

Combination Investigation / Vehicle to Vehicle
Dynamic Science, Inc. / Case Number: 2002-75-053A
2000 Toyota 4-Runner SUV
Colorado
May, 2002

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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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<p>16. Abstract</p> <p>This three vehicle collision occurred in Colorado in May, 2002 at 1330 hours. The crash occurred within the confines of a four-leg intersection. The case vehicle is a 2000 Toyota 4-Runner driven by a lap and shoulder belt restrained 32-year-old female (170 cm/67 in, 53 kg/117 lbs). The front right seat was occupied by a lap and shoulder belt restrained 71-year-old female (150 cm/59 in, 54 kg/120 lbs). She was seated in a bucket seat that had been adjusted to between the middle and rear most track position. The rear left seat was occupied by a restrained 41-year-old male (168 cm/66 in, 61 kg/134 lbs). The case vehicle was equipped with driver's and front right passenger's air bags, front seat belt pretensioners, and front seat belt force limiters.</p> <p>The first other vehicle is a 1999 Dodge Stratus driven by a 26-year-old female. The second other vehicle is a 1990 Chevrolet Lumina driven by a 21-year-old male. There were two additional occupants in this vehicle. The case vehicle was traveling southbound on a four-lane divided roadway approaching the intersection. The Dodge Stratus was traveling northbound in the left hand turn lane. The Chevrolet Lumina was stopped facing east in the eastern leg of the intersection. The Dodge Stratus turned in front of the case vehicle. The front of the case vehicle (11FDEW2) struck the right side of the Dodge Stratus. The case vehicle sustained a longitudinal delta v of -22 km/h (-13.7 mph) and a lateral delta v of 8 km/h (4.9 mph). The front air bags in the case vehicle deployed at this time. The other vehicle sustained a longitudinal delta v of -25 km/h (-15.5 mph) and a lateral delta v of -21 km/h (-13 mph). The case vehicle rotated clockwise and there was a second "sideslap type" impact between the left side of the case vehicle and the right side of the Dodge Stratus. The case vehicle was then redirected to the west and struck the front of the Chevrolet Lumina.</p> <p>The driver of the case vehicle sustained contusions to the right hand and the right leg. The rear occupant complained of pain to one of his legs. They were both transported to a local trauma center by ground ambulance. They were both treated and released. The front right occupant was pronounced dead on arrival at the trauma center. She sustained a heart laceration, a liver laceration, a subdural hematoma, and a cervical spine fracture.</p>				
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Accident Investigation
Case Number: 2002-75-053A

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BACKGROUND:

Description: This possible front right seat occupant air bag related fatality case was generated through NASS PSU 75. The case vehicle is equipped with redesigned air bags. DSI was assigned the case on May 28, 2002. This three-vehicle case was investigated as a combination case.

Investigation Type:	Combination
Crash Location:	Colorado
Crash Date:	May, 2002
Notification Date:	May 28, 2002
Field Work Completed:	NA

SUMMARY:

This three vehicle collision occurred in Colorado in May, 2002 at 1330 hours. The crash occurred within the confines of a four-leg intersection. The northern leg of the intersection is comprised of two southbound travel lanes, a left hand turn lane, a right hand turn lane, a dirt median, and two northbound travel lanes. The southern leg of the intersection is comprised of two northbound travel lanes, a left hand turn lane, a right hand turn lane, a dirt median, and two southbound travel lanes. The eastern leg of the intersection is comprised of a westbound travel lane, a left hand turn lane, and an eastbound travel lane. The intersection is controlled by a tri-color traffic signal. The asphalt roadways are straight and level. The speed limit is 72 km/h (45 mph).

