her feet and hands is unknown. The driver's seat was positioned approximately in the middle-track position, and her seat back was slightly reclined. The position of the tilt steering column could not be determined. The driver was restrained by her manual, three-point, lap-and-shoulder safety belt.

The case vehicle's first impact with the Lexus LX 470 caused the driver to continue forward and move to the left along a path opposite the case vehicle's 300 degree direction of principal force as the case vehicle decelerated longitudinally and accelerated latterly to the right. The driver loaded her safety belt causing an abrasion to her left chest and contusions across her hips. Her right thigh contacted the steering wheel bruising the thigh. Her right knee and shin contacted the knee bolster bruising the knee and shin. Her left upper torso contacted her deployed seat-back mounted side impact air bag causing superficial abrasions to her left upper arm and elbow and superficial lacerations to her left upper arm. The driver's left upper arm also contacted the left front door fracturing the upper arm. Her left thigh and shin contacted the left front door bruising the thigh and shin. The impact broke out the driver's door window glass, and the flying glass caused multiple lacerations to her face. As the front of the LX 470 crushed the driver's door to maximum engagement and the vehicle's rotated, the driver's head passed under her deployed side curtain air bag, through the driver's door window and contacted the LX 470's right fender and radio antenna base. The driver's head contact dented the fender and left a deposit of the driver's hair on the antenna base. The contact to the fender crushed the driver's skull, bruised her left eye and fractured her neck. In addition, she lacerated her larynx on the left front window sill. The driver's side curtain air bag was prevented from fully deploying as the driver's seat rotated outward (i.e., to the left) during the impact due to the crush of the driver's sill and floor pan. The space between the seat back and the "B" pillar was completely closed off, and the driver's head restraint blocked the full deployment of her side curtain air bag. The driver was removed from the case vehicle by rescue personnel. They pried the case vehicle's driver door open, cut the

driver's safety belt and removed her from the case vehicle. The driver sustained a fatal injury and was transported from the scene by the medical examiner.

CRASH CIRCUMSTANCES

Crash Environment: The trafficway on which the case vehicle was traveling was a two-lane, undivided, city street, traversing in a north and south direction. The trafficway on which the Lexus LX 470 and the Mazda were traveling was a seven-lane divided city street traversing in an east and west direction. The two trafficways formed a four-leg intersection. Each leg of the intersection was controlled by three phase traffic signals. The case vehicle's approach roadway was on the south leg of the intersection. It had one northbound and one southbound lane, and a short channelized right turn lane separated by a painted island. The northbound travel lane was 3.5 meters (11.5 feet) in width, and the southbound travel lane was 3 meters (9.8 feet) in width. The Lexus LX 470's approach roadway was on the west leg of the intersection. It had two through lanes and a right and left turn lane. The roadway was divided by a painted median approximately 1.9 meters (6.2 feet) in width. Each through lane was approximately 3.5 meters (11.5) in width. The Mazda's approach roadway was on the east leg of the intersection. It also had two through lanes and a right and left turn lane. Each through lane was approximately 3.4 meters (11.2) in width, and the roadway was divided by a grass median approximately 2.9 meters (9.5 feet) in width near the intersection.. Pavement markings for the case vehicle consisted of solid, double yellow center lines and white edge lines. Pavement marking for the LX 470 consisted of broken white lane lines, which became solid white lane lines near the intersection and solid white turn lane lines and turn arrows. Pavement markings for the Mazda consisted of broken white lane lines, which became solid white lane lines near the intersection, solid white turn lane lines and turn arrows, solid yellow median lines and solid white outer edge lines. The speed limit for the case vehicle was 72 km.p.h. (45 m.p.h.). The speed limit for the LX 470 and the Mazda was 80 km.p.h. (50 m.p.h.). At the time of the crash the light condition was daylight, the atmospheric condition was clear, and the roadway pavement was dry, level bituminous with an estimated coefficient of friction of 0.70. Traffic density was light and the site of the crash was urban commercial. See the Crash Diagram at the end of this report.

Pre-Crash: The case vehicle was northbound in the northbound lane (**Figure 1**), and the driver was intending to travel straight through the intersection and continue north. The Lexus LX 470 was eastbound in the inside through lane (**Figure 2** below), and the driver was intending to travel straight through the intersection and continue east. The Mazda was westbound in the inside through lane, and the driver was intending to continue straight through the intersection and continue west. It is not known if the driver of the case vehicle took any action to avoid the crash. The crash occurred within the intersection (**Figure 3** below) between the case vehicle and the LX

Figure 1: Approach of case vehicle northbound to the intersection

470. The Mazda became involved in the crash as it was approaching the intersection. It was impacted by the case vehicle's left front wheel, which had broken off the case vehicle as a result of the impact with the LX 470.

Figure 2: Approach of the Lexus LX 470 to the intersection, eastbound in the inside through lane

Figure 3: Overview of area of impact (arrow) from eastbound inside lane (approach of Lexus LX 470)

Figure 4: Damage to front of Lexus LX 470 due to impact with left side of case vehicle, each increment on rods is 5 cm (2 in)

Figure 5: Damage to case vehicle's left fender and left front door due to impact with front of LX 470

