Side Air Bag Investigation/ Vehicle to Vehicle
Dynamic Science, Inc. / Case Number: DS04008
2004 Lexus RX330
California
April, 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.

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16. Abstract

This on-scene, in-depth investigation focused on the deployment of the left side thoracic air bag of a FMVSS 208 Compliant vehicle. In addition, the left side impact also resulted in deployments of the driver's frontal air bag and knee air bag. This two vehicle crash took place in April, 2004 at 1510 hours. The weather was clear and the crash occurred at a three-leg intersection.

The case vehicle is a 2004 Lexus RX 330 four-door sport utility vehicle that was being driven by a fully restrained 63 year-old female. The case vehicle is equipped with nine air bags which include: front air bags for the driver and front right passenger positions, seat back laterally mounted side thoracic air bags for both front bucket seats, a driver's knee air bag located under the steering column and side curtains for the outboard seat positions of both the front and second rows. The driver of the case vehicle was traveling westbound, approaching the intersection in the left turn lane with the intention of turning left. It appears that the driver of the case vehicle initiated the left turn and entered the intersection at a slow rate of speed without adhering to the red signal phase.

The other vehicle is a 1998 Ford F-150 pickup truck that was being operated by a 21 year-old male and according to the police, the front, right seated position was occupied by a 21 year-old female. The other vehicle was proceeding northbound at a passenger estimated speed of approximately 80 km/h (50 mph). The driver of the Ford pickup truck was intending to proceed north through the intersection when the case vehicle turned left in front of their path of travel.

The front of the other vehicle (Ford F-150) impacted the left fender/door region of the case vehicle. Upon impact, the driver's front air bag, knee air bag and left side thoracic air bag deployed. The driver's frontal air bag, knee air bag and left side thoracic air bags deployed. The involved vehicles disengaged, coming to their respective final rest positions. The driver of the case vehicle sustained a concussion with multiple facial abrasions and reported left side pain. She underwent numerous radiographic tests which all proved to be negative. She was released from the hospital one day following the crash. The driver of the other vehicle reportedly sustained a laceration to his left hand and the front, right seated passenger reportedly sustained minor contusions to her chest and leg.

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Crash Investigation
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BACKGROUND:

The focus of this on site investigation was the performance of the side air bags that were installed in a 2004 Lexus RX330 four-door sport utility vehicle that was being driven by a restrained 63 year-old female. The case vehicle was equipped with nine air bags. There are frontal air bags for the driver and front right passenger positions, in addition to seat back mounted side thoracic side air bags for both front bucket seat positions. A driver's knee air bag is mounted immediately beneath the steering column/lower instrument panel area. Side curtains are present for the outboard seat positions of both the front and second rows. The case vehicle was also equipped with front pretensioners that operate in concert with the air bag sensor assembly. The Lexus was struck on the left side by a 1998 Ford F-150 pickup truck. The impact resulted in sufficient longitudinal and lateral deceleration of the Lexus to command the deployment of deployment of the driver's seat back mounted, side thoracic air bag, the driver's frontal air bag, and the driver's knee air bag. The driver of the case vehicle sustained a concussion (AIS-2) with multiple facial abrasions (AIS-1) and reported left side pain. She underwent numerous radiographic tests which all proved to be negative. She was released from the hospital one day following the crash.

Figure 1. Front, left three-quarter view 2004 Lexus

This Side Air Bag Investigation case was initially identified by a NHTSA review of GES police reports. Dynamic Science, Inc. (DSI) was notified of the crash on April 21, 2004. Field work was completed on May 10, 2004.

