Certified Advanced 208-Compliant Air Bag and Hybrid Vehicle Investigation
Vehicle to Objects
Dynamic Science, Inc. / Case Number: DS06023
2006 Lexus RX440h
Washington
September 2006

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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-site investigation focused on the Certified Advanced 208-Compliant air bag and hybrid systems in a 2006 Lexus RX440h. This single vehicle crash occurred in September 2006 at 0102 hours in an urban area of Washington. The crash occurred in the southbound lane of a two-way city street.

The case vehicle was a 2006 Lexus RX440h being driven by a restrained 22-year-old male. There were no other occupants in the vehicle. The driver of the Lexus was traveling south in the right curb lane. A police officer that was in the area observed the Lexus and estimated the vehicle's precrash speed at around 80 - 97 km/h (50 - 60 mph). The Lexus was traveling on a straight section of roadway, then entered an elbow curve to the left. The driver fell asleep, failed to negotiate the curve and impacted the right curb several times with the case vehicle's right tires.

The Lexus traveled over the curb, across a grassy strip and the front right of the Lexus impacted a large utility pole. At impact, the driver's front and knee air bags deployed and his seat belt retractor pretensioner actuated. During this impact, the pole traveled past the right front bumper corner and became wedged between the engine compartment and the right front tire. The Lexus came to final rest still in contact with the pole, facing southeast. The driver reported to police that he was not injured in the crash, but he was screened by fire department personnel and was transported to an area trauma center as a precaution. The case vehicle was towed due to damage and was later declared a total loss.

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Dynamic Science, Inc.
Crash Investigation
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Background

Description

This on-site investigation focused on the performance of the Certified Advanced 208-Compliant air bag and hybrid systems in a 2006 Lexus RX440h. This single vehicle crash occurred in September 2006 at 0102 hours in an urban area of Washington. The crash occurred in the southbound lane of a two-way city street.

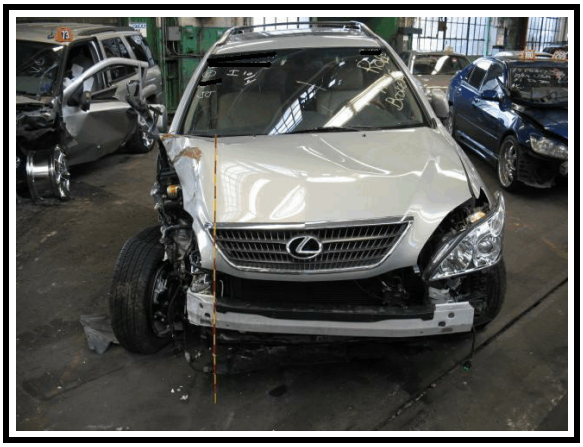

Figure 1. Front - 2006 Lexus RX440h

The case vehicle was a 2006 Lexus RX440h being driven by a restrained 22-year-old male. There were no other occupants in the vehicle. The driver of the Lexus was traveling south in the right curb lane. A police officer that was in the area
observed the Lexus and estimated the vehicle's precrash speed at around 80 - 97 km/h (50 - 60 mph). The Lexus was traveling on a straight section of roadway, then entered an elbow curve to the left. The driver fell asleep, failed to negotiate the curve and impacted the right curb several times with the case vehicle's right tires.

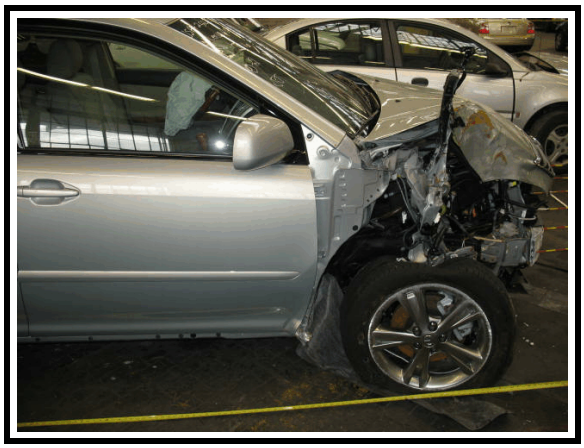

Figure 2. Right front damage

The Lexus traveled over the curb, across a grassy strip and the front right of the Lexus impacted a large utility pole. At impact, the driver's front and knee air bags deployed and his seat belt retractor pretensioner actuated. During this impact, the pole traveled past the right front bumper corner and became wedged between the engine compartment and the right front tire. The Lexus came to final rest still in contact with the pole, facing southeast. The driver reported to police that he was not injured in the crash, but he was screened by fire department personnel and transported to an area trauma center as a precaution. The case vehicle was towed due to damage and later declared a total loss.

