September 14, 1999

TRANSPORTATION RESEARCH GROUP
CRASH RESEARCH SECTION

VERIDIAN ENGINEERING
(FORMERLY CALSPAN SRL CORPORATION)
BUFFALO, NEW YORK 14225

CALSPAN ON-SITE SIDE IMPACT AIR BAG DEPLOYMENT INVESTIGATION

CALSPAN CASE NO. CA99-26

VEHICLE #1 - 1998 LEXUS LS 400
VEHICLE #2 - 1997 DODGE 3500 PICKUP TRUCK

LOCATION - STATE OF TENNESSEE

CRASH DATE - JULY, 1999

Contract No. DTNH22-94-D-07058

Prepared for:

U.S. Department of Transportation
National Highway Traffic Safety Administration
Washington, D.C. 20590

DISCLAIMER

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no responsibility for the contents or use thereof.

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the National Highway Traffic Safety Administration.

The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points are coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety systems.

TECHNICAL REPORT STANDARD TITLE PAGE

1. *Report No.* CA99-26	2. *Government Accession No.*	3. *Recipient's Catalog No.*	
4. *Title and Subtitle* Veridian Engineering Remote Air Bag Deployment Investigation Vehicle #1 - 1998 Lexus LS 400 Vehicle #2 - 1997 Dodge 3500 Pickup Truck equipped with a dump body Location - State of Tennessee		5. *Report Date*: September, 1999 6. *Performing Organization Code*	
7. *Author(s)* Crash Research Section		8. *Performing Organization Report No.*	
9. *Performing Organization Name and Address* Veridian Engineering Transportation Research Group Crash Research Section P.O. Box 400 Buffalo, New York 14225		10. *Work Unit No.* C01115.0242.(0000-0009) 11. *Contract or Grant No.* DTNH22-94-D-07058	
12. *Sponsoring Agency Name and Address* U.S. Department of Transportation National Highway Traffic Safety Administration Washington, D.C. 20590		13. *Type of Report and Period Covered* Technical Report Crash Date: July, 1999 14. *Sponsoring Agency Code*	
15. *Supplementary Notes* On-site investigation of a side impact air bag deployment crash that resulted in moderate injuries to the driver.			

16. *Abstract*

This crash involved a 1998 Lexus LS 400 which was traveling north on a business related undivided three lane roadway when it entered a four leg intersection that was controlled by overhead traffic control lights and was struck on the left side plane by a 1997 Dodge pickup truck which was traveling east in the right lane of a four lane divided dry asphalt roadway with a 72 km/h (45 mph) posted speed limit.

The frontal plane of the Dodge struck the left side plane of the Lexus at a WinSMASH computed impact speed of 40.9 km/h (25.4 mph). The lateral delta V was computed as 29.5 km/h (18.3 mph). The Lexus sustained direct damage to the left side with the maximum crush of 40.6 cm (16.0") located at the mid door just below the rearview mirror resulting in a maximum intrusion of 33 cm (13"). The generated collision deformation classification (CDC) code for the Lexus was 10-LYAW-3.

The Lexus was equipped with a supplemental restraint system (SRS) which included dual front air bags and seat mounted side impact air bags The driver's side air bag was the only air bag which deployed during the crash sequence. The side impact air bag was cylindrical in design and deployed forward a measured distance of 27.9 cm (11.0") from the forward leading edge of the seat back support. There was a tether sewn between the inboard and outboard surfaces of the air bag which measured 7.6 cm (3.0") in length. The vertical height of the air bag measured 29.2 cm (11.5") located at the stitching for the tethers. There were no visible contact points on the surface of the air bag.

The driver, a 41 year old female who was using the continuous loop manual lap and shoulder restraint belt, suffered a concussion (AIS-2), a fracture of the left clavicle (AIS-2), and contusions (AIS-1) of the left side of her body. The clavicle injury was attributed to torso belt loading and the concussion was attributed to impact forces. She was transport to a local medical facility where she was treated and released. The 31 year old driver of the Dodge and the 17 year old right front passenger were not injured.

