

On-scene Investigation / Vehicle to Vehicle
Dynamic Science, Inc. / Case Number: DS97-020
1995 Volvo 850 GLT 4-door Station Wagon
California
September 1997

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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 crash-worthiness performance of the involved vehicle(s) or their safety systems.

Technical Report Documentation Page

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16. Abstract <p>This collision occurred in California in February, 1997 at 1046 hours. This was a two vehicle, angle-broadside type collision at a four-leg intersection. The collision occurred during daylight hours, visibility was good, the weather was clear and the roadway was dry. Vehicle 1, a 1995 Volvo 850 GLT station wagon was equipped with a Supplemental Restraint System (SRS) that consisted of dual driver's and front right passenger's air bags and pyrotechnic pretensioners in the front three point manual lap and shoulder seat belt systems. In addition to the SRS, Vehicle 1 was equipped with side air bags, SIPSABAG, in the driver's and the front right bucket seat backs. Vehicle 1 was driven by an unrestrained 37-year-old female (62 in/157.5 cm, 115 lbs/52.2 kg), and was traveling westbound in the far left lane and intending to cross through the intersection. Vehicle 2, a 1992 right side driven Grumman Long Life Vehicle (LLV) driven by a 52 year-old-male (65 in/165 cm, 135 lbs/61.2 kg), was southbound and came to a full stop at the intersection. The driver of Vehicle 2 did not see any east-west traffic and began to traverse across the intersection. The front of Vehicle 2 struck the right side of Vehicle 1, beginning rearward of the right front wheel well. At impact, the longitudinal forces exceeded the threshold of the driver's and front right passenger's air bags in Vehicle 1, and they deployed. In addition, the front right seat's SIPSABAG deployed. After impact, Vehicle 1 rotated clockwise and the left rear tires impacted the raised concrete curb on the south-west corner. This impact acted as a fulcrum and tripped the rear end, and Vehicle 1 began to roll over onto its left side about its longitudinal axis. Vehicle 1 continued sliding partially on the grassy roadway median with the rear half of the vehicle and the roadway surface with the front half of the vehicle. Vehicle 1 rolled over onto its rooftop and struck the concrete curb. Vehicle 1 rolled over five quarter turns, and came to final rest on its left side heading east approximately 29.7 m (97.5 ft) west of the south-east curb.</p> <p>The driver of Vehicle 1 was not wearing the available lap and shoulder belts. The pyrotechnic pretensioners in the front manual lap and shoulder belt systems were triggered and the belts were locked in the retracted position. The driver of Vehicle 1 was fully ejected out of the driver's side window and onto the roadway just before the vehicle came to final rest, and Vehicle 1 probably rolled over her. Fire paramedics were dispatched to the scene at 1046 hours, and arrived at 1050 hours. They treated the driver of Vehicle 1 at the scene and noted that she was combative and disoriented. Fire paramedics transported her to a trauma center at 1103 hours. They arrived at the trauma center at 1108 hours. The driver of Vehicle 1 received ER treatment for her injuries and due to the severity of her injuries, was admitted to the hospital with a Glasgow Comma Scale of (11). The driver of Vehicle 1 was hospitalized for thirty-one days, and when she was released she went to physical rehabilitation for approximately six weeks.</p> <p>Vehicle 1 sustained moderate to major damage about the entire vehicle. The impact between Vehicle 1 and Vehicle 2 was the highest delta v and a CDC of 01RDEW2 with a positive 25 degrees PDOF, and a maximum crush of 10 cm (3.9 in) at C3 for Vehicle 1. The damage portion of WinSmash was utilized to compute a delta v. WinSmash computed a total delta v of 13.2 km/h (8.2 mph), a longitudinal delta v of -11.9 km/h (- 7.4 mph), and a latitudinal delta v of -5.6 km/h (-3.5 mph). The results fit the collision model but appear low. Vehicle 1 was towed from the scene due to the damage.</p>					
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Dynamic Science, Inc.
Accident Investigation
Case Number: DS97-020

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BACKGROUND:

Description: This case was initiated in response to a report of the case vehicle being equipped with side air bags: Volvo's Side Impact Protection System (SIPSBAG). This case is being conducted as an on-scene investigation. This case was reported to the NHTSA by the investigating police department, and Dynamic Science, Inc. was notified on September 09, 1997. Vehicle 1 was inspected at a vehicle storage facility where it was being stored by the attorney representing the driver of Vehicle 1. No one else was present at the inspection of Vehicle 1, but the investigation was videotaped by the storage facility personnel.