SUMMARY

Crash Site

This two vehicle, front to side obtuse angle impact occurred in April 2004 at 1510 hours. The weather was clear and the crash occurred at a three-leg intersection. The east leg of the intersection consists of one eastbound travel lane and two westbound lanes (+1.7%) with a designated left turn only lane and a left/right turn lane. The south leg of the intersection is comprised of a right turn lane and a northbound through travel lane that had a +7% grade. There are two southbound travel lanes and a double yellow center line separates the north/southbound traffic. The north leg consists of one northbound lane and two southbound travel lanes (one left turn only lane). The speed limit for the north/southbound roadway is 45 mph (72 km/h) and the posted speed limit for

Figure 2. Pre-impact trajectory of other vehicle and point of impact in foreground

the east leg of the intersection is 35 mph (56 km/h). There are numerous tri-colored traffic signal s present which regulate traffic for both roadways.

Figure 3. Pre-impact trajectory of case vehicle and point of impact in foreground

Pre-Crash

The case vehicle was a 2004 Lexus RX 330 four-door sport utility vehicle that was being driven by a fully restrained 63 year-old female (158 cm, 62 in/ 58 kg, 110 lbs) The case vehicle is equipped with nine air bags which include; front air bags for the driver and front right passenger positions, seat back laterally mounted side thoracic air bags for both front bucket seats, a driver's knee air bag located under the steering column and side curtains for the outboard seat positions of both the front and second rows. The driver of the case vehicle was traveling westbound, approaching the intersection in the left turn lane with the intention of turning left. It appears that the driver of the case vehicle initiated the left turn and entered the intersection at a slow rate of speed without adhering to the red signal phase.

The other vehicle was a 1998 Ford F-150 pickup truck that was being operated by a 21 year-old male and according to the police, the front, right seated position was occupied by a 21 year-old female. It was unknown whether the driver or the passenger were restrained at the time of the crash. The other vehicle was proceeding northbound in the second lane at a passenger estimated speed of approximately 80 km/h (50 mph). The driver of the Ford pickup truck was intending to proceed north through the intersection when the case vehicle turned left in front of their path of travel.

Crash

The front of the other vehicle (Ford F-150 pickup truck) impacted the left fender/door region (10LYEW3) of the case vehicle in an obtuse angle front to side impact configuration. Upon impact, the driver's front air bag, knee air bag and left side thoracic air bag deployed. The total velocity change for the case vehicle was calculated utilizing the Missing Vehicle Algorithm of the WinSmash collision model and was 20 km/h (12 mph) . The longitudinal change in velocity was -12.9 km/h (-8.0 mph) and the latitudinal Delta V was calculated to be 15.3 km/h (9.5 mph).[1] The driver's frontal air bag, knee air bag and left side thoracic air bags deployed. The pretensioner for the applied driver's three-point lap and shoulder belt activated and the webbing was found to be spooled out.

[1] The insurance company for the driver of the case vehicle would not grant permission for the harvest and acquisition of the vehicle's EDR

Post-Crash

The involved vehicles disengaged, coming to their respective final rest positions. The driver of the case vehicle sustained a concussion (AIS-2) with multiple facial abrasions (AIS-1) and reported left side pain. She underwent numerous radiographic tests which all proved to be negative. She was released from the hospital one day following the crash. The driver of the other vehicle reportedly sustained a laceration (AIS-1) to his left hand and the front, right seated passenger reportedly sustained minor contusions (AIS-1) to her chest and leg.

VEHICLE DATA - 2004 Lexus RX330

The 2004 Lexus RX330 was identified by the Vehicle Identification Number (VIN): JTJGA31U040xxxxxx. The 2004 Lexus RX330 was equipped with a 3.3 liter 6 cylinder engine along with a five speed automatic transmission. The case vehicle was equipped with power assisted ventilated front and solid rear disc brakes, front wheel driver, and power steering. The front suspension has independent struts with coil springs, L-shaped lower arms, gas pressurized shock absorbers and stabilizer bar. The rear suspension consists of independent dual link struts with coil springs, dual links, strut rods, gas pressurized shock absorbers and stabilizer bar. In addition, the case vehicle was equipped with tire pressure monitor sensors, seatbelt pretensioners with force limiters, anti-lock braking system (ABS) and a vehicle stability control (VSC) which detects side slip of the wheels and corrects the problem using modulation of engine power in conjunction with an application of the braking system.