17. *Key Words* Left front side impact air bag deployment Lateral delta 29.5 km/h (18.3 mph) 41 year old female driver AIS-2 (Moderate)		18. *Distribution Statement* General Public	
19. *Security Classification (of this report)* Unclassified	20. *Security Classification (of this page)* Unclassified	21. *No. of Pages*	22. *Price*

TABLE OF CONTENTS

FINAL CASE REPORT
VERIDIAN CASE NO. CA99-26
SIDE IMPACT AIR BAG INVESTIGATION
SUBJECT VEHICLE: 1998 LEXUS LS 400
LOCATION: STATE OF TENNESSEE
CRASH DATE: JULY, 1999

BACKGROUND

This crash was first detected by the GES quality control staff at Veridian Engineering and subsequently reviewed by the Veridian Engineering SCI team before it was forwarded to the Field Operations Branch (FOB) of the National Highway Traffic Safety Administration (NHTSA). Upon further review by the FOB, the Veridian Engineering SCI team was requested on July 1, 1999 by the SCI Manager to pursue this crash as an on-site investigation. The SCI team member was on-site the next day and completed the documentation of the target vehicle, a scene inspection, and interviews with the driver and owner of the second vehicle involved in the crash. This investigation focused on the driver's side air bag deployment event and its interaction with the driver during the crash event.

SUMMARY

This crash involved a 1998 Lexus LS 400 which was traveling north on a business related undivided three lane roadway when it entered a four leg intersection that was controlled by overhead traffic control lights **(refer to Figure 1)**. From the physical evidence at the scene, it appeared that the Lexus had just begun to accelerate from a stopped position when it was struck on the left side by a 1997 Dodge 3500 pickup chassis with a dump body. The Dodge was traveling east in the right lane of a four lane undivided, positive 3.5 percent slope, dry asphalt roadway with a 72 km/h (45 mph) posted speed limit **(refer to Figure 2)**.

Figure 1 View of the Lexus' northbound trajectory just prior to the point of impact (POI)

Figure 2 View of the trajectory for the Dodge 30 m from the POI

The frontal plane of the Dodge struck the left side plane of the Lexus at a WinSMASH computed impact speed of 40.9 km/h (25.4 mph). The Lexus sustained direct damage to the left side which began near the left front bumper corner and ended at the rear edge of the driver's door. The maximum crush of 40.6 cm (16.0") was located mid door just below the rearview mirror. The maximum intrusion of the interior side structure in this area measured 33 cm (13"). The generated collision deformation classification code (CDC) was 10-LYAW-3 **(refer to Figure 3)**.

The Lexus was equipped with a supplemental restraint system (SRS) which included dual front air bags and side impact air bags mounted in the outboard aspects of the front seat back supports. The driver's side air bag was the only air bag which deployed during the crash sequence **(refer to Figure 4)**. The side impact air bag was cylindrical in design and deployed forward a measured distance of 27.9 cm (11.0") from the forward leading edge of the seat back support. There was a tether sewn between the inboard and outboard surfaces of the air bag which measured 7.6 cm (3.0") in length. The vertical height of the air bag measured 29.2 cm (11.5") located at the stitching for the tethers **(refer to Figure 5)**. There were no visible contact points on the surface of the air bag.

Figure 3 Left front angular corner view of the Lexus illustrating the length of contact and depth of crush

Figure 4 Lateral view of the front seat row of the 1998 Lexus showing the deployed left front side impact air bag

Figure 5 Closer view of the deployed left front side impact air bag

The driver, a 41 year old female who was using the continuous loop manual lap and shoulder restraint belt, suffered a concussion, a fracture of the left clavicle, and contusions of the left side of her body. She was transported via ambulance to a local medical facility where she was treated and released.

The Dodge had been repaired prior to the on-site investigation, however, the collision repair shop indicated that the front of the truck had less than 30 cm (12") of crush. The frontal air bag system in this vehicle did not deploy during the crash. The 31 year old male driver of the truck was not injured nor was the 17 year old male front right occupant.

The following figure **(Figure 6- Scene Schematic)** illustrates the collision configuration.