Investigation Type: On-scene

Crash Location: California

Crash Date: February, 1997 at 1046 hours

Notification Date: September 9, 1997

Field Work Completed: October 10, 1997

SUMMARY:

This collision occurred in California in February, 1997 at 1046 hours. This was a two vehicle, angle-broadside type collision at a four-leg intersection. The east-west roadway is asphalt surfaced, with two marked lanes in each direction and a separate left turn lane for westbound traffic to turn southbound. There are no traffic controls for east-west traffic. The posted speed limit for east-west traffic is 40 km/h (25 mph). The north-south roadway is asphalt surfaced, with one marked lane in each direction. There were standard stop signs for north-south traffic, which were erect and visible. The posted speed limit for north-south traffic is 40 km/h (25 mph). The collision occurred during daylight hours, visibility was good, the weather was clear and the roadway was dry. There were no viewing obstructions in either direction.



Figure 1. Direction of travel for Vehicle 1, and final rest for both vehicles.

Vehicle 1, a 1995 Volvo 850 GLT station wagon was equipped with a Supplemental Restraint System (SRS) that consisted of dual driver's and front right passenger's air bags and pyrotechnic

pretensioners in the front three point manual lap and shoulder seat belt systems. In addition to the SRS, Vehicle 1 was equipped with side air bags, SIPSBAG, in the driver's and the front right bucket seat backs.

Vehicle 1 was driven by an unrestrained 37-year-old female (62 in/157.5 cm, 115 lbs/52.2 kg), and was traveling westbound in the far left lane and intending to cross through the intersection. Vehicle 2, a 1992 right side driven Grumman Long Life Vehicle (LLV)¹ driven by a 52 year-old-male (65 in/165 cm, 135 lbs/61.2 kg), was southbound and came to a full stop at the intersection.

The driver of Vehicle 2 did not see any east-west traffic and began to traverse across the intersection. The front of Vehicle 2 struck the right side of Vehicle 1, beginning rearward of the right front wheel well.

At impact, the longitudinal forces exceeded the deployment threshold of the driver's and front right passenger's air bags in Vehicle 1, and both frontal airbags deployed. In addition, the front right seat's SIPSBAG deployed (see Figure 2). The front right seat's SIPSBAG did not play a role in the injuries sustained by the driver. The driver's seat SIPSBAG did not deploy.

After impact, Vehicle 1 rotated clockwise and the left rear tires impacted the raised concrete curb on the south-west corner. This impact acted as a fulcrum and tripped the rear end, and Vehicle 1 began to roll over onto its left side about its longitudinal axis. Vehicle 1 continued sliding partially on the grassy roadway median with the rear half of the vehicle and the roadway surface with the front half of the vehicle. Vehicle 1 rolled over onto its rooftop and struck the concrete curb. Vehicle 1 rolled over five quarter turns, and came to final rest on its left side heading east approximately 29.7 m (97.5 ft) west of the south-east curb.

The driver of Vehicle 1 was not wearing the available lap and shoulder belts. The pyrotechnic pretensioners in the front manual lap and shoulder



Figure 2. Right front seat SIPSBAG.



Figure 3. Driver's seat belt pretensioners.

¹ V.I.N. breaks down as a 1990 Chevrolet S10 Utility vehicle.

belt systems were triggered and the belts were locked in the retracted position (see Figure 3). The driver of Vehicle 1 was fully ejected out of the driver's side window and onto the roadway just before the vehicle came to final rest, and Vehicle 1 probably rolled over her. Fire paramedics were dispatched to the scene at 1046 hours, and arrived at 1050 hours. They treated the driver of Vehicle 1 at the scene and noted that she was combative and disoriented. Fire paramedics transported her to a trauma center at 1103 hours. They arrived at the trauma center at 1108 hours.