The 2004 Lexus RX330was equipped with Goodyear Eagle RSA P235/55R18 tires. The case vehicle is equipped with a Tire Pressure Monitor system which operates utilizing sensors that are located in the valve stems of each tire and signal to alert the driver/operator if the tire pressure falls below a predetermined level. The manufacturer recommended cold tire pressure is 207 kPa (30 psi). The specific tire data is as follows:

Tire	Tread	Measured pressure	Maximum pressure
LF	8 mm (10/32 in)	165 kPa (24 psi)	303 kPa (44 psi)
LR	8 mm (10/32 in)	200 kPa (29 psi)	303 kPa (44 psi)
RR	8 mm (10/32 in)	207 kPa (30 psi)	303 kPa (44 psi)
RF	8 mm (10/32 in)	221 kPa (32 psi)	303 kPa (44 psi)

The front seating positions in the 2004 Lexus RX330 were configured with leather covered forward facing bucket seats that were undamaged. Both front bucket seats are equipped with adjustable head restraints that were undamaged. The seat track position for the left front seat was electronically controlled and was adjusted between the middle position and the forward most seat track position. The front right seat track was adjusted between the middle and rearmost seat track position.

The second row consists of a leather covered split bench with folding seat back supports. The seat accommodates three occupants and there are three manual three-point lap and shoulder restraints available. There are adjustable head restraints available at all three second row seated positions and they were undamaged. The second row, split bench seat is equipped with

adjustable seat tracks which were noted to be fully rearward at all three rear seated positions.

VEHICLE DAMAGE

Exterior Damage - 2004 Lexus RX330

The case vehicle sustained significant deformation to its left side plane with direct contact initiating 123.0 cm (48.4 in) forward of the left rear axle and extending 162.0 cm (63.8 in) forward. The combined direct and induced damage was 273.0 cm (107.5 in) in length. The left side doors were jammed shut. A hydraulic power spreader/wedgie tool was used to open the left front door at the B-pillar post. The left rear door was also opened as a result of the rescue efforts. After the door was opened , it was forcibly moved forward and the deployed left side air bag curtain was cut away for easier access to the injured driver. Damaged components included the left fender, left front, side door glazing, left side doors, left sill, hood, grille and front windshield glazing. Six equidistant crush measurements were documented along the left lower sill region and the residual measured crush profile is as follows: C_1 = 0 cm, C_2 = 9.0 cm (3.5 in), C_3 = 11.0 cm (4.3 in), C_4 = 14.0 cm (5.5 in), C_5 = 28.0 cm (11.0 in), C_6 = 10.0 cm (3.9 in). The maximum crush depth was 40.0 cm (15.7 in.) and was located at the lower left A-pillar.

There were surface scratches noted to the right quarter panel and right rear door panel that were attributed to moving the vehicle in the salvage yard (not related to crash). The left wheelbase was shortened by 2.5 cm (1.0 in.) while the right wheelbase was elongated by 3.0 cm (1.2 in).

CDC:	10LYEW3	
Delta V:	Total	20.0 km/h (12.4 mph)
	Longitudinal	-12.9 km/h (-8.0 mph)
	Latitudinal	15.3 (9.5 mph)
	Energy	40,202 joules

Interior Damage - 2004 Lexus RX330

The interior greenhouse area of the case vehicle sustained intrusion which was isolated to the left front and left rear seated positions due primarily to the lateral displacement of numerous components. The left kick-panel (forward of the A-pillar), left A and B-pillars, left front door panel, left sill and the left rear door panel were displaced laterally while the instrument panel at the front left position intruded longitudinally due to induced buckling.