Crash: The front of the Lexus LX 470 (**Figure 4**) impacted the left fender, left front wheel and left front door of the case vehicle (**Figure 5**) causing the case vehicle's driver and front right air bags to deploy. In addition, the impact caused the driver's seat back-mounted side impact air bag and side curtain air bag to deploy as well. As a result of the impact, the LX 470 rotated counterclockwise and the case vehicle rotated clockwise. The case vehicle's left quarter panel (**Figure 6** below) impacted the LX 470's right rear and right front doors (**Figure 7** below). The case vehicle continued rapid clockwise rotation due to the initial impact and the right portion of the back bumper and trunk lid impacted the LX 470's right rear corner. This third impact between the two vehicles is supported by the post-impact trajectory of the case vehicle shown on the police crash diagram and the corresponding damage to the case vehicle's back bumper and trunk lid (**Figure 8** below), and the damage to the LX 470's right rear corner (**Figure 9**) below. The height of the damage on right rear corner of the LX-470 indicates that during the spin-out phase of the crash, the back of the case vehicle was off the ground to some extent and the LX 470 was tilted

over to the right to some extent when this impact occurred. No other source for these damages could be identified. Following the crash between the case vehicle and the LX 470, the left front wheel separated from the case vehicle, traveled northeast and impacted the front of the westbound Mazda. The driver of the Mazda indicated in her statement to police that she saw the crash, stopped her car quickly and began to backup because the case vehicle was traveling toward her. Her car was then impacted on the front right by the case vehicle's left front wheel.

Figure 6: Damage to case vehicle's left quarter panel due to impact with LX 470's right side doors

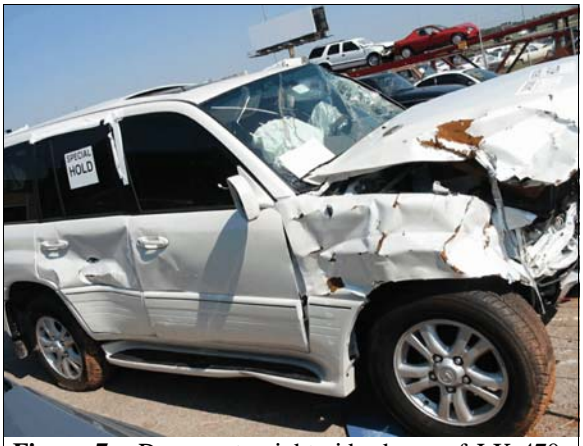


Figure 7: Damage to right side doors of LX 470 from impact with case vehicle's left quarter panel

Figure 8: Damage to right portion of case vehicle's back bumper and trunk lid (arrows) from impact with the right rear corner of the LX 470

Figure 9: Overview of damage to right rear corner of LX 470 (arrows) due to impact with back of case vehicle

Post-Crash: The impact with the Lexus LX 470 caused the case vehicle to rotate clockwise and travel northeast through the grass median and into the east leg of the intersection. It traveled along a curvilinear path through the left turn lane and inside through lane of the westbound roadway, back to the southeast through the grass median and came to rest in the east leg of the intersection in the inside eastbound lane facing southeast. The impact with the case vehicle caused the Lexus LX 470 to rotate counterclockwise and travel northeast into the westbound lanes of the east leg of the intersection. The LX 470 rotated counterclockwise about 260 degrees, rolled over one quarter roll onto its left side (**Figure 10** below) and came to rest in the middle of the two westbound

through lanes facing southwest. The Mazda came to rest in the inside westbound lane facing west. The police crash report indicated the driver backed the vehicle to its final rest position.

Figure 10: Overview of rollover damage to left side of Lexus LX 470

CASE VEHICLE

The 2002 Lexus IS 300 was a rear wheel drive, four-door sedan (VIN: JTHBD192420------) equipped with a 3.0L, I6 engine; four speed, automatic transmission; four wheel, anti-lock brakes; electronic traction control, redesigned driver and front right passenger air bags, front seat back-mounted side impact air bags, front side curtain air bags; manual, three-point, lap and shoulder seat belts in all seat positions and driver and front right safety belt pretensioners with belt force limiters. The case vehicle's wheelbase was 267 centimeters (105.1 inches). The case vehicle's odometer reading at the time of inspection is not known because the vehicle was equipped with an electronic odometer.

The various sensors in the case vehicle's advanced occupant restraint system analyze the frontal impact severity and determine if the front air bags should be deployed. The crash sensors in the side of the vehicle analyze side impact severity and deploy the front seat back-mounted side impact air bag and side curtain air bag to provide added protection to the head and torso of the driver or front right passenger during a side impact.

CASE VEHICLE DAMAGE

Exterior Damage: The case vehicle sustained direct damage to the left corner of the front bumper, left fender, hood, left front wheel, left A-pillar, left front door and left rear door due to the first impact with the Lexus LX 470. The direct damage started 70 centimeters (27.6 inches) forward of the left rear axle and extended 231 centimeters (90.9 inches) along the side of the case vehicle. Crush measurements were taken at the mid-fender level, and maximum crush was measured as 36 centimeters (14.2 inches) occurring at C_4 (**Figure 11**). The second impact with the LX 470 produced direct damage to the case vehicle's left quarter panel, left corner of the back bumper and the trunk lid. The direct damage started 26 centimeters (10.2 inches) forward of the left rear axle and extended rearward along the quarter panel for 120 centimeters (47.2 inches). Crush measurements were taken at the upper quarter panel level, and maximum crush was

Figure 11: Top view of crush to case vehicle's left front side (driver's door also damaged by rescue activities), each increment on rods is 5 cm (2 in)

measured as 22 centimeters (8.7 inches) occurring at C_2 (**Figure 12**). The third impact with the LX 470 produced direct damage to the right portion of the case vehicle's back bumper and trunk lid. The direct damage started 3 centimeters (1.2 inches) left of the right rear bumper corner and extended approximately 50 centimeters (19.7 inches) along the back bumper and trunk lid. There was no residual crush to the back bumper due to the recovery of the back bumper's plastic fascia. However, there was about 3 centimeters (1.2 inches) of crush to the top right corner of the trunk lid. The table below shows the case vehicle's crush measurements for the first impact.