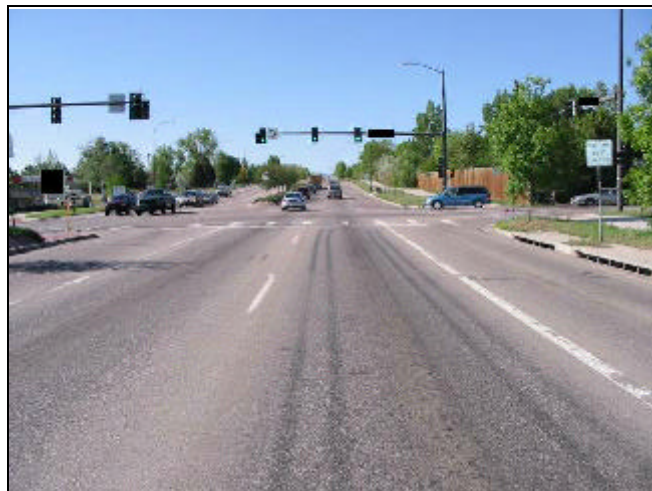


Figure 1. Path of travel—case vehicle (southbound)



Figure 2. Path of travel—first other vehicle (northbound)

The case vehicle is a 2000 Toyota 4-Runner driven by a lap and shoulder belt restrained 32-year-old female (170 cm/67 in, 53 kg/117 lbs). She was seated in a bucket seat that had been adjusted to between the middle and rear most track position. The seat belt anchorage was in the full up position. The front right seat was occupied by a lap and shoulder belt restrained 71-year-old female (150 cm/59 in, 54 kg/120 lbs). She was seated in a bucket seat that had been adjusted to between the middle and rear most track position. The seat belt anchorage was in the full up position. The rear left seat was occupied by a restrained 41-year-old male (168 cm/66 in, 61 kg/135 lbs).

The first other vehicle is a 1999 Dodge Stratus driven by a 26-year-old female. The second other vehicle is a 1990 Chevrolet Lumina driven by a 21-year-old male. There were two additional occupants in this vehicle.

The case vehicle was traveling southbound on a four-lane divided roadway approaching the intersection. The Dodge Stratus was traveling northbound in the left hand turn lane. The Chevrolet Lumina was stopped facing east in the eastern leg of the intersection. The

Dodge Stratus turned in front of the case vehicle. The front of the case vehicle (11FDEW2) struck the right side of the Dodge Stratus. The case vehicle sustained a longitudinal delta v of -22 km/h (-14 mph) and a lateral delta v of 8 km/h (5 mph). The front air bags in the case vehicle deployed at this time. The other vehicle sustained a longitudinal delta v of -25 km/h (-16 mph) and a lateral delta v of -21 km/h (-13 mph). The case vehicle rotated clockwise and there was a second “sideslap type” impact between the left side of the case vehicle and the right side of the Dodge Stratus. The case vehicle was then redirected to the west and struck the front of the Chevrolet Lumina.



Figure 3. Front, case vehicle



Figure 4. Left side, case vehicle

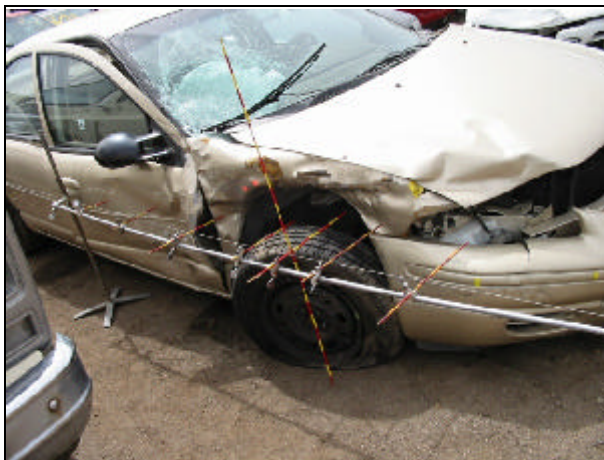


Figure 5. First other vehicle—Dodge Stratus



Figure 6. Second other vehicle—Chevrolet Lumina

EMS personnel were notified and arrived as shown below:

Crash	1330
EMS notified	1330
EMS arrived at scene	1335
EMS arrived at hospital	1356

The driver sustained contusions to the right hand and the right leg. The rear occupant complained of pain to one of his legs. They were both transported to a local trauma center by ground ambulance. They were both treated and released. The front right occupant was pronounced dead on arrival at the trauma center. She sustained a heart laceration, a liver laceration, a subdural hematoma, and a cervical spine fracture.

The driver of the Dodge Stratus sustained a laceration to her right upper extremity (AIS 2) as well a multiple minor (AIS 1) contusions. She was transported to a local trauma center where she was treated and released.

There were no reported injuries to the occupants of the Chevrolet Lumina.