The driver of Vehicle 1 received ER treatment for her injuries and due to the severity of her injuries, was admitted to the hospital with a Glasgow Comma Scale of (11). The driver of Vehicle 1 sustained a left distal cervical internal carotid laceration (AIS 5) which caused a left parietotemporal infarct (not coded, not due to occlusion). A 1 cm round hemorrhagic contusion to the right frontal lobe of the brain (AIS 3), and a large contusion to left parietal region (AIS 4) with parenchymal hemorrhaging. She had a blow out fracture of the left orbit (AIS 3) with a fracture of the left lateral wall of left maxillary sinus (not coded per AIS90 coding protocol). She had multiple bilateral frontal rib fractures (AIS 4) with bilateral pneumothoraces. Medical records only indicate fractures of left 4th and 7th ribs. She sustained closed blunt head trauma (AIS 7). The driver's face sustained a contusion of the periocular area with an eyelid laceration, and some conjunctival hemorrhaging to the left side of her face (all AIS 1). She further sustained a large laceration to lateral aspect of zygoma and temporal bones (AIS 1), and multiple facial lacerations (AIS 1) including avulsion of the left lateral canthus (AIS 1). She had multiple lacerations and abrasions about the head, forehead and periorbital area (all AIS 1). All of these injuries were as a result of the driver's ejection and striking the ground. The exception are the rib fractures on the left side which were possibly caused by contact with the driver's door, loading the door as the Vehicle 1 hit the curb—event 2.

The driver of Vehicle 1 also had bilateral comminuted fractures of superior and inferior pubic rami (AIS 3), which were possibly caused by loading on the driver's door. She had a traverse comminuted nondisplaced fracture (AIS 3) of the left distal femoral shaft. She had a right lower extremity hematoma with a small laceration (AIS 1). These injuries were possibly caused by contact with the left instrument panel and below of Vehicle 1.

The driver of Vehicle 1 sustained internal injuries consisting of a splenic hemorrhage contusion/hematoma (AIS 2) and a laceration and contusion to the liver (both AIS 2). It is not known what caused these injuries.

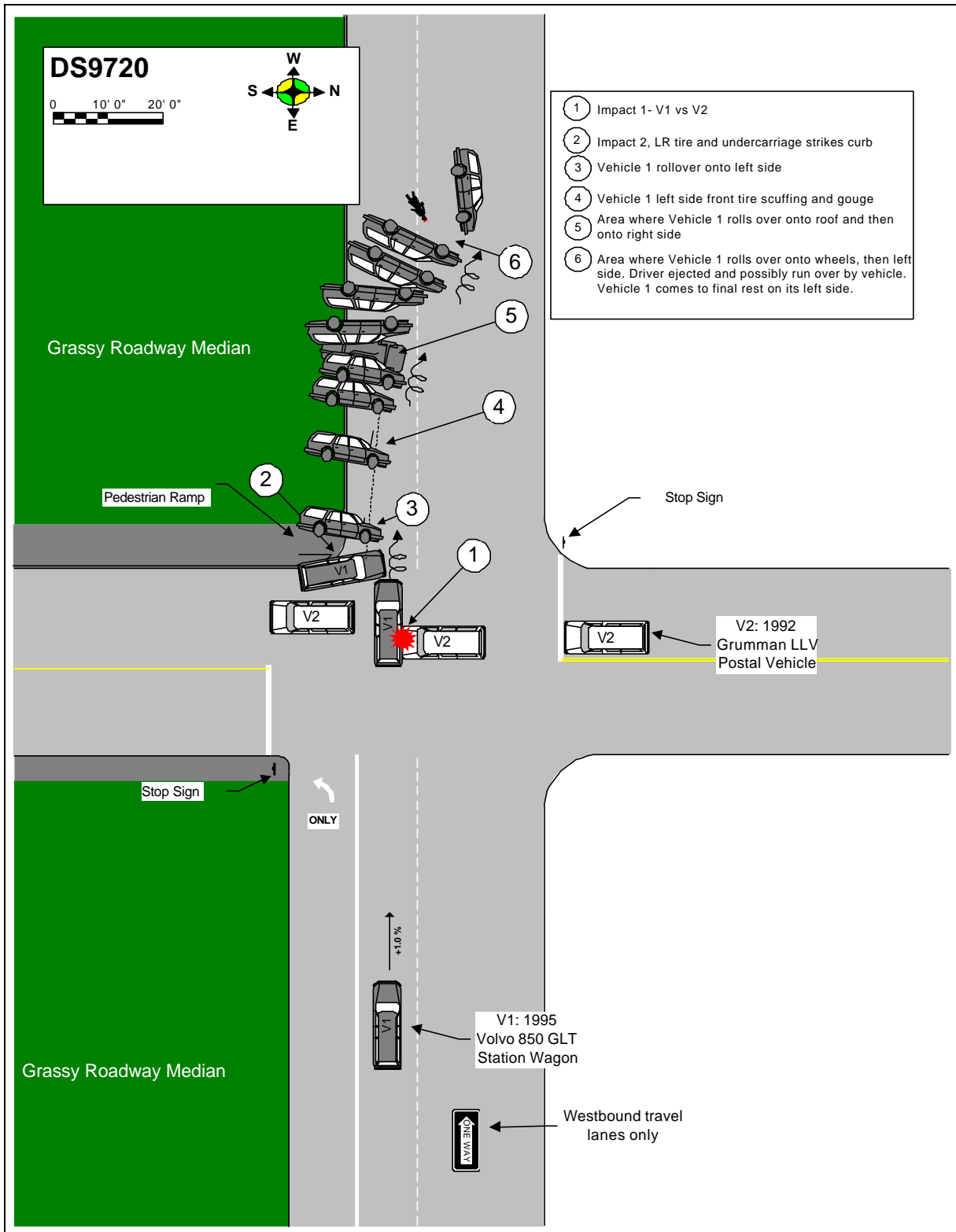
The driver of Vehicle 1 was hospitalized for thirty-one days, and when she was released she went to physical rehabilitation for approximately six weeks.