Figure 12: Top view of crush to case vehicle's left quarter panel

Units	Event	Direct Damage		Field L	C_1	C_2	C_3	C_4	C_5	C_6	Direct	Field L
		Width CDC	Max Crush								±D	±D
cm	1	231	36	176	0	22	23	36	5	14	69	91
in		90.9	14.2	69.3	0.0	8.7	9.1	14.2	2.0	5.5	27.2	35.8

The table below shows the case vehicle's crush measurements for the second impact.

Units	Event	Direct Damage		Field L	C_1	C_2	C_3	C_4	C_5	C_6	Direct	Field L
		Width CDC	Max Crush								±D	±D
cm	2	120	22	120	5	22	11	6	2	0	168	168
in		47.2	8.7	47.2	2.0	8.7	4.3	2.4	0.8	0.0	66.1	66.1

The case vehicle's left side wheelbase was shortened 22 centimeters (8.7 inches) while the right side wheelbase was shortened 1 centimeter (0.4 inch). Induced damage from the three impacts involved the front bumper, front grille, hood, right fender, roof, left front door, left rear door, left quarter panel, trunk lid, and the left side windows and backlight were broken out.

The case vehicle's recommended tire size was: P215/45ZR17 and the vehicle was equipped with tires of this size. The case vehicle's tire data are shown in the table below.

Tire	*Measured Pressure*		*Recommended Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kpa	psi	kpa	psi	milli-meters	32nd of an inch			
LF	0	0	228	33	6	8	Unknown, car on top of wheel	No	Yes
RF	90	13	228	33	6	8	None	No	No
LR	214	31	228	33	5	6	None	No	No
RR	214	31	228	33	4	5	None	No	No

Vehicle Interior: Inspection of the case vehicle's interior revealed occupant contact to the left front door panel and left arm rest (**Figure 13**). In addition, the driver most likely contacted her deployed front air bag as well as her deployed seat back-mounted side impact air bag, and front side curtain air bag. Blood spots were found on the driver's front and seat back-mounted side impact air bags, but no other occupant contact marks were found on any of the air bags, and no other occupant contact evidence was found on the case vehicle's interior. Numerous passenger compartment intrusions were observed including the driver's door, left sill, left floor pan, left A-pillar, left side panel forward of the left A-pillar, steering assembly, left instrument panel (**Figure 14**) and left toe pan. There appeared to be compression of the energy absorbing steering column, but no deformation of the steering wheel rim was observed (**Figure 14**).

Figure 13: Occupant contact to case vehicle's left front door (door has also been damaged from rescue activities)

Figure 14: Steering wheel and instrument panel intrusion into case vehicle's driver space, overview of steering assembly and top air bag module flap

Damage Classification: Based on the vehicle inspection, the CDCs for the case vehicle were determined to be: **10-LYAW-3** (**300** degrees) for the impact with the front of the Lexus LX 470 (i.e., first impact), **09-LZAW-3** (**270** degrees) for the impact with the right rear and right front doors of LX 470 (i.e., second impact) and, **00-BZEW-1** for the non-horizontal impact with the right rear corner of the LX 470 (i.e., third impact).

The WinSMASH reconstruction program, damage only algorithm, was used to reconstruct the case vehicle's highest severity impact (i.e., 1st impact). The Total, Longitudinal, and Lateral Delta Vs are, respectively: 41 km.p.h. (25.5 m.p.h.), -20.5 km.p.h. (-12.7 m.p.h.), and 35.5 km.p.h. (22.1 m.p.h.). The collision fits the reconstruction model, but the results appear to be low. Based on the damage to the vehicles, the large disparity in the mass of the vehicles (i.e., the mass ratio of the LX470 to case vehicle is 1.7 to 1.0) and the post-impact trajectories of the vehicles, this contractor estimates the Delta-V range for the case vehicle to be between 48 km.p.h. (30 mph) and 64 km.p.h. (40 mph) The WinSMASH reconstruction program, damage only algorithm, was also used to reconstruct the case vehicle's second highest severity impact (i.e., 2nd impact). The Total, Longitudinal, and Lateral Delta Vs are, respectively: 10.0 km.p.h. (6.2 m.p.h.), 0.0 km.p.h. (0.0 m.p.h.), and 10.0 km.p.h. (6.2 m.p.h.). The results of the WinSMASH reconstruction appear to be low for this impact as well. The case vehicle was towed due to damage.

Figure 15: Case vehicle's steering wheel, lower left air bag module flap and air bag, steering wheel rotated right about 90 degrees

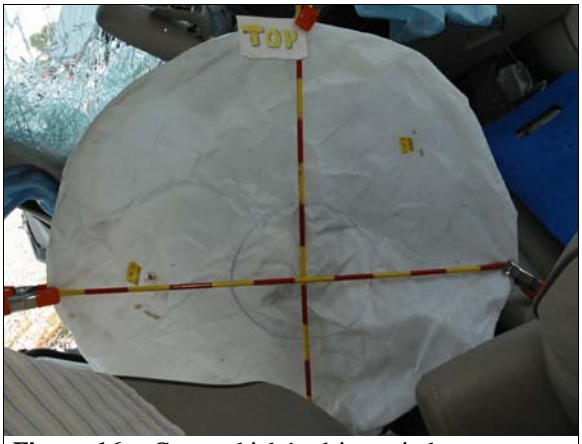


Figure 16: Case vehicle's driver air bag, camera rotated right to align with top of steering wheel

AUTOMATIC RESTRAINT SYSTEM

The case vehicle was equipped with redesigned front air bags, front seat back-mounted side impact air bags and side curtain air bags. The driver and front right passenger air bags, left side curtain air bag and driver's seat back-mounted side impact air bags all deployed as a result of the crash.