The documented intrusions are as follows:

Position	Intruded Component	Magnitude of Intrusion	Direction
LF	Kick panel	17.0 cm (6.7 in)	Lateral
LF	Door panel	17.0 cm (6.7 in)	Lateral
LF	Sill	14.0 cm (5.5 in)	Lateral
LR	B-pillar	12.0 cm (4.7 in)	Lateral
LR	Door panel	12.0 cm (4.7 in)	Lateral
LF	Instrument panel	5.0 cm (1.9 in)	Longitudinal
LF	A-Pillar	3.0 cm (1.2 in)	Lateral

The laminated AS-1 windshield glazing was cracked during the crash and was subsequently cut out by rescue personnel. The front, left tempered side glazing disintegrated due to the impact forces. Occupant contact scuff marks were identified to the front left side door armrest, and center console. In addition lipstick cosmetic transfers were noted to the drivers deployed frontal air bag and the steering column rotated 4.0 cm (1.6 in) vertically upward probably due to occupant loading. There were no known injuries related to the occupant loading.

The interior of the case vehicle consisted of two leather covered front bucket seats. The second row was composed of a split bench with folding seatback supports. There are adjustable head restraints at all five interior seated positions. There was no damage noted to the interior seats or head restraints.

MANUAL RESTRAINT SYSTEMS - 2004 Lexus RX330

The driver's manual restraint system consisted of a continuous loop three-point lap and shoulder belt with a free sliding latch plate and an Emergency Locking Retractor (ELR). The shoulder belt adjuster was in the fully down position. The driver's lap and shoulder belt exhibited evidence of occupant loading. The plastic material of the free sliding latch plate loop showed a belt webbing load pattern with abraded plastic. There was a documented scuff/ retractor load mark noted to the drivers shoulder belt webbing. In addition, the pretensioner activated and locked the excess webbing in a spooled out position upon vehicle inspection.

The front, right passengers manual restraint system also consisted of a continuous loop three-point lap and shoulder belt with a free sliding latch plate and a switchable retractor. The shoulder belt adjuster was in the full down position. There was not an occupant seated at this position.

The three seated positions of the rear split bench seat were equipped with manual three-point lap and shoulder belts with free sliding latch plates and switchable retractors. The rear outboard sets are equipped with LATCH anchor points located beneath the seat bight.

Figure 4. View showing spooled out webbing

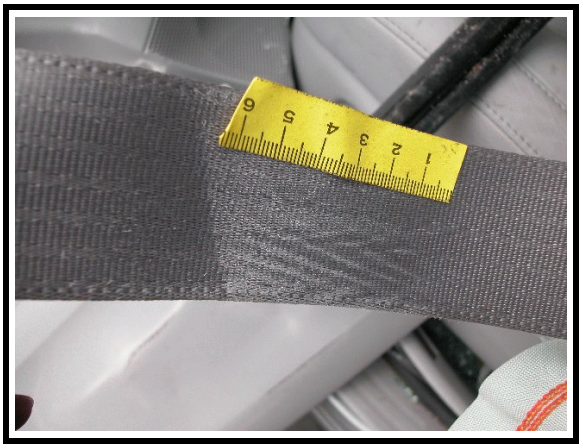

Figure 5. Scuff and retractor marks to drivers belt webbing

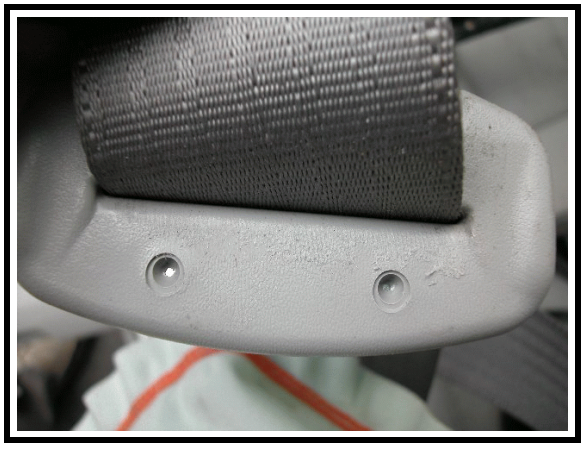

Figure 6. View showing belt load pattern to plastic free sliding latch plate loop

FRONTAL, SIDE and KNEE AIR BAG SYSTEMS - 2004 Lexus RX330

The Lexus RX330 was equipped with a supplemental restraint system that consists of a driver's frontal air bag, front passenger air bag, driver's knee air bag that is mounted below steering column, side thoracic air bags that are mounted at the lateral aspects of the front seat back supports, and side rail mounted curtain shield air bags. In addition, the Lexus was equipped with seatbelt pretensioners for the front seated positions.