This crash was identified by DSI personnel and provided to NHTSA on October 18, 2006. On October 20, 2006, NHTSA requested that the vehicle be inspected and the Electronic Data Recorder (EDR) be removed if insurance permission could be obtained. Attempts were made to secure insurance permission for EDR retrieval, but the request was not granted before the Lexus was sold at auction. The vehicle inspection was completed on October 26, 2006.

There were difficulties determining the correct crash location. The insurance company did not have a copy of the police report and did not know the investigating police jurisdiction. On November 8, 2006, the investigating jurisdiction was finally determined to be a university police agency and a police report was obtained the same day. The scene inspection was completed on November 8, 2006.

Summary

Crash Site

This single vehicle crash occurred in September 2006 in an urban area of Washington. The crash occurred in the southbound lane of a city street.

In the case vehicle's pre-crash area there was one north and one southbound travel lane, separated from one another by a center, left-turn only lane. In the area where the elbow curve begins, the center turn lane becomes a raised median containing trees and small shrubs. On the west side of the street there was a dedicated parking lane that ends just before the southbound lane begins to curve to the left. Adjacent to the travel lanes, there were curbs that were approximately 15.0 cm (5.9 in) high and 14.0 cm (5.5 in) wide. Adjacent to the curbs were sections of grass followed by sidewalks.

All of the travel lanes were composed of asphalt and were dry at the time of the crash. In the case vehicle's pre-crash area, the southbound travel lane has a 2% uphill grade. In the area where the southbound lane curves to the left, there is a negative 2% roadway superelevation. Per the police report, the weather was clear at the time of the crash and the roadway was illuminated by overhead street lights. The posted speed limit was 48 km/h (30 mph).

Figure 3. Approach of case vehicle to curve (south)

Figure 4. Approach of case vehicle to roadway departure point & pole (south)

Pre-Crash

The case vehicle was a 2006 Lexus RX440h being driven by a restrained 22-year-old male. There were no other occupants in the vehicle. The Lexus was traveling south in the right curb lane at a driver estimated speed of 64 km/h (40 mph). Just before the crash occurred, a police officer that was in the area observed the Lexus and estimated the vehicle's pre-crash speed at around 80 - 97 km/h (50 - 60 mph). The Lexus was traveling on a straight section of roadway, then entered the elbow curve.

Crash

The driver fell asleep, likely prior to entering the curved section of roadway and failed to negotiate the curve. Just prior to the Lexus' roadway departure, the case vehicle's right tires contacted the curb several times, resulting in damage to both tire rims. The right front tire sidewall was holed (12RFWS1) as a result of the curb contact. The right rear tire sustained gouging/scuffing to the rim (12RBWS1). There were three distinct and separate sections of damaged curb documented during the scene inspection.

After scraping alongside the curb, the Lexus traveled over the curb, across the grass strip and the front right of the Lexus (12FREE5) impacted a large utility pole. The impact severity was moderate and resulted in the deployment of the driver's front and knee air bags and activation of his seat belt pretensioner. The barrier equivalent routine of the WinSmash program computed a total delta V of 15.0 km/h (9.3 mph). The longitudinal and lateral components were -15.0 km/h (-9.3 mph) and 0.0 km/h (0.0 mph), respectively.

Figure 5. Approximate roadway departure area (southeast)

Figure 6. One section of curb damage

The WinSmash results appear to be low. This may be attributed to the fact that there was narrow end engagement at the right front bumper corner, resulting in minimal front bumper crush from the pole impact. During this crash event, the pole traveled past the bumper corner and became wedged between the engine compartment and the right front tire. The Lexus came to final rest still in contact with the pole, facing southeast.

Figure 7. Impacted pole (east)

Post-Crash

The driver reported to police that he was not injured in the crash, but he was screened by fire department personnel and transported to an area trauma center as a precaution. He was treated and released within a few hours. He sustained a cervical strain and minor right knee lacerations and abrasions. The case vehicle was towed due to damage and later declared a total loss.