Vehicle 1 sustained moderate to major damage about the entire vehicle. The impact between Vehicle 1 and Vehicle 2 was the highest delta v; Vehicle 1 was assigned a CDC of 01RDEW2 with a positive 25 degrees PDOF, and had a maximum crush of 10 cm (3.9 in) at C3. The damage portion of WinSmash was utilized to compute a delta v. WinSmash computed a total delta v of 13.2 km/h (8.2 mph), a longitudinal delta v of -11.9 km/h (- 7.4 mph), and a latitudinal delta v of - 5.6 km/h (- 3.5 mph). The results fit the collision model but appear low. Vehicle 1 was towed from the scene due to the damage.

The PAR indicates that the driver of Vehicle 2 was wearing the available lap and shoulder belts. He did not report any injuries. Vehicle 2 sustained moderate contact damage to the front bumper, hood, grille area, and the front left fender. The impact between Vehicle 1 and Vehicle 2 was the highest delta v and a CDC for Vehicle 2 was estimated as 10FDEW1 with a negative 50 degrees

PDOF, with a maximum extent zone of one. The damage portion of WinSmash was utilized to compute delta v. WinSmash computed a total delta v of 12.1 km/h (7.5 mph), a longitudinal delta v of -7.8 km/h (- 4.8 mph), and a latitudinal of 9.3 km/h (5.7 mph). The results fit the collision model and appear reasonable. Vehicle 2 was driven from the scene.

Scene Diagram



DETAILED INFORMATION**Vehicles**Vehicle 1

Description:	1995 Volvo 850 GLT 4-door Station Wagon	
VIN:	YV1LW5537S2XXXXXX	
Odometer:	28317 kilometers (17596 miles)	
Engine:	2.4 L-V4	
Reported Defects:	None noted	
Cargo:	Two child restraints in vehicle	
Damage Description:	There was moderate damage to the right side beginning just forward of the rear wheel well from impact with Vehicle 2. There was major damage to the top of the vehicle from rollover damage and striking the curb as it rolled over. There was moderate damage to left side of the vehicle from the rollover. The rear axle was damaged from contact with the curb. The windshield had been cracked and starred from the rollover and from contact with the front right passenger's air bag and module cover.	
CDC (1 st event/impact):	01RDEW2	
Delta V (Highest):	Total	13.2 km/h (8.2 mph)
	Longitudinal	- 11.9 km/h (-7.4 mph)
	Latitudinal	- 5.6 km/h (-3.5 mph)
	Energy	12,495 joules (9,221 ft-lbs)



Figure 5. Right side damage to Vehicle 1.