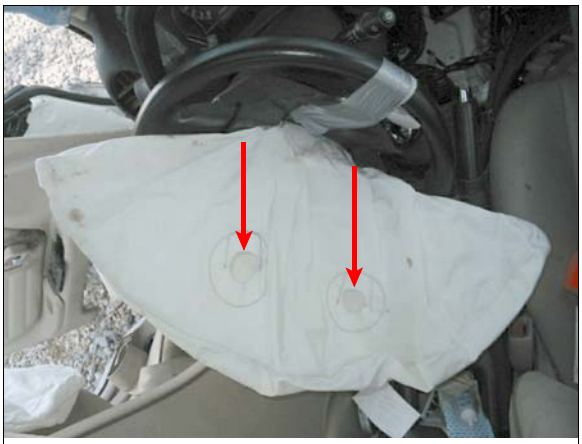


Figure 17: Top view of case vehicle's driver air bag vent ports

The case vehicle's driver air bag was located in the steering wheel hub. An inspection of the air bag module cover flaps and the air bag fabric revealed that the cover flaps opened at the designated tear points (**Figure 14** above and **Figure 15**). There was no evidence of damage during the deployment to the air bag module cover flaps or the air bag material. The air bag module cover consisted of three irregularly shaped cover flaps, each constructed of vinyl. The upper module cover flap was approximately 15 centimeters

(5.9 inches) in width with a semi-circular center section that joined at the tear seam with two lower flaps, each 9 centimeters (3.5 inches) in width at their widest point. The deployed driver's air bag (**Figure 16** above) was round with a diameter of about 60 centimeters (23.6 inches). The air bag was designed with two tethers, each approximately 11 centimeters (4.3 inches) in width and had two vent ports (**Figure 17** above), each approximately 3 centimeters (1.2 inches) in diameter, located at about the 10 and 2 o'clock positions.

The case vehicle driver's seat back-mounted side impact air bag was located in the left side of the driver's seat back. Inspection of the seat back showed that the air bag module cover flap opened at its designated tear points, and there was no evidence of damage during the deployment to the air bag material or the cover flap. The cover flap (**Figure 18**) was rectangular in shape, constructed of vinyl and was 25.5 centimeters (10 inches) in height and 11 centimeters (4.3 inches) in width. The deployed seat-back mounted side impact air bag (**Figure 19**) was approximately 36 centimeters (14.2 inches) in width and 26 centimeters (10.2 inches) in height. No vent ports or tether straps were visible on the air bag.

Figure 18: Case vehicle driver's seat-mounted side air bag module flap; each increment on rod is 5 cm (2 in)

Figure 19: Case vehicle driver's seat-mounted side air bag

The case vehicle driver's side curtain air bag was located in the left roof side rail and "A"-pillar (**Figure 20** below). Inspection of the air bag revealed no evidence of damage to the air bag during the deployment. However, the evidence indicates the rear portion of the side curtain air bag was obstructed during its deployment by the driver's head restraint (**Figure 21** below), due to the outward (i.e., to the left) displacement of the driver's seat during the impact. The intrusion of the left front sill and floor pan tilted the driver's seat outward and completely closed the space between the B-pillar and the head restraint (**Figure 21** below). The displaced head restraint obstructed the deployment of the driver's side curtain air bag preventing it from fully extending down between the B-pillar and the driver's seat back (**Figure 22** below). The deployment of the side curtain air bag was obstructed to the extent that the air bag's rear anchor strap was prevented from fully deploying and separating from its rear two ties (**Figure 23** below), and the air bag bunched-up on top of the head restraint. The inflatable portion of the driver's side curtain air bag was approximately 88 centimeters (34.6 inches) in

length and 30 centimeters (11.9 inches) in height. The rear anchor strap was approximately 25 centimeters (9.8 inches) in length. The air bag had no visible vent holes.

Figure 20: Overview of case vehicle driver's side curtain air bag

Figure 21: Case vehicle driver's head restraint obstructing driver's side curtain air bag

Figure 22: Overview of case vehicle driver's side curtain air bag obstructed by driver's headrest

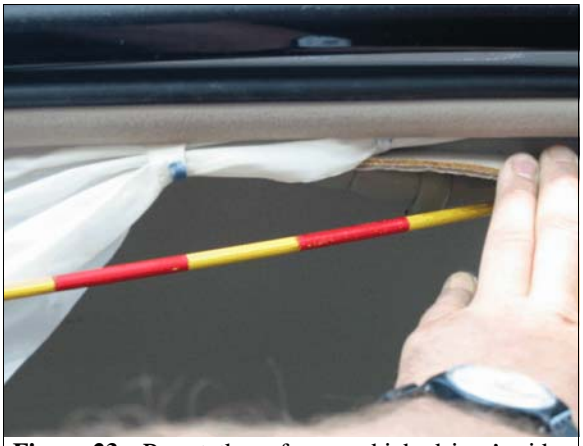


Figure 23: Rear tether of case vehicle driver's side curtain air bag, photo taken from outside vehicle

The front right passenger's air bag was located in the top of the instrument panel (**Figure 24**). Inspection of the air bag module cover flaps and the air bag fabric revealed that the cover flaps opened at the designated tear points. There was no evidence of damage during the deployment to the module cover flaps (**Figure 25** below) or the air bag material. However, several water stains were observed on the air bag material as a result of the vehicle being stored outdoors. The air bag module cover flaps were rectangular in shape and constructed of pliable vinyl. The upper module cover flap was 26 centimeters (10.2 inches) in width and 5 centimeters (2 inches) in height. The lower module cover flap was 26 centimeters (10.2

Figure 24: Case vehicle's front right instrument panel, front right air bag located above glove box (arrow)

inches) in width and 6 centimeters (2.4 inches) in height. The deployed front right passenger air bag (**Figure 26**) was rectangular in shape and was approximately 60 centimeters (23.6 inches) in height and approximately 45 centimeters (17.7 inches) in width. The air bag was designed without tethers but had two vent ports, each approximately 6.5 centimeters (2.6 inches) in diameter located at approximately the 9 and 3 o'clock positions.