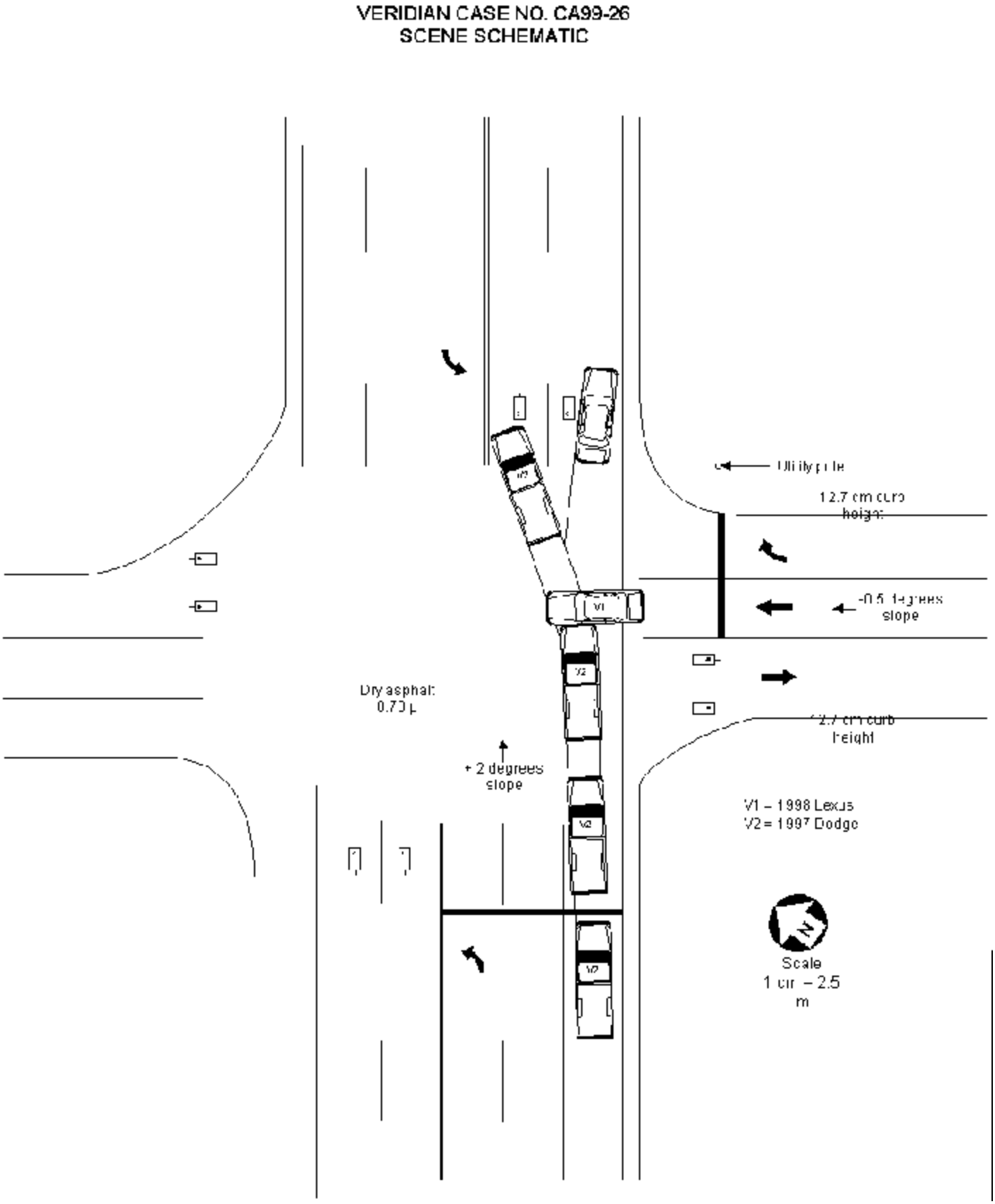

Figure 6- Scaled scene schematic

VEHICLE DATA

Exterior - 1998 Lexus LS 400

The 1998 Lexus LS 400 four door sedan was equipped with a Supplemental Restraint System (SRS) which included dual frontal air bags and front seat back support mounted side impact air bags. The driver's side air bag deployed as the result of the impact with the Dodge 3500 pickup truck equipped with a dump body. Exterior damage to the Lexus involved the front bumper, the hood, the left front fender, left front wheel and axle, left A-pillar, left front door, left front door glazing, the left B-pillar, the left rear door, the left rear quarter panel, and the windshield. The maximum crush of 40.6 cm (16.0") was located below the left door mounted rearview mirror or 208.3 cm (82.0") forward from the left rear axle center at the mid door trim level. The direct contact damage length measured 194.3 cm (76.5") with the rear most end of the contact located 123.2 cm (76.5") forward of the left rear axle center. The left side crush profile is listed in the following table:

Lexus Crush Profile			
Impact with the Dodge	C_1 = 0	C_2 = 4.4 cm (1.75")	C_3 = 33.7 cm (13.25")
	C_4 = 27.9 cm (11.0")	C_5 = 19.1 cm (7.5")	C_6 = 0.6 cm (0.25")

CDC

The Lexus rotated clockwise and sideslapped the Dodge resulting in a minor damage pattern. The contact damage involved intermittent scratches and minor dents that extended from the leading edge of the left rear door to the left rear side tail light. The collision deformation classification for the first impact was **10-LYAW-3** and **09-LZEW-1** for the subsequent sideslap.