Vehicle Data - 2006 Lexus RX440h

The 2006 Lexus RX440h was identified by the Vehicle Identification Number (VIN): JTJHW31U462xxxxxx. The vehicle's odometer reading at the time of the inspection was 2,551 km (1,585 m). The case vehicle is a four-door, all wheel drive crossover utility vehicle with a rear liftgate and seating for five. It was equipped with a 3.3 liter 6-cylinder engine, a continuously variable transmission, front and rear disc anti-lock brakes (ABS), a brake assist system including electronic brake distribution, electronic traction control via ABS and engine management, electronic stability control, collapsible brake and driver footrest pedals and a tilt and telescoping steering wheel with a collapsible steering column.

The case vehicle also came equipped with an Adaptive Front Lighting System (AFS) which is designed to enhance nighttime visibility, especially while traveling on winding roadways. When activated, the system can pivot the left headlamp up to 15 degrees and the right headlamp up to five degrees, resulting in greater illumination of the roadway while traversing curves. The AFS can be deactivated by pushing a button that is located on the lower left instrument panel. At the time of the vehicle inspection, the AFS feature was on.

The case vehicle's stability control feature is called the Vehicle Dynamics Integrated Management (VDIM) system. According to the vehicle manufacturer, the VDIM system goes beyond conventional stability control systems that are designed to react to a specific situation or environmental condition. The VDIM system actually anticipates vehicle instability and will automatically make any necessary corrections in order to increase vehicle stability. The driver reported that there was no loss of traction or control during the pre-crash phase. The driver fell asleep before his vehicle departed the roadway.

The RX440h's Hybrid Synergy Drive system uses the fourth generation of Toyota's hybrid system. It is a gas-electric system that combines a gas engine with three electric motor-generators that draw on 30 modules of nickel metal-hydride batteries. There are two high-torque electric drive motor-generators, one for driving the front wheels and the other for the rear wheels. The third electric motor starts the engine, recharges the batteries and runs the vehicle's power accessories. The batteries are split into three groups that are largely housed under the second row seats. The stability control feature and electronic brake system function in a way that help recharge the vehicle's batteries. The hybrid system is designed to shut itself down whenever the vehicle sensors detect a rollover situation. The hybrid power train adds 136 kg (300 lb) of weight to the RX440h, but most of that weight is mounted low in the vehicle. The rigidity of the Lexus's chassis was increased in order to manage the additional mass of the hybrid system. Some of the Hybrid Synergy Drive system interior components were visible through a panel located behind the second row seat backs, but the batteries themselves were not visible. Given the location and severity of the vehicle damage, it is highly unlikely that the integrity of the batteries were compromised during the crash.

This Lexus was equipped with advanced occupant protection systems including multi-stage Certified Advanced 208-Compliant driver and front right passenger air bags. Additional standard safety features for this vehicle include front row seat back mounted side air bags, a driver knee air bag, left/right roll-sensing side curtain air bags that deploy into both seating rows and dual front seat belt pretensioners with force limiters. These safety features will be discussed further in the Manual and Supplemental Restraint sections of this report.

Figure 8. Location of the nickel metal-hydride batteries (under 2nd row seats)

Figure 9. View behind/below the 2nd row seat backs

The 2006 Lexus RX440h was equipped with Michelin Energy P235/55R18 tires and a direct tire pressure monitoring system. The recommended cold tire pressure was 207 kPa (30 psi) for the front and rear. The specific tire information is as follows:

Position	Measured Pressure	Measured Tread Depth	Restricted	Damage
LF	200 kPa (29 psi)	7 mm (9/32 in)	No	None
LR	207 kPa (30 psi)	7 mm (9/32 in)	No	None
RR	207 kPa (30 psi)	7 mm (9/32 in)	No	No tire damage; rim scrapes
RF	Flat	7 mm (9/32 in)	Yes	Separated from axle, holed, gouged; rim scrapes

Figure 10. Damage to right front tire

Figure 11. Closer view of holed/damaged RF tire sidewall

The front row seating in the 2006 Lexus RX440h was configured with dual leather bucket seats. The seats were equipped with adjustable head restraints that were not damaged. The 2006 RX440h comes equipped with front row Dynamic Head Restraints, which are designed to deploy automatically during certain types of crashes.