Scene Diagram

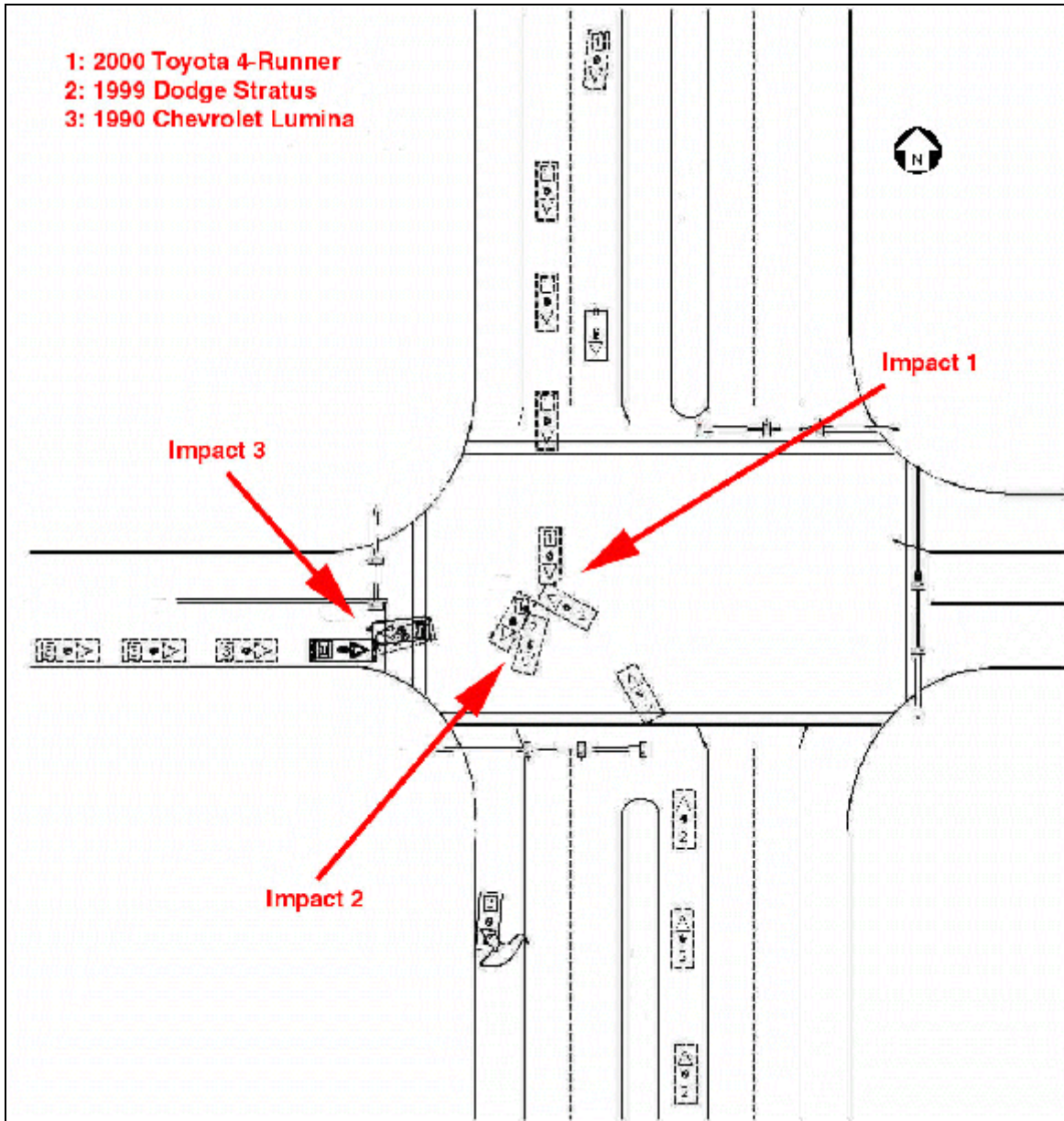


Figure 7. Scene diagram

DETAILED INFORMATION**Vehicles**Case vehicle

Description:	2000 Toyota 4-Runner SUV 4x4	
VIN:	JT3HN86R9Y0xxxxxx	
Odometer:	25,885 km (16,084 miles)	
Engine:	6 cylinder, 3.38 L	
Reported Defects:	None	
Cargo:	34 kg (75 lbs) – luggage rack, running boards, clothes	
Damage Description:	Moderate frontal damage to bumper, grille and hood. Minor damage to left side near left door. Vehicle towed due to damage.	
CDC:	Impact 1: 11FDEW2 Impact 2: 09LPEW1 Impact 3: 12F99999	
Delta V (Impact 1):	Total	23 km/h (14.3 mph)
	Longitudinal	-22 km/h (-13.7 mph)
	Latitudinal	8 km/h (5.0 mph)
	Energy	117,562 joules (86,713 ft-lbs)