Safety Equipment:

Vehicle 1 was equipped with a Supplemental Restraint System (SRS) that consisted of dual driver's and front right passenger's air bags and pyrotechnic pretensioners in the front three point manual lap and shoulder seat belt systems. In addition to the SRS, Vehicle 1 was equipped with side air bags, SIPSBAG, in the driver's and the front right bucket seat backs. The steering wheel hub mounted driver's air bag is circular and is 55.5 cm (21.9 in) in diameter; it has two vent holes and two tethers. There are ten horizontal and three vertical folds. There were markings on the center of the air bag that appeared to be oil residue. There were black smudges on the right side that appeared to be from contact with the interior module covers. The module cover has an "H" configuration. There were no indications of any damage or occupant contact. The mid-mount passenger's air bag measures 33 cm (13 in) by 50 cm (19.7 in); it is not tethered and one vent hole on the right side of the air bag.

There was damage found to the windshield from interior and exterior contacts. On the left side, the windshield was cracked as a result of contact with the ground/curb. On the right side of the windshield, the windshield was cracked and starred as a result of loading from the deploying front right passenger's air bag and module cover.

In the side air bag system, SIPSBAG, both the air bag module and the sensor are fitted into the seat. These units are connected by non-electrical means (see Figure 6)². The bag has a volume of 12 liters and is made of polyamide with an internal coating of silicone rubber. The sensor is a speed sensitive, mechanically triggered, pyrotechnic device. It has a firing pin which penetrates a small percussion cap. The conditions required to trigger the device are:

- Speed > 2 m/s
- Force > 500 N
- Stroke > 2 mm



Figure 6. The SIPSBAG system has sensor (1), non-el connection (2), and bag module (3) in the seat.

² Data and image were obtained from a paper that was presented at the 14th ESV Conference (Paper no. 94 S6 O 13), *SIPSBAG - A New, Seat-Mounted Side Impact Airbag System*, Stig Pilhall, Johnny Korner, Bengt Ouchterlony.

Vehicle 2

Description:	1992 Grumman Long Life Vehicle-Mail truck	
VIN:	1GBCS10E6L2XXXXXX	
Odometer:	27748 kilometers (17242 miles)	
Engine:	2.5 L - L4	
Reported Defects:	None noted	
Cargo:	122 kg (269 lb)—as indicated on police report	
Damage Description:	Moderate contact damage to the front bumper, hood, grille area, and the front left fender—per police report	
CDC (Event/impact 1):	10FDEW1—estimated from police photographs	
Delta V ³ :	Total	12.1 km/h (7.5 mph)
	Longitudinal	- 7.8 km/h (-4.8 mph)
	Latitudinal	9.3 km/h (5.7 mph)
	Energy	24,741 joules (18,259 ft-lbs)



Figure 7. Exterior damage to Vehicle 2.

³ Calculated using WinSmash damage algorithm. d1 and d0 calculated from new car assessment test number 1667—1992 S10 Chevrolet vehicle.

Occupants

<u>Vehicle 1</u>	Occupant 1
Age/Sex:	37/Female
Seated Position:	Front right
Seat Type:	Leather-covered bucket seat
Height:	157.5 cm (62 in)
Weight:	52 kg (115 lbs)
Occupation:	Physician
Pre-existing Medical Condition:	None indicated on medical records
Alcohol/Drug Involvement:	Not Applicable
Driving Experience:	Presumed to be > 21 years
Body Posture:	Normal, upright
Hand Position:	Both hands probably on steering wheel
Foot Position:	Right depressing accelerator pedal, left on floor board
Restraint Usage:	Lap and shoulder belts available but not used
Air bag:	Driver's and front right passenger's frontal air bags deployed as a result of impact
Side air bag:	Front right passenger's seat mounted air bag deployed as a result of impact
Pretensioners:	Both front seats were equipped with pretensioners on the seat belt retractors. Both of the pretensioners had fired and the seat belts were locked in a retracted position.