The second row was configured as a leather 40/20/40 split bench seat with adjustable folding backs and fore/aft seat track adjustments. All three second row seating positions were equipped with adjustable head restraints that were not damaged. The second row outboard seating positions were equipped with the lower anchor points that are part of this vehicle's Lower Anchors and Tethers for Children (LATCH) system. All three second row seating positions were equipped with child safety seat top tether anchor points, located on the backside of the seat backs.

Vehicle Damage

Exterior Damage - 2006 Lexus RX440h

Damage Description: The 2006 Lexus RX440h sustained moderate tire damage as a result of impacting the concrete curb. Both of the case vehicle's right tires contacted the curb several times, resulting in significant rim damage. The right front tire sidewall was also gouged and holed as a result of the curb contact. The Collision Deformation Classification (CDC) for this impact was 12RFWS1. There was contact to the right rear tire. The CDC for this impact was 12RBWS1. The Lexus RX440h sustained moderate front end damage as a result of the impact with the utility pole. The case vehicle sustained 26.0 cm (10.2 in) of direct damage beginning 50.0 cm (19.7 in) right of the precrash center point of the vehicle, extending along the front bumper to the right. During this impact, the pole traveled past the right front bumper corner and became wedged between the engine compartment and the right front tire. The right front tire separated from the axle and was restricted post-crash. The right wheelbase was shortened by 2.0 cm (0.8 in).

Figure 12. Front damage (bumper cover & right fender found inside vehicle)

Figure 13. Front crush profile - 2006 Lexus RX440h

Figure 14. Front view - 2006 Lexus RX440h - Exemplar vehicle (online photo)

The bumper cover was dislodged and was found inside the passenger compartment at the inspection. The additional freespace was accounted for in the crush profile. Six crush measurements were documented along the front bumper backing bar as follows: C1=0.0 cm (0.0 in), C2=3.0 cm (1.2 in), C3=6.0 cm (2.4 in), C4=8.0 cm (3.1 in), C5=9.0 cm (3.5 in), C6=16.0 cm (6.3 in). The bumper backing bar had a width of 122.0 cm (48.0 in). The location of maximum crush was at the right front bumper corner. The direct damage from this impact extended 88.0 cm (34.6 in) down the right side of the Lexus. The CDC for this impact was 12FREE5.

CDC (Impact 1):	12RFWS1	
(Impact 2):	12RBWS1	
(Impact 3):	12FREE5	
Delta V (Impact 3):	Total	15.0 km/h (9.3 mph)
	Longitudinal	-15.0 km/h (-9.3 mph)
	Latitudinal	0.0 km/h (0.0 mph)
	Energy	21,237 Joules (15,664 ft lb)

Figure 15. Close-up of direct damage from pole impact

Interior Damage - 2006 Lexus RX440h

The 2006 Lexus RX440h sustained minor interior damage due to occupant contact and normal air bag deployment related damage.

The driver's retractor pretensioner actuated during the crash and was locked in place post-impact. The lower left instrument panel was scuffed near the steering column due to contact with the deploying driver knee air bag. There was a tan transfer located on the knee air bag that directly matched up with the location of the instrument panel scuff. During the driver interview, the driver reported that he was wearing khakis at the time of the crash, but given the location of the tan transfer on the knee air bag, it is more likely the transfer was due to contact between the bag and the instrument panel, not the driver's clothing.

There was no integrity loss and no passenger compartment intrusion. The four doors and rear liftgate remained closed during the crash and were still operational post-crash. The windshield was damaged during the pole impact, resulting in cracks to the lower right corner, extending upward. There was no other glazing damage and no sign of visible occupant contact to any of the windows.

Manual Restraint Systems - 2006 Lexus RX440h

The 2006 Lexus RX440h was configured with manual 3-point lap and shoulder belts for each of the five seating positions. Both front seat belts were equipped with retractor pretensioners and force limiters. The driver's pretensioner actuated during the crash. The passenger side pretensioner did not actuate; there was no occupant in this seating position. The left front seat belt anchorage adjustment was found in the center position and the right front adjustment was in the full up position. The driver's safety belt was configured with a sliding latch plate and an emergency locking retractor (ELR). All of the other seating positions were equipped with sliding latch plates and switchable ELR/automatic locking retractors.