Figure 7. View showing deployed drivers air bag

The driver's frontal air bag deployed during the crash. The driver air bag module was located in the center steering wheel hub with asymmetric horizontal flaps with side vertically oriented flap tear seams. The diameter of the deflated circular air bag was 54.0 cm (21.3 in.). It was equipped with two internal tether straps and had two exhaust vent port holes at the 11 and 01 o'clock positions. The maximum deflated air bag excursion was measured at 33.0 cm (12.9 in.). There were two 5.0 cm (2 in.) vertical tears located on the back of the air bag that were 17 cm (6.7 in.) apart. In addition, the back side of the air bag exhibited numerous small cuts or abrasions due to flying glass fragments. There were documented blood spatters and deposits noted at the front, center of the drivers air bag and residual lip stick cosmetic transfers were noted along the bottom seam.

Figure 8. View showing deployed knee air bag

The front, left lower instrument panel mounted knee air bag deployed as a result of the left side impact. The module flaps consists of an asymmetric horizontal tear seam cover that opened at the designated areas. The deflated knee air bag measured 24.0 cm (9.4 in.) at the base and 55.0 cm (21.7 in.) at the leading edge. There was no damage or evident areas of occupant contact noted to the driver's knee air bag.

The front, left lateral seat back mounted side thoracic air bag deployed as a result of the left side impact. The deflated air bag unit measured 54.0 cm (21.3 in.) vertically and 25.0 cm (9.8 in.) wide. There were a total of 8 (4 on each side of air bag) vertically situated exhaust vent port holes that measured 0.5 cm (0.2 in) in diameter. The left, outboard surface of the thoracic air bag exhibited scuff marks that were attributed to contact with the intruding front, right door panel/armrest.

The left side roof side rail mounted curtain shield air bag deployed resultant to the left side impact forces. The entire curtain shield measured 167.0 cm (65.7 in.) in length and 39.0 cm (15.3 in.) in width. The forward section that extended from the left side B-pillar to the left A-pillar was cut out by rescue personnel during the extrication process. The were no indications of apparent occupant contacts noted to the side shield curtain.

The front, right passenger air bag was a top instrument panel mounted air bag module with non-visible tear seams. The front, right air bag, the right side thoracic air bag and the right side rail mounted curtain shield air bags did not deploy.

Figure 9. View showing deployed left side curtain shield air bag

Figure 10. View showing deployed left side thoracic air bag

VEHICLE DATA - 1998 Ford F-150

Description:	1998 Ford F-150 Full Size Pickup Truck	
VIN:	Unknown	
Odometer:	Unknown	
Engine:	Unknown	
Reported Defects:	Unknown	
Cargo:	Unknown	
Damage Description:	Moderate, Frontal Deformation/specifics unknown	
CDC:	N/A	
Delta V:	Total	18.0 km/h (11.2 mph)
	Longitudinal	-18.0 km/h (-11.2 mph)
	Latitudinal	0.0 km/h
	Energy	16,912 joules

OCCUPANT DEMOGRAPHICS - 2004 Lexus RX330

	Driver
Age/Sex:	63/Female
Seated Position:	Front, left
Seat Type:	Bucket, leather covered
Height:	158 cm (62 in)
Weight:	58 kg (110 lb)
Occupation:	Unknown
Pre-existing Medical Condition:	Unknown
Alcohol/Drug Involvement:	None (<0.01%)
Driving Experience:	Unknown
Body Posture:	Upright, specifics are unknown
Hand Position:	Unknown
Foot Position:	Right foot lightly depressing accelerator pedal while left foot on floor
Restraint Usage:	Three-point manual lap and shoulder belt available and used.
Air bag:	Deployment of the front, left drivers air bag, deployment of the driver's knee air bag, deployment of front, left seat back (laterally mounted) thoracic air bag and deployment of the left side air bag curtain.