**Figure 8.** Front, case vehicle

During the initial impact, the case vehicle sustained 104 cm (41 in) of direct contact that extended across the entire frontal end width of the vehicle. Maximum crush was located 19 cm (8 in) right of C3 and measured 50 cm (20 in). The principle direction of force was within the 11 o'clock sector and was an estimated 340 degrees. The impact energy was managed by the forward structures of the vehicle. The damaged components included the bumper fascia and reinforcement bar, upper and lower radiator supports, and the hood. There was a 10 cm (3.9 in) reduction of the wheelbase on the left side.



Figure 9. Left side, case vehicle

During the second impact, the vehicle sustained 78 cm (31 in) of direct contact that extended just forward of the rear wheel well. Maximum crush was located 40 cm (16 in) forward of the rear axle and measured 3 cm (1 in). The principle direction of force was within the 9 o'clock sector and was an estimated 270 degrees. This was a minor side-slap type impact. The damaged components included the left rear door and the frame rail.

During the third impact, the vehicle sustained an unknown amount of damage to the front of the vehicle. Any damage caused by this impact was essentially masked by the first impact.

Safety systems discussion

The driver's manual restraint system consisted of a continuous loop 3-point lap and shoulder safety belt with a sliding latch plate. The shoulder belt anchorage adjustment was in the full up position. The front right passenger manual restraint system consisted of a continuous loop 3-point lap and shoulder safety belt with a sliding latch plate. The shoulder belt anchorage adjustment was in the full up position. The front seat belts were equipped with pretensioners and seat belt force limiters. The case vehicle was equipped with driver's and front right passenger's air bags.

The driver air bag module was located in the center hub of the steering wheel rim. The air bag module cover had an H-configuration. The upper flap measured 16 cm (6 in) wide by 5 cm (2 in) high. The lower flap measured 15 cm (6 in) wide by 8 cm (3 in) high. The diameter of the deflated circular air bag was 56 cm (22 in). It was equipped with two tethers and had two vent ports (11 and 1 o'clock positions). There was no contact evidence on the face of the air bag.

The front right passenger air bag module was located in the transition between the top and middle instrument panel. The module cover had an H-configuration. The upper flap measured 23 cm (9 in) wide by 7 cm (3 in) high. The lower flap measured 23 cm (9 in) wide by 7 cm (3 in) high. The deflated air bag measured 60 cm (24 in) high by 55 cm (22 in) wide. The air bag was untethered and had two vent ports (3 and 9 o'clock positions). There was no contact evidence on the face of the air bag.

Upon impact, both front seat belt pretensioners fired and both front air bags deployed.

Other vehicle

Description:	1999 Dodge Stratus four-door sedan	
VIN:	11B3EJ46C6XNxxxxxx	
Odometer:	62,765 km (38,628 miles)	
Engine:	4 cylinder, 2 L	
Reported Defects:	None	
Cargo:	9 kg (20 lbs)	
Damage Description:	Moderate lateral crush to right front fender/door. Vehicle towed due to damage.	
CDC:	Impact 1: 01FRAE6 Impact 2: 03RBEW2	
Delta V (Impact 1):	Total	33 km/h (20.5 mph)
	Longitudinal	-25 km/h (-15.5 mph)
	Latitudinal	-21 km/h (-13.0 mph)
	Energy	11,526 joules (8,501 ft lbs)

During the initial impact, the case vehicle sustained 36 cm (14.2 in) of direct across the front bumper starting at the front right bumper corner. Maximum crush was located at C6 and measured 10 cm (4 in). There was direct contact that extended from the bumper corner rearward to the front right door. The principle direction of force was within the 1 o'clock sector and was an estimated 40 degrees. The impact energy was managed by the forward structures of the vehicle. The damaged components included the bumper fascia, right fender, right tire, and the hood. There was impact related damage to the windshield. There was a slight reduction of the wheelbase on the right side.