Figure 16. Deployed knee air bag and instrument panel scuff

Figure 17. Driver's seat belt (retractor pretensioner actuated)

Supplemental Restraint Systems - 2006 Lexus RX440h

The 2006 Lexus RX440h was equipped with advanced occupant protection systems including multi-stage Certified Advanced 208-Compliant driver and front right passenger air bags. The multi-stage air bags were certified by the manufacturer to meet the advanced air bag requirements of Federal Motor Vehicle Safety Standard (FMVSS) No. 208.

According to the vehicle manufacturer, the dual stage front air bags deploy depending on factors that include the severity of the crash, the location of each occupant's seat track position and whether or not there is a right front passenger. In certain conditions the passenger sensing system will turn off the right front air bag. There is a passenger air bag status indicator light that displays the status of the passenger front air bag while the vehicle is running.

Additional standard safety features for this vehicle include front row seat back mounted side air bags, a driver knee air bag, and left/right side roll-sensing side curtain air bags that deploy into both seating rows. Only the driver's front and knee air bags deployed during the collision sequence. The front row seat belts were equipped with retractor pretensioners and force limiters. During the pole impact, the driver's seat belt pretensioner actuated.

The driver's front air bag was mounted in the center of the steering wheel hub. The air bag module cover flaps had a Y configuration. Both the left and right flaps measured 7.0 cm (2.8 in) wide at the top edges, 6.5 cm (2.6 in) wide at the bottom edges, 6.0 cm (2.4 in) high along the inner flap edges and 5.0 cm (2.0 in) along the outer flap edges. The top cover flap measured 9.0 cm (3.5 in) wide along the top, 7.0 cm (2.8 in) high along the outer flap edges and 12.0 cm (4.7 in) wide along the lower flap edge.

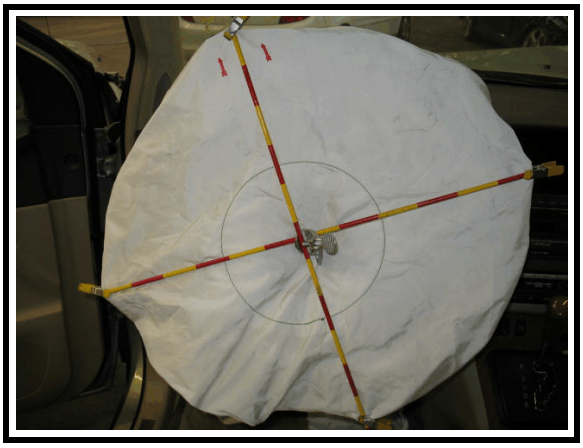

Figure 18. Driver front air bag (arrows point to top of bag)

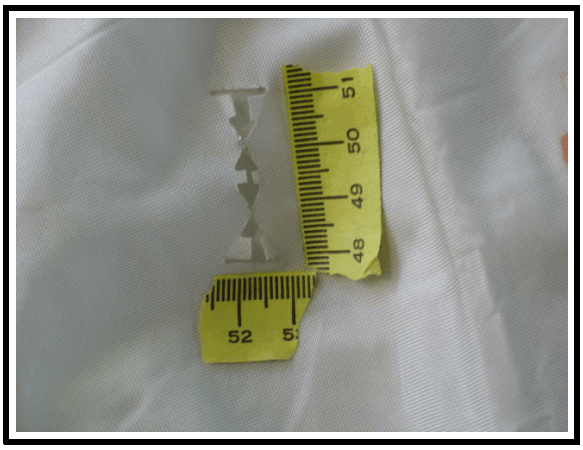

Figure 19. Close-up of one the driver's front air bag vent ports

The deployed air bag was circular in shape and measured 60.0 cm (23.6 in) high/wide in its deflated state. The maximum excursion of the deflated front air bag measured 34.0 cm (13.4 in) from the module face. The longitudinal distance between the module face and the driver's seat back as it was found at the inspection was 68.0 cm (26.8 in). The air bag had two internal tethers and there were two vent ports located on the back of the bag at the 11 and 1 o'clock positions. There was no damage to the air bag or air bag module cover flaps. There were a few cover flap deployment streaks found in the upper right quadrant on the front of the deployed air bag.