Interior - 1998 Lexus LS 400

Interior vehicle damage to the 1998 Lexus LS 400 was attributed to the deployment of the Supplemental Restraint System (SRS) and extensive lateral vehicle intrusion from the first impact sequence with the Dodge 3500 pickup truck **(refer to Figure 7)**. Intruded components included: the left front door armrest; the A-pillar; the left front seat cushion; the left floor sill; the left front door pane; and the left B-pillar **(refer to Figures 8&9)**. The following table lists the intruded values of these components.

Figure 7 Overhead view of the intrusion in the vicinity of the left front side impact air bag

Component	Intruded Value
Leading edge of left front door armrest at the location of the window control panel	33.0 cm (13.0")
Left front door panel above the door release handle at the beltline	22.2 cm (8.75")
Door surface at A-pillar	16.5 cm (6.5")
A-pillar	11.4 cm (4.5")
B-pillar	8.9 cm (3.5")
Driver seat cushion	12.7 cm (5.0")
Left floor sill	6.4 cm (5.0")

Figure 9 View of the left side of the vehicle illustrating the intruded components

Figure 10 View showing the intrusion of the left side components from the driver's seat looking forward

The manual restraint belt was a continuous loop with an adjustable latching plate. It was designed with a dual mode webbing sensitive/inertia force locking mechanism which activated during the field pull test. The left front latch plate exhibited scratch marks which was indicative of routine belt usage. The driver indicated that she was wearing the restraint belt at the time of the crash and attributed her well being to the performance of the belt system and not to the side impact air bag deployment. The belt did not exhibit any visual impact related evidence of occupant loading. The motorized D-ring was adjusted in a mid to bottom adjustment area which was located 4.1 cm (1.625") above the full down position over a measured adjustment range of 9.8 cm (3.875").

The 6-way motorized adjustable tan leather driver seat was located 2.5 cm (1.0") forward of the full rear position over an adjustment range of 24.1 cm (9.5"). The incline of the seat cushion measured 21 degrees with the leading edge of the seat cushion 27.9 cm (11.0") above the floor. The seat cushion measured 47.6 cm (18.75") longitudinally and 53.3 cm (21.0") laterally. The vertical height of the seat back support measured 57.2 cm (22.5") with a 45.7 cm (18.0") width. It was reclined 27 degrees from vertical. The adjustable head restraint was in the down position and measured 23.5 cm (9.25") laterally and 21.0 cm (8.25") vertically. The seat did not exhibit any driver related contact evidence.

The driver's side air bag was mounted in the outboard aspect of the driver seat back support. During the SRS

actuation sequence, the air bag exerted pressure against the leather seat covering resulting in a vertical tear that allowed the air bag to deploy in a forward direction. The top portion of the tear was located 8.9 cm (3.5") below the top of the back support and extended downward 25.4 cm (10.0"). The tear seam was located 5.1 cm (2.0") rearward from the leading edge of the back support.

The control switches for the seat memory adjustment and torso belt height adjustment on the left front door showed scuff marks from contact with the lateral aspect of the steering wheel rim as the door panel intruded laterally during the crash **(refer to Figure 10)**. The steering wheel did not exhibit any deformation or loading by the driver.

Figure 11 View of the contact evidence on the control pane for the seat positioning

Figure 12 View of the side impact air bag label located above the seat adjustment controls on the outboard surface of the seat

The right front seat was adjusted in the full rear position. A white letter label was attached to the outboard side of the seat just above the seat adjustment controls which read, "SRS SIDE AIRBAG" **(refer to Figure 11)**. The seat back support was reclined 29 degrees.

The latch plate of the right front three point manual restraint belt indicated infrequent usage. The motorized D-ring was adjusted 6.4 mm (0.25") down from the full up position.

The windshield was cracked and torn as the result of impact related damage. The tear in the windshield laminate was located along the windshield header beginning at the left A-pillar and extending 5.8 cm (20.0") to the right. The static width of the tear was 5.1 cm (2.0").

1997 Dodge 3500 Pickup Dump Body

The 1997 Dodge 3500 pickup truck was equipped with a dump body which was used in a commercial landscaping enterprise. The repair shop indicated that the vehicle sustained damage to the front bumper, hood, right front fender, and right front door. The shop estimated that the crush to the front bumper was less than 30 cm (12"). The cost of repair was $11,400. The vehicle weight with the dump body was estimated at 3,850 kg (8,500 lbs.). The vehicle was towed from the scene.

SPEED RECONSTRUCTION

The WinSMASH speed reconstruction algorithm was used to compute relative delta V and impact speed values. The output from the damage and trajectory routines indicated that the Lexus experienced a lateral delta V of 29.5 km/h

(18.3 mph) as shown in the following table. This value appeared to be consistent with the damage profile of the vehicle and was sufficient to deploy the side impact air bag.