OCCUPANT DEMOGRAPHICS - 1998 Ford F-150

	Driver	Occupant 2
Age/Sex:	21/Male	21/Female
Seated Position:	Front, left	Front, right
Seat Type:	Unknown	Unknown
Height:	Unknown	Unknown
Weight:	Unknown	Unknown
Occupation:	Unknown	Unknown
Pre-existing Medical Condition:	Unknown	Unknown
Alcohol/Drug Involvement:	None	None
Driving Experience:	Unknown	Unknown
Body Posture:	Unknown	Unknown
Hand Position:	Unknown	Unknown
Foot Position:	Right foot applying heavy brake application while his left foot was likely on the floor	Unknown
Restraint Usage:	Unknown	Unknown

OCCUPANT INJURIES - 2004 Lexus RX330

Driver: Injuries obtained from Emergency Medical Service (EMS), Emergency Room, Radiologist and Hospital Discharge Summary reports.

Injury	OIC Code	Injury mechanism	Confidence
Concussion	161000.2, 0	Driver's frontal air bag	Probable
Multiple left side facial abrasions	290202.1,2	Flying glass fragments	Possible

OCCUPANT INJURIES - 1998 Ford F-150

	Injury	OIC Code	Injury mechanism	Confidence
Driver	Laceration to left hand	790602.1, 2	Unknown	NA
Front right occupant	Chest contusion	490402.1,9	Unknown	NA
	Bilateral leg / lower extremity contusions	890402.1,3	Unknown	NA

OCCUPANT KINEMATICS - 2004 Lexus RX330

Driver kinematics

The 63 year-old female driver (158 cm., 62 in/ 58 kg, 110 lbs) was wearing the available three-point manual lap and shoulder belt with the shoulder belt webbing most likely extending across her chest region and the lap belt situated at her hip region. This is based upon heavy abrasions noted to the free sliding latch plate loop, belt webbing stretch marks and obtained official medical data. The front, left seat was adjusted between the middle and forward most seat track position. She responded to the 10 o'clock (320 degree) principle direction of force by moving forward and to her left. She heavily loaded the applied lap and shoulder belt webbing as the pretensioner actuated. The applied shoulder belt along with the lap belt, prohibited extended forward movement of her upper and lower torso. Her knees likely contacted the deploying knee air bag which did not result in injury. Her head and face likely pitched downward as her face contacted the lower seam area of the drivers air bag. This was evidenced by a residual lip stick cosmetic transfer. She reportedly sustained numerous left side facial abrasions (AIS-1) due to flying glass fragments. In addition, she was diagnosed with blunt head trauma or a concussion (AIS-1) due to her interaction with the driver's air bag.

The case vehicle rotated in a rapid clockwise fashion and the driver likely responded by moving to her left. She made contact with the left door arm rest as evidenced by a residual scuff mark. Her left flank are probably contacted the deploying thoracic, left side air bag. She complained of left side pain, however, did not receive any injuries due to her interaction with the armrest and air bag. The left side of her face and head likely contacted the left side curtain shield air bag, but did not sustain further injuries.

As the case vehicle came to its final rest position, the restrained driver was maintained in her respective seated position. The left front door was jammed shut and the driver needed to be extricated from the vehicle. Rescue personnel opened the left front by use of a hydraulic power spreader/ wedgie device and the driver was subsequently transported to a hospital vis ground ambulance. She was treated for her injuries and observed over night due to her age and possible head injury. The driver was released from the hospital one day after the crash.

Attachment 1. Scene Diagram