Figure 25: Case vehicle's front right air bag module flaps

CRASH DATA RECORDING

The ECU, was harvested from the case vehicle, sent to NHTSA and then forwarded to the manufacturer. The manufacturer indicated that the case vehicle's ECU was not equipped with an Event Data Recorder (EDR).

Figure 26: Case vehicle's front right air bag; each stripe on the rods is five centimeters (two inches)

CASE VEHICLE DRIVER KINEMATICS

The case vehicle's driver [29-year-old, (unknown race and ethnic origin) female; 160 centimeters and 47 kilograms (63 inches, 104 pounds)] was most likely seated in an upright driving position. The location of her feet relative to the foot controls and the position of her hands at the time of the crash is unknown. The driver's seat was found positioned approximately in the middle-track position with the seat back slightly reclined. The driver's seat was most likely in this position at the time of the crash because the intrusion and damage from the crash jammed the seat in this position. The adjusted position of the tilt steering column could not be determined due to the crash induced damage to the steering column and instrument panel.

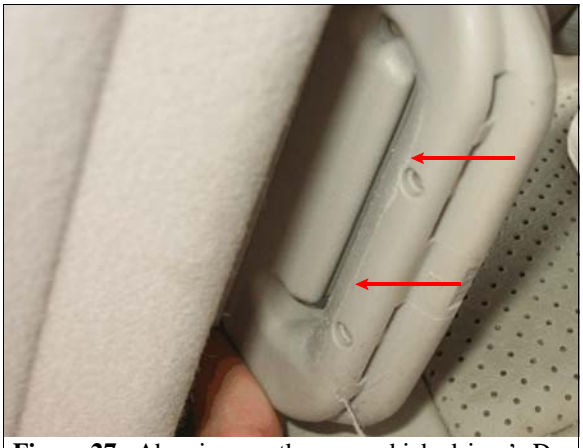


Figure 27: Abrasions on the case vehicle driver's D-ring (arrows)

The case vehicle's driver was restrained by her manual, three-point, lap-and-shoulder safety belt system. Inspection of the safety belt assembly revealed heavy abrading on the D-ring (**Figure 27**), and abrading and stretching of the shoulder belt (**Figure 28** below). In addition, the safety belt system was equipped with a retractor-mounted pretensioner and load limiter, which activated as a result of the crash.

The case vehicle's first impact with the Lexus LX 470 caused the driver to continue forward and move to the left along a path opposite the case vehicle's 300 degree direction of principal force as the case vehicle decelerated longitudinally and accelerated latterly to the right. The driver loaded her safety belt causing an abrasion to her left chest and contusions across her hips. Her right thigh contacted the steering wheel bruising the thigh. Her right knee and shin contacted the knee bolster bruising the knee and shin. Her left upper torso contacted her deployed seat-back mounted side impact air bag causing superficial abrasions to her left upper arm and elbow and superficial lacerations to her left upper arm. The driver's left upper arm also contacted the left front door fracturing her upper arm. Her left thigh and shin contacted the left front door bruising the thigh and shin. The impact broke out the driver's door window glass, and the flying glass caused multiple lacerations to her face. As the front of the LX 470 crushed the driver's door to maximum engagement and the vehicle's rotated, the driver's head passed under her deployed side curtain air bag, through the driver's door window and contacted the LX 470's right fender and radio antenna base. The driver's head contact dented the fender and left a deposit of the driver's hair on the antenna base (**Figure 29**). The contact to the fender crushed the driver's skull and bruised her left eye and fractured her neck. In addition, she lacerated her larynx on the left front window sill. The driver's side curtain air bag was prevented from fully deploying as the driver's seat rotated outward (i.e., to the left) during the impact due to the crush of the driver's sill and floor pan. The space between the seat back and the "B" pillar was completely closed off, and the driver's head restraint blocked the full deployment of the driver's side curtain air bag. Following the initial impact, the driver most likely rebounded off the door to some degree, and the subsequent side-slap impact caused her to move to the left along a path opposite the case vehicle's 270 degree direction of principal force, and she most likely impacted her door again (**Figure 30** and **Figure 31** below).

Figure 28: Case vehicle driver's shoulder belt, its stretched and abraded

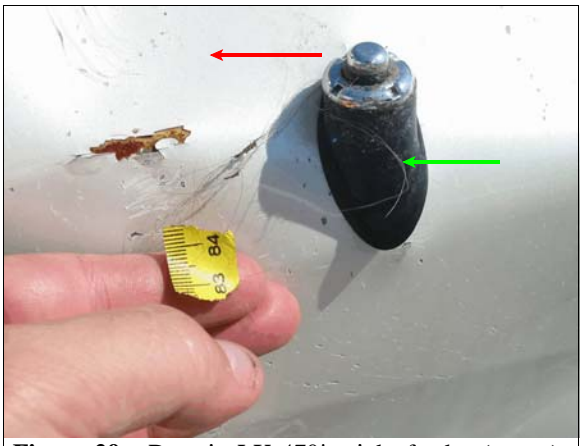


Figure 29: Dent in LX 470's right fender (arrow) and hair on antenna base (yellow tape and green arrow) due to case vehicle driver's head contact

Figure 30: Occupant contact to case vehicle's left front door (door has also been damaged from rescue activities)

The driver then moved rearward into her seat back as the back of the case vehicle impacted the right rear corner of the LX 470. The case vehicle's driver remained restrained in her seat as the case vehicle traveled to its final rest position She had to be extricated from her vehicle. Rescue personnel pried the case vehicle's left front door open, cut the driver's safety belt (**Figure 32**), and removed her from the case vehicle.