Figure 10. Front, Status—initial impact

During the second impact, the vehicle sustained 107 cm (42 in) of direct contact to the right rear. Maximum crush was located at C1 and measured 18 cm (7.1 in). The principle direction of force was within the 3 o'clock sector and was an estimated 90 degrees. The damaged components included the rear bumper fascia, right rear tail light, and right rear quarter panel.



Figure 11. Right side, Stratus—second impact

Second other vehicle

Description:	1990 Chevrolet Lumina two-door coupe	
VIN:	2G1WN14T0L9xxxxxx	
Odometer:	Unknown	
Engine:	3.1 L, 6 cylinder	
Reported Defects:	None	
Cargo:	None	
Damage Description:	Minor crush to left front bumper and fender.	
CDC:	11FLEE1	
Delta V:	Total	12 km/h (7.5 mph)
	Longitudinal	-12 km/h (-7.5 mph)
	Latitudinal	2 km/h (1.2 mph)
	Energy	7,872 joules (5,806 ft lbs)

During this impact, this vehicle sustained 29 cm (11 in) of direct contact to the front left bumper. The maximum crush was located at C1 and measured 4 cm (2 in). The principle direction of force was within the 11 o'clock sector and was an estimated 340 degrees. The impact energy was managed by the forward structures of the vehicle. The damaged components included the bumper facia and reinforcement bar and the left fender. There was no measured change in the wheelbase dimensions. There were no glazing fractures and all doors remained operational.



Figure 12. Front, Lumina

Occupants

<u>Case vehicle</u>	Occupant 1	Occupant 2	Occupant 3
Age/Sex:	32/Female	71/Female	41/Male
Seated Position:	Front left	Front right	Second seat left
Seat Type:	Cloth covered bucket seat that had been adjusted to between the middle and rear most track position	Cloth covered bucket seat that had been adjusted to between the middle and rear most track position	Cloth covered split bench with folding back
Height:	170 cm (67 in)	150 cm (59 in)	168 cm (66 in)
Weight:	53 kg (117 lbs)	54 kg (120 lbs)	61 kg (135 lbs)
Occupation:	Unknown	Unknown	Unknown
Pre-existing Medical Condition:	None noted	Lung cancer with metastases ¹ to the liver	None noted
Alcohol/Drug Involvement:	None	None	None
Driving Experience:	Unknown	NA	NA
Body Posture:	Sitting upright	Sitting upright	Sitting upright
Hand Position:	Both hands on the steering wheel.	Unknown	Unknown
Foot Position:	Left on floor, right on accelerator	On floor	On floor
Restraint Usage:	Lap and shoulder belt available, used	Lap and shoulder belt available, used	Lap and shoulder belt available, used
Air bag:	Driver's air bag available, deployed	Front right passenger air bag available, deployed	NA

¹Cancer that started from cancer cells from another part of the body

Other vehicle (Stratus)

Age/Sex:	26/Female
Seated Position:	Front left
Seat Type:	Bucket seat, adjusted to forward most seat track position
Height:	165 cm (65 in)
Weight:	60 kg (132 lbs)
Occupation:	Unknown
Pre-existing Medical Condition:	None noted
Alcohol/Drug Involvement:	None
Driving Experience:	Unknown
Body Posture:	Unknown
Hand Position:	Unknown
Foot Position:	Unknown
Restraint Usage:	Lap and shoulder belt available, used
Air bag:	Steering wheel mounted air bag available, deployed

<u>Other vehicle (Lumina)</u>	Driver	Occupant 2	Occupant 3
Age/Sex:	21/Male	24/Male	16/Male
Seated Position:	Front left	Front right	Rear right
Seat Type:	Unknown	Unknown	Unknown
Height:	Unknown	Unknown	Unknown
Weight:	Unknown	Unknown	Unknown
Occupation:	Unknown	Unknown	Unknown
Pre-existing Medical Condition:	None noted	None noted	None noted
Alcohol/Drug Involvement:	None	None	None
Driving Experience:	Unknown	NA	NA
Body Posture:	Unknown	Unknown	Unknown
Hand Position:	Unknown	Unknown	Unknown
Foot Position:	Unknown	Unknown	Unknown
Restraint Usage:	Lap and shoulder belt used, per police report	Lap and shoulder belt used, per police report	Lap and shoulder belt used, per police report