<u>Vehicle 2</u>	Occupant 1
Age/Sex:	52/Male
Seated Position:	Front left
Seat Type:	Unknown
Height:	165 cm (65 in)
Weight:	61 (135 lbs)
Occupation:	Postal worker
Pre-existing Medical Condition:	None noted
Alcohol/Drug Involvement:	Not applicable
Driving Experience:	Presumed > 36 years
Body Posture:	Unknown
Hand Position:	Unknown
Foot Position:	Unknown
Restraint Usage:	Lap and shoulder belts used—indicated on police report

Injuries and Injury Mechanisms

Vehicle 1

	<u>INJURY</u>	<u>OIC CODE</u>	<u>ICD-9</u>	<u>SOURCE</u>
Driver:	Left distal cervical internal carotid artery traumatic intimal dissection. Caused left parietotemporal infarct—not coded, not due to occlusion.	121002.5, 2	900.03	Ground
	1 cm round hemorrhagic contusion to right frontal lobe of brain, and large contusion to left parietal region. There is also parenchymal hemorrhaging.	140606.3, 1 140608.4, 2	851.40 851.40	Ground Ground
	Blow out fracture of left orbit. Fracture of left lateral wall of left maxillary sinus—not coded.	251204.3, 2	802.8	Ground
	Multiple bilateral frontal rib fractures with bilateral pneumothoraces. Medical records only indicate fractures of left 4 th and 7 th ribs	450232.4, 3	807.00	Possibly from the driver's door
	Bilateral comminuted fractures of superior and inferior pubic rami.	852604.3, 1 852604.3, 2	808.2 808.2	Possibly from the driver's door
	Transverse comminuted nondisplaced fracture of left distal femoral shaft.	851814.3, 1	821.01	Possibly left instrument panel
	Splenic hemorrhage contusion/hematoma.	544210.2, 2	865.01	Unknown
	Laceration and contusion to the liver.	541810.2, 1 541820.2, 1	864.02 864.01	Unknown
	Closed/blunt head trauma	115099.7, 0	854.00	Ground

Contusion of periocular area with eyelid laceration, and some conjunctival hemorrhage; left side of face.	297402.1, 2 297602.1, 2 240416.1, 2	921.1 870.0 372.72	Ground
Large laceration to lateral aspect of zygoma and temporal bones.	290600.1, 2	873.0	Ground
Multiple facial lacerations including avulsion of left lateral canthus.	290600.1, 0 290800.1, 2	873.49 873.49	Ground
Multiple lacerations and abrasions about the head, forehead and periorbital area	190600.1, 5 190202.1, 5 290600.1, 2 290202.1, 2	873.0 910.0 873.42 918.0	Ground
Right lower extremity has hematoma with a small laceration.	890402.1, 1 890602.1, 1	924.10 891.0	Ground

Vehicle 2

Driver: Not injured

Occupant Kinematics

Vehicle 1 was traveling eastbound in the far left lane and intending to cross through the intersection. The driver was seated upright in a leather covered bucket seat. She was not wearing the available lap and shoulder belt. The seat was slightly reclined and was adjusted to middle seat track position. The driver did not take any evasive actions and the front of Vehicle 2 struck the right side of Vehicle 1. As Vehicle 1 sustained an estimated longitudinal Δv of -11.9 km/h (-7.4 mph), both the driver's side and passenger side frontal air bags deployed. The front right side air bag also deployed at this point. The impact caused the driver to move forward and to the right in response to the positive 25 degree PDOF. Her upper torso probably contacted the driver's air bag, and her lower legs probably contacted the lower left instrument panel area causing injuries to her right leg and pelvis as described earlier. As Vehicle 1 began a clockwise rotation, the driver responded by moving to her right and rearward. Vehicle 1 impacted the south-west curb with its left rear tire and began to rollover onto its left side. As Vehicle 1 rolled over onto its top and back onto all four wheels, the unrestrained driver was bouncing all about the vehicle. Vehicle 1 then began to rollover onto its left side and at this point the driver was probably fully ejected through the driver's side window. It is possible that Vehicle 1 rolled over the driver at this point. Vehicle 1 came to final rest several feet away from where the driver was found lying on the ground (see Figure 8). All of the driver's internal head and external facial injuries were as a result of the driver striking the ground when she was ejected. It is not clear what caused her spleen and liver injuries, but it is thought that they may have resulted from Vehicle 1 rolling over the driver. There was evidence of driver contact to the driver's air bag, the left front instrument panel area and the driver's door panel. Blood was found on the roof liner just above the driver's seat.



Figure 8. Final rest area of Vehicle 1 and its driver ejected from front left door glazing.