Figure 31: Top view of driver's door and driver's seat

Figure 32: Case vehicle driver's seat belt has been cut in two

CASE VEHICLE DRIVER INJURIES

The police crash report indicated the case vehicle's driver sustained a "K" (fatal) injury and was transported from the scene by the medical examiner. The table below shows the case vehicle driver's injuries and injury mechanisms.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Crushed skull including multiple posterior and posterolateral skull fractures with brain matter extruding from open[1] left lateral fracture and from left ear	maximum 113000.6,0	Exterior surface of other motor vehicle	Certain	Post-mortem examination
2	Fracture neck, not further specified	moderate 650216.2,6	Exterior surface of other motor vehicle {indirect injury}	Probable	Post-mortem examination

[1] Laceration, 12 x 8 cm (4.7 x 3.1 in), over left lateral scalp was associated with skull fractures.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
3	Fracture left upper arm, not further specified	moderate 752600.2,2	Left side interior surface, excluding hardware and/or armrest	Certain	Post-mortem examination
4	Laceration {fracture} larynx {thyroid and/or cricoid} cartilage, not further specified	moderate 340204.2,5	Left front window sill	Possible	Post-mortem examination
5	Contusion {ecchymosis} left periorbital area	minor 297402.1,2	Exterior surface of other motor vehicle	Probable	Post-mortem examination
6	Injury {hemorrhage} left conjunctiva	minor 240416.1,2	Exterior surface of other motor vehicle	Probable	Post-mortem examination
7	Lacerations, multiple, 16 x 8 cm (6.3 x 3.1 in) area face, not further specified	minor 290600.1,0	Noncontact injury: flying glass, left front glazing	Probable	Post-mortem examination
8	Abrasion, irregular, obliquely oriented, 8 x 2 cm (3.1 x 0.8 in) near left breast	minor 490202.1,2	Torso portion of safety belt system	Certain	Post-mortem examination
9	Contusions bilateral anterior hip areas	minor 590402.1,8	Lap portion of safety belt system	Certain	Post-mortem examination
10	Abrasions, superficial and irregular posterior left upper arm and lateral left elbow	minor 790202.1,2	Air bag, driver's side impact	Probable	Post-mortem examination
11	Lacerations {cuts}, superficial, posterior left upper arm	minor 790602.1,2	Air bag, driver's side impact	Probable	Post-mortem examination
12	Contusion left anterolateral thigh, not further specified	minor 890402.1,2	Left side interior hardware and/or armrest	Probable	Post-mortem examination
13	Contusion left anterolateral shin, not further specified	minor 890402.1,2	Left side interior surface, excluding hardware and/or armrest	Probable	Post-mortem examination
14	Contusions (x 3) anterior and anteromedial right thigh, not further specified	minor 890402.1,1	Steering wheel rim	Probable	Post-mortem examination
15	Contusion right lateral knee	minor 890402.1,1	Knee bolster, driver's, right of steering column	Probable	Post-mortem examination

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
16	Contusions anterior and antero-medial right shin	minor 890402.1,1	Knee bolster, driver's, right of steering column	Probable	Post-mortem examination

1ST OTHER VEHICLE

The 2004 Lexus LX 470 was an all wheel drive, four-door sport utility vehicle (VIN: JTJHT00W343------) equipped with a 4.7L, V8 engine, four speed automatic transmission and four wheel anti-lock disc brakes. The LX 470 was also equipped with dual stage driver and front right passenger air bags, front seat back-mounted side impact air bags, and front and middle seat row side curtain air bags with rollover sensor. The LX 470's wheelbase was 285 centimeters (112.2 inches). The vehicle's odometer reading is not known.

Exterior Damage: The LX 470's initial impact with the case vehicle involved the front bumper, grill and hood. The right fender was also directly damaged as the LX 470 rotated counterclockwise from the impact. The direct damage started at the front right bumper corner and extended across the full width of the front bumper. The residual maximum crush was measured as 44 centimeters (17.3 inches) occurring at C_3. The LX 470's second impact with the case vehicle involved the right front and right rear doors. The direct damage began 7 centimeters forward of the right axle and extended 164 centimeters forward along the side of the vehicle. The residual maximum crush was measured as 11 centimeters (4.3 inches) occurring at C_3. The LX 470's third impact with the case vehicle involved the rear corner of the right quarter panel. The residual maximum crush for this impact was approximately three centimeters (1.2 inches) and occurred above the belt line on the right D-pillar. The LX 470's fourth impact involved the entire left side of the vehicle. The residual maximum crush for the rollover occurred at the roof side rail over the left rear window. The maximum crush was not determined. The table below shows the crush profile for the LX 470's front impact (i.e, first impact).

Units	Event	Direct Damage		Field L	C_1	C_2	C_3	C_4	C_5	C_6	Direct	Field L
		Width CDC	Max Crush								±D	±D
cm	1	152	44	146	5	26	44	41	40	35	0	0
in		59.8	17.3	57.5	2.0	10.2	17.3	16.1	15.7	13.8	0.0	0.0

The table below shows the crush profile for the LX 470's right side impact (i.e., second impact).

Units	Event	Direct Damage		Field L	C_1	C_2	C_3	C_4	C_5	C_6	Direct	Field L
		Width CDC	Max Crush								±D	±D
cm	2	164	44	164	0	6	11	5	1	0	-48	-48
in		64.6	17.3	64.6	0.0	2.4	4.3	2.0	0.4	0.0	-18.9	-18.9

The LX 470's right side wheelbase was reduced 3 centimeters (1.2 inches) while the left side wheelbase was reduced 1 centimeter (0.4). Induced damage involved the hood, roof, right quarter panel and tailgate.