The front right passenger air bag was a mid instrument mount. There was no occupant seated in this position and the air bag was suppressed and did not deploy during the crash.

The driver's knee air bag was mounted below the steering column. The air bag module cover flaps had a H configuration. Both the top and bottom cover flaps measured 25.0 cm (9.8 in) wide. The top flap measured 4.0 cm (1.6 in) high and the bottom flap measured 5.0 cm (2.0 in) high.

The deployed air bag was rectangular in shape and measured 57.0 cm (22.4 in) wide by 36.0 cm (14.2 in) high. There was an additional piece of fabric stitched onto the lower right quadrant of the front of the knee air bag that measured 20.0 cm (7.9 in) wide by 31.0 cm (12.2 in) high. The maximum excursion of the deflated knee air bag measured 33.0 cm (13.0 in) from the module face.

There was no damage to the module cover flaps. There was some dirt on the left half of the front of the deployed knee air bag. There was a faint tan transfer to the upper left quadrant on the front of the bag. The location of the transfer directly matched up with the location of a scuff to the lower left instrument panel and likely occurred during the deployment.

Figure 20. Driver's deployed knee air bag

Figure 21. Additional piece of fabric stitched onto the lower right section of the knee air bag

Occupant Demographics - 2006 Lexus RX440h

	Driver
Age/Sex:	22/Male
Seated Position:	Front left
Seat Type:	Leather covered bucket seat
Height:	188 cm (74 in)
Weight:	84 kg (185 lb)
Occupation:	Not employed
Pre-existing Medical Condition:	None
Alcohol/Drug Involvement:	BAC = 0.042% (Source: official medical records) No drugs found
Driving Experience:	6 years
Body Posture:	Sitting upright, forward facing
Hand Position:	Right hand on steering wheel at the 2 o'clock position Left hand on steering wheel at the 10 o'clock position
Foot Position:	Right foot on brake, left foot on floorboard
Restraint Usage:	Manual 3-point lap and shoulder belt - used
Air bag:	Front air bag available - deployed Knee air bag available - deployed Seat back mounted side air bag available - nondeployed Side curtain available - nondeployed

Occupant Injuries - 2006 Lexus RX440h

Driver: Injuries obtained from ER records, radiology records, toxicology test results and the driver interview.

Injury	OIC Code	Injury Mechanism	Confidence Level
Cervical muscle strain	640278.1,6	Impact forces	Probable
Multiple lacerations, minor, right knee	890602.1,1	Car keys, in ignition	Probable
Abrasion, minor, right knee	890202.1,1	Car keys, in ignition	Probable

Occupant Kinematics - 2006 Lexus RX440h

Driver Kinematics

The 22-year-old male driver of the case vehicle was seated in an upright posture in the leather covered bucket seat and was restrained by the manual lap and shoulder belt. The seat belt anchorage adjustment was set to the center position. The driver's seat was adjusted to between the center and fully rearward track position. His seat back was slightly reclined at an 11 degree angle and his seat cushion was positioned at a 12 degree angle.

A police officer who was in the area, observed the Lexus during the precrash phase and estimated its speed at around 80 - 97 km/h (50 - 60 mph). Given the vehicle's speed as it entered the elbow curve to the left, it is likely that the driver's upper body pitched somewhat to his right before the Lexus departed the roadway. As the RX440h's right tires struck and scraped along the right curb, the driver's upper body may have pitched even further to his right. The case vehicle eventually departed the roadway and traveled a short distance before it struck the utility pole with its front end. During the pole impact, the driver's safety belt pretensioner actuated, and his front and knee air bags deployed. The male driver initiated a forward trajectory towards the 12 o'clock direction of force. His safety belt likely limited his forward movement due to the deployed pretensioner. The driver may have engaged the deployed front air bag with his face and head, although there was no visible evidence of occupant contact found anywhere on the bag. It is likely that the driver's knees and lower legs came in contact with the deployed knee air bag, but the only sign of contact was attributed to contact between the bag and the lower left instrument panel.

The Lexus came to final rest still in contact with the pole, facing southeast. The driver reported to police that he was not injured, but he was screened by fire department personnel and was transported to an area trauma center as a precaution. He was treated and released within a few hours. This driver sustained a cervical strain and minor right knee lacerations and abrasions.

Figure 22. Driver's seating area

Attachment 1. Scene Diagram