Injuries and Injury Mechanisms

Case vehicle

	<u>INJURY</u>	<u>OIC CODE</u>	<u>ICD-9</u>	<u>SOURCE</u>
Driver:	Hand contusion, right	790402.1,1	923.20	Windshield
	Lower extremity contusion, right	890402.1,1	924.5	Knee bolster
Front right occupant:	Subarachnoid hemorrhage	140684.3,9	852.00	Head rest ² (Air bag related)
	Cerebral hematoma	140650.4,9	853.0	Head rest (Air bag related)
	Cervical neck fracture	650216.2,6	805.00	Air bag
	Heart laceration	441008.3,4	861.02	Shoulder belt
	Liver laceration	541820.2,1	864.00	Lap belt
Rear left occupant:	Complained of pain to leg, unknown aspect			

²SCI changed source for the neck injury from the B-pillar to the air bag and changed the source of the head injuries from the B-pillar to the head rest.

Other vehicle (Dodge Stratus)

	<u>INJURY</u>	<u>OIC CODE</u>	<u>SOURCE</u>
Driver:	Upper extremity muscle laceration, right	740400.2,1	Air bag
	Scalp contusion/subgaleal hematoma	190402.1,6	Left B pillar
	Lower extremity skin contusion, bilateral	890402.1,3	Knee bolster
	Upper extremity skin contusion, right	790402.1,1	Center instrument panel and below
	Lower extremity skin contusion, right	890402.1,1	Belt restraint webbing / buckle

Other vehicle (Chevrolet Lumina)

	<u>INJURY</u>	<u>OIC CODE</u>	<u>SOURCE</u>
Driver:	No known injuries		

Occupant Kinematics

The front left seat was occupied by a lap and shoulder belt restrained 32-year-old female (170 cm/67 in, 53 kg/117 lbs). She was seated in a bucket seat that had been adjusted to between the middle and rear most track position. The seat belt anchorage was in the full up position. Both hands were on the steering wheel. This seat position was equipped with a driver's air bag, a seat belt pretensioner, and seat belt force limiters. Upon impact, the driver's pretensioner fired and the frontal air bags deployed. The driver responded to the 11 o'clock direction of force by moving forward and to the left and loading the pretensioned and locked manual restraint system. She likely contacted the air bag to some degree, but there were no residual occupant contacts. Her right hand came off the steering wheel and struck the windshield—causing a minor contusion. An unspecified part of her right leg struck the knee bolster—causing a contusion.



Figure 13. Driver's seated position

The front right seat was occupied by a lap and shoulder belt restrained 71-year-old female (150 cm/59 in, 54 kg/120 lbs). She was seated in a bucket seat that had been adjusted to between the middle and rear most track position. The seat belt anchorage was in the full up position. This seat position was equipped with a front right passenger air bag, a seat belt pretensioner, and seat belt force limiters. Upon impact, the seat belt pretensioner fired and the passenger air bag deployed. The front right occupant responded to the 11 o'clock direction of force by moving forward and to the left and loading the pretensioned and locked manual restraint system—causing the liver and heart lacerations. Both knees engaged the glove compartment. As this occupant pitched forward, she engaged the deployed air bag with her head (the interviewee reported blood coming from her mouth). Her head was forced rearward—causing the neck fracture. She continued rebounding rearward until striking the head restraint—causing the brain injuries.



Figure 14. Hand contact to windshield

The rear left seat occupant was occupied by a restrained 41-year-old male (168 cm/66 in, 61 kg/135 lbs). He was seated in a fabric covered split bench seat. Upon impact, this occupant responded to the 11 o'clock direction of force by moving forward and to the left and loading manual restraint system. He likely engaged the plastic fascia on the back of the left side pillar—fracturing the plastic. There were no reports of any injuries from this contact.



Figure 15. Deployed passenger air bag



Figure 16. Front right occupant seated position



Figure 17. Front right occupant knee contacts to glove compartment



Figure 18. Front right passenger seat back and seat belt