The LX 470'S recommended tire size was: P275/60R18, and the vehicle was equipped with tires of this size. The LX 470's tire data are shown in the table below.

Tire	*Measured Pressure*		*Recommended Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kpa	psi	kpa	psi	milli-meters	32nd of an inch			
LF	207	30	200	29	8	10	Sidewall scraped	Yes	No
RF	214	31	200	29	8	10	None	No	No
LR	207	30	221	32	9	11	None	No	No
RR	62	9	221	32	7	9	None	No	No

Damage Classification: Based on the vehicle inspection the CDCs for the LX 470 were determined to be: **01-FDEW-2** (**20** degrees) for the impact with the left side of the case vehicle (i.e., first impact), **03-RPEW-2** (**90** degrees) for the impact with the left quarter panel of the case vehicle (i.e., second impact), **00 RBHE-2** for the non horizontal impact with the back bumper and trunk lid of the case vehicle (i.e., third impact), and **00-LDAO-2** for the rollover (i.e., fourth impact).

The WinSMASH reconstruction program, damage only algorithm, was used to reconstruct the LX 470's highest severity impact (i.e., first impact). The Total, Longitudinal, and Lateral Delta Vs are, respectively: 24.0 km.p.h. (14.9 m.p.h.), -22.6 km.p.h. (-14.0 m.p.h.), and -8.2 km.p.h. (-5.1 m.p.h.). The collision fits the reconstruction model, but based on the front damage to the vehicle, the results appear to be low,. The LX 470's EDR recorded a maximum longitudinal Delta V of -44.7 km.p.h. (-27.8 m.p.h.). The WinSMASH reconstruction program, damage only algorithm, was also used to reconstruct the LX 470's second highest severity impact (i.e., second impact). The Total, Longitudinal, and Lateral Delta Vs are, respectively: 6.0 km.p.h. (3.7 m.p.h.), 0.0 km.p.h. (0.0 m.p.h.), and -6.0 km.p.h. (-3.7 m.p.h.). The results of

the WinSMASH reconstruction appear to be low for this impact as well. The LX 470 was towed due to damage.

Automatic Restraint System: The LX 470 was equipped with dual stage driver and front right passenger air bags, front seat back-mounted side impact air bags, and front and middle seat row side curtain air bags. In addition, the LX 470 was equipped with a rollover sensor. The driver and front right passenger air bags and both side curtain air bags deployed as a result of the crash. Both front air bags deployed due to the front impact with the left side of the case vehicle. The right side curtain air bag most likely deployed due to the right side-slap impact with the case vehicle's left quarter panel. It is this contractor's opinion that the left side curtain air bag (**Figures 33** and **34**) deployed as a result of the driver side leading rollover, which occurred late in the crash sequence as the case vehicle rotated counterclockwise and rolled over onto its left side to final rest. The EDR data indicated that the rollover sensor was active, however; the rollover deployment time and roll angle at deployment were recorded respectively as 0.0 milliseconds and 0.0 degrees. It is not understood why zeroes were reported for these data fields. The investigation indicated that the left side curtain air bag performed as designed. The deployment of the left side curtain air bag prevented the driver's head from contacting the left front window as the case vehicle rolled onto its left side. The police crash report indicated injuries to the driver's arms and torso, but no injuries were reported to his head.

Figure 33: Back section of left side curtain air bag, each increment on rods is 5 centimeters (2 inches)

Figure 34: Driver's portion of the LX 470's left side curtain air bag, yellow tape shows possible driver occupant contact scuff on air bag

The LX 470's left side curtain air bag was located in the left roof side rail and "A"-pillar. Inspection of the air bag revealed no evidence of damage to the air bag during the deployment. A possible driver contact scuff was observed on the front portion of the air bag just above the front of the driver's door arm rest. The air bag was otherwise unremarkable. The inflatable portion of the left side curtain air bag was approximately 185 centimeters (72.8 inches) in length and 37 centimeters (14.6 inches) in height. The rear anchor strap was approximately 20 centimeters (7.9 inches) in length while the front anchor strap was approximately 35 centimeters (13.8 inches) in length.

The LX 470's driver air bag was located in the steering wheel hub. An inspection of the air bag module cover flaps and the air bag fabric revealed that the cover flaps opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag module cover flaps or the air bag material. The deployed driver's air bag was round with a diameter of approximately 62 centimeters (24.4 inches). The air bag was designed with two tethers, each approximately 6.5 centimeters (2.6 inches) in width and had two vent ports, each approximately 3 centimeters (1.2 inches) in diameter, located at the 11 and 1 o'clock positions. Inspection of the air bag was unremarkable except for a large stain on the top front portion of the air bag, which appeared to be dirt and was most likely related to post-crash handling of the vehicle. Dirty hand prints and other dirty smears were found in other locations on the interior.

Crash Data Recording: The ECU, which houses the EDR, was harvested from the LX 470, sent to NHTSA, and then forwarded to the manufacturer for decoding. Data provided by the manufacturer indicated that there was a stage two deployment (i.e., both stage one and stage two fired simultaneously) of the driver and front right passenger air bags, the time from algorithm enable to deployment command was 8 milliseconds, and maximum recorded longitudinal Delta V was -44.7 km.p.h. (-27.8 m.p.h.) occurring at 150 milliseconds. The data also indicated that the air bag warning lamp was off, the driver was restrained by his safety belt and his seat was in the full rear track position. Lastly, the deployment time for the rollover side curtain air bag was indicated as 0.0 milliseconds, and the roll angle at which the side curtain air bag deployed was indicated a 0.0 degrees. A data element entitled "R/O CSA-Manual Cut Off" was reported as "Deployment Mode", which indicated that the rollover sensor was active at the time of the crash.