WinSMASH 1.02.001		Lexus	Dodge
Impact Speed		13.1 km/h (8.2 mph)	40.9 km/h (25.4 mph)
Total delta V	Damage	32.5 km/h (20.2 mph)	15.4 km/h (9.6 mph)
	Trajectory	32.1 km/h (19.9 mph)	15.2 km/h (9.5 mph)
Longitudinal delta V	Damage	-13.7 km/h (-8.5 mph)	-13.7 km/h (-8.5 mph)
	Trajectory	13.0 km/h (-8.1 mph)	-13.7 km/h (-8.5 mph)
Lateral delta V	Damage	29.5 km/h (18.3 mph)	-7.0 km/h (-4.3 mph)
	Trajectory	29.4 km/h (18.2 mph)	-6.6 km/h (-4.1 mph)
Energy dissipated		67,598 joules (49,885 ft-lb)	57,209 joules (42,221 ft-lb)
Barrier equivalent speed		30.7 km/h (19.1 mph)	16.6 km/h (10.3 mph)

SUPPLEMENTAL RESTRAINT SYSTEM (SRS)

The Supplemental Restraint System (SRS) in the 1998 Lexus LS 400 was designed with dual front air bags (steering wheel mounted and top mounted front right passenger air bag) and two side impact air bags (left and right front seat back support mounted). Only the driver's side air bag deployed during the crash sequence as designed.

Driver's Side Air Bag

The left front side impact air bag was mounted in the outboard aspect of the driver's seat back support (called the seat back bolster). During the SRS actuation sequence, the air bag exerted pressure against the leather seat covering resulting in a vertical tear that allowed the forward excursion of the air bag. The tear was located 5.1 cm (2.0") rearward from the leading edge of the seat support and 8.9 cm (3.5") below the top of the back support. The tear in the seat support covering measured 25.4 cm (10.0") vertically.

The air bag was a cylindrical cone shape with the width measuring 25.4 cm (10.0") at the seat back support and 29.2 cm (11.5") at the tether located 14.6 cm (5.75") from the end of the air bag. Stretching the air bag laterally at the tether, the air bag width measured 7.6 cm (3.0"). The longitudinal length of the air bag measured 33.0 cm (13.0"). The tether was secured to the air bag by green colored thread which formed a pattern which measured 2.2 cm (0.875") wide and 8.9 cm (3.5") vertically **(refer to Figure 12)**. The material of the air bag appeared to be a heavy denier with a fine mesh weave. There were no visible vent ports. An inspection

Figure 12 Side surface of the driver's side air bag facing the left front door panel

of the air bag fabric did not reveal any obvious driver contact evidence. An air bag identification number was inked printed on the surface facing the door panel which read:

73905-50020 MU3029921

INJURY DATA

The 41 year old female driver, who was approximately 162.6 cm (64.0") tall, moved laterally and loaded the torso belt resulting in a fracture of the left clavicle and a concussion. She sustained contusions of the left side of her body which was attributed to contact with the side impact air bag and left front door surface. She was taken by ambulance to a local medical treatment facility where she was treated and released. Refer to the following table for a listing of injuries, the respective AIS-90 injury code, and correlating injury source.

INJURY	AIS-90	INJURY SOURCE
1. Concussion	161000.2,0	Impact forces
2. Fracture of the left clavicle, mid-shaft with slight displacement at the fracture site	752200.2,2	Torso belt
3. Contusions of the left side of the body	490402.1,2	Left side door panel
4. Superficial abrasion of the left hand	790202.1,2	Left side disintegrated glazing

The driver and the right front passenger in the Dodge were not injured in the crash.

OCCUPANT KINEMATICS

Driver Of The Lexus

The driver of the Lexus traveling northbound was in the process of traveling through the four leg intersection when her vehicle was struck on the left side plane by the front of the Dodge 3500 pickup truck. The collision resulted in a 10 o'clock principal direction of force and a WinSMASH computed lateral delta V of 29.5 km/h (18.3 mph). The Lexus rotated in a clockwise rotation and came to the final rest position 10.4 m (34.1') from the point of impact.

The driver who had her seat adjusted near the rear adjusted position was properly wearing the three point continuous loop lap and torso belt. During the crash sequence, the driver moved laterally and contacted the deployed side impact air bag with the left side of her torso. Her left shoulder loaded the torso belt resulting in a fracture of the left clavicle. The driver's head very likely moved laterally in a flexion motion which resulted in a concussion. The driver's left leg contacted the intruding left front door panel while her left arm move laterally and was abraded by the disintegrating driver side window glazing.