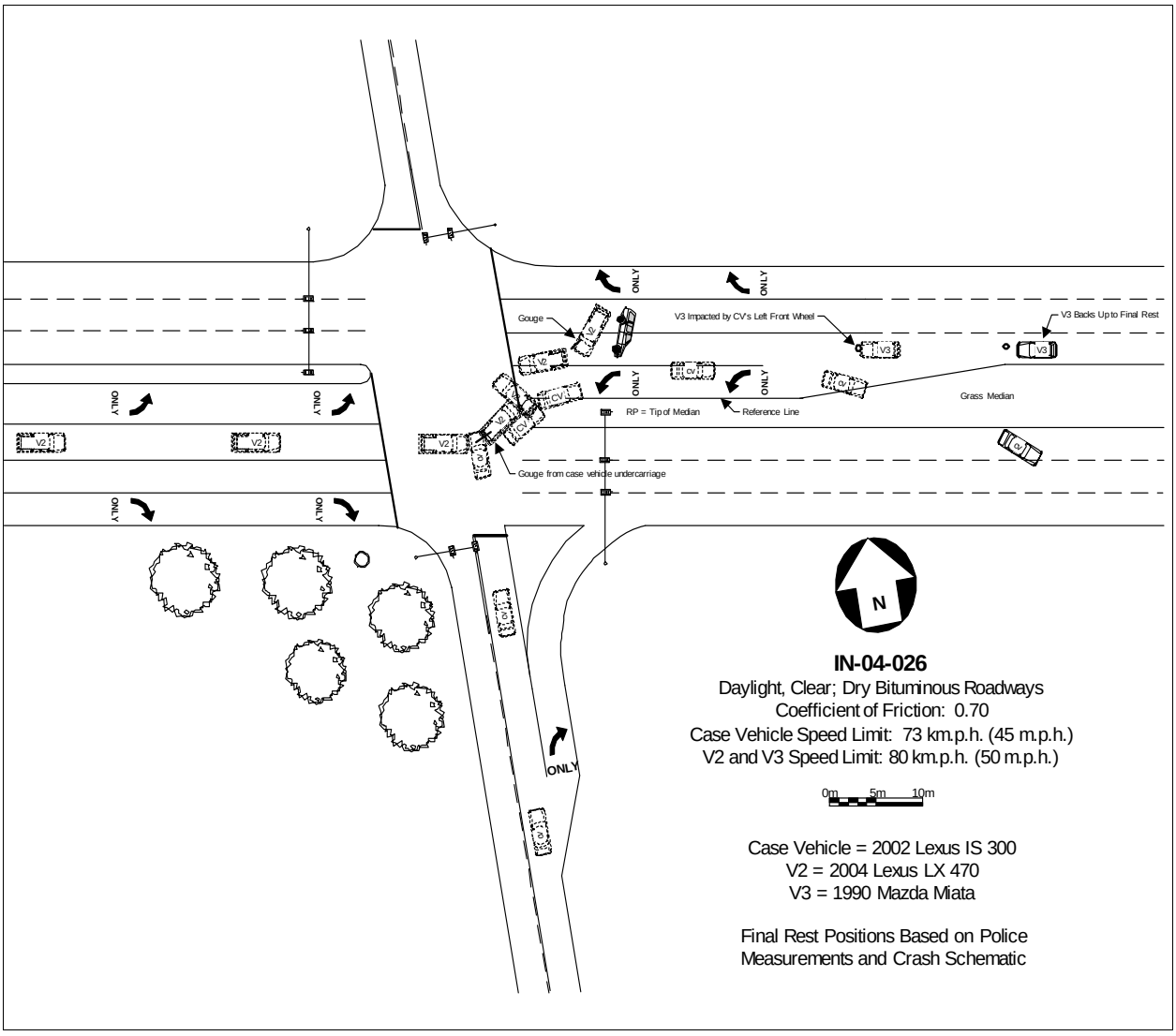
LX 470's Occupants: According to the police crash report, the LX 470's driver [39-year-old, (unknown race and ethnic origin) male] was restrained by his manual, three-point, lap-and-shoulder, safety belt system. The police crash report indicated the driver sustained an "A" (incapacitating) injury and was transported to a treatment facility. The police crash report indicated the driver sustained injuries to his arms as well as internal and external injuries to his torso. In addition, the police crash report indicated the driver was not ejected from his vehicle as a result of the crash.

2ND OTHER VEHICLE

The 1990 Mazda MX-5 Miata was a front wheel drive, two door sport coupe (VIN: JM1NA3511L0------). The Miata was equipped with a driver air bag which did not deploy as a result of this vehicle's impact.

Exterior Damage: The Mazda was driven from the scene by the driver. The Mazda was not inspected. No damage photographs of the Mazda were available; therefore, no CDC could be assigned.

Mazda's Occupants: According to the police crash report, the Miata's driver [41-year-old, (unknown race and ethnic origin) female] was restrained by her manual, three-point, lap-and-shoulder safety belt system. The police crash report indicated the driver was not injured as a result of the crash.


ONLY
Gouge
V3 Impacted by CV's Left Front Wheel
V3 Backs Up to Final Rest
V2
V3
CV
Grass Median
RP = Tip of Median
Reference Line
Gouge from case vehicle undercarriage
N
IN-04-026
Daylight, Clear; Dry Bituminous Roadways
Coefficient of Friction: 0.70
Case Vehicle Speed Limit: 73 km.p.h. (45 m.p.h.)
V2 and V3 Speed Limit: 80 km.p.h. (50 m.p.h.)
0m 5m 10m
Case Vehicle = 2002 Lexus IS 300
V2 = 2004 Lexus LX 470
V3 = 1990 Mazda Miata
Final Rest Positions Based on Police
Measurements and Crash Schematic