

On-scene Investigation / Vehicle to Tree
Dynamic Science, Inc. / Case Number: DS97030
1996 Nissan Sentra GXE 4-door
California
December, 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 crashworthiness performance of the involved vehicle(s) or their safety systems.

Technical Report Documentation Page

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16. Abstract <p>This was a single vehicle collision which occurred in California in December, 1997 at 0253 hours. The roadway is a two way, five lane, asphalt surfaced divided roadway. There are two lanes for northbound traffic and two lanes for southbound traffic. Traffic is divided by a two way left turn lane, and the northbound travel lanes curve slightly to the left. Along the east edge of the roadway, there is a gutter, a concrete curb, and a sidewalk. The roadway is lit by overhead standard street lights, and the posted speed limit is 56 km/h (35 mph). Vehicle 1, a 1996 Nissan Sentra GXE 4-door equipped with a driver's and right front passenger's air bags, was driven by an unrestrained 35-year-old female (168.9 cm/66.5 in, 78.5 kg/173 lb).</p> <p>Vehicle 1 was headed northbound in the far right lane. As the roadway curved to the left, Vehicle 1 did not negotiate the curve and continued straight running up and over the north-east edge concrete curb. The front right, front left, and rear right tires were flat. The front right and rear right tire rims were also dented from the impact with the concrete curb. The impact with the curb was not of sufficient magnitude to the deploy the air bags. There was no indication that the driver took any evasive maneuvers after the vehicle struck the curb. Vehicle 1 continued in a northerly direction and collided head-on into a tree (34.0 cm/13.4 in diameter) approximately 20 m (65 ft) from impact with the concrete curb. Vehicle 1 came to rest heading north on all four wheels and resting with its front end against the tree. Vehicle 1 sustained major damage to the entire front end. Event number 4, the front end of Vehicle 1 striking the tree, was the highest delta v event. A CDC of 12FCEN3 has been assigned to the impact with the tree, and maximum crush was measured at C³ and equaled 82.3 cm (32.4 in). The barrier portion of the WinSmash algorithm computed a total delta v of 68.3 km/h (42.4 mph), a longitudinal delta v of - 68.3 km/h (- 42.4 mph), and a latitudinal delta v of 0. The results fit the collision model and appear reasonable. Vehicle 1 was towed from the scene.</p> <p>Vehicle 1 did not negotiate the curve on the roadway, and it ran up and over the concrete curb. Vehicle 1 continued moving forward, and struck a tree head on. The curb impact placed the driver forward, out of position and within the path of the deploying driver's air bag. At impact with the tree, the driver went forward and both of her knees struck the lower instrument panel. The driver engaged the air bag, loaded thru the air bag and then the steering wheel; deforming the upper and lower portion of the steering wheel rim. Bbasically wrapping herself around the steering wheel. The driver sustained a fractured cervical spinal column, with a spinal cord contusion which were the cause of death. The neck injury appears to have been caused by both the forward movement of the driver as she wrapped around the steering wheel—flexion of her cervical spine, and the rearward acceleration as the air bag deployed and rotated her head backwards—extension of her cervical spine. There were abrasions to either side of the neck indicating that the air bag was engaged at some point.</p> <p>Fire paramedics arrived at the scene and treated the driver of Vehicle 1. She was transported via ground ambulance to a county hospital. On December 26, 1997 life support systems were suspended at the request of her family and she expired at 0825 hours.</p>					
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Accident Investigation
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BACKGROUND:

Description: This case was initiated in response to a reported driver fatality as a result of the driver's air bag deployment. The collision was reported to the NHTSA by the local police department investigating the collision. Dynamic Science, Inc. was notified on December 30, 1997. The police officer who reported the collision was present at the inspection of the case vehicle.

Investigation Type: On-scene

Crash Location: California

Crash Date: December 1997 at 0253 hours

Notification Date: December 30, 1997

Field Work Completed: January 06, 1998

SUMMARY:

This was a single vehicle collision which occurred in California in December, 1997 at 0253 hours. The roadway is a two way, five lane, asphalt surfaced divided roadway. There are two lanes for northbound traffic and two lanes for southbound traffic. Traffic is divided by a two way left turn lane, and the northbound travel lanes curve slightly to the left. Along the east edge of the roadway, there is a gutter, a concrete curb (14.6 cm/5.75 high), and a sidewalk. The roadway is lit by overhead standard street lights, and the posted speed limit is 56 km/h (35 mph).



Figure 1. Scene of collision.

Vehicle 1, a 1996 Nissan Sentra GXE 4-door equipped with a driver's and front right passenger's air bags, was driven by an unrestrained 35-year-old female (168.9 cm/66.5 in, 78.5 kg/173 lb¹). The driver of Vehicle 1 had stopped at fast food restaurant just prior to the collision and purchased food. The restaurant is less than 0.8 km (.5 mi) from the scene of the collision. The clerk stated that the driver appeared intoxicated, her speech was slurred and she struck her head on the rear view mirror as she got money out of her wallet.

Vehicle 1 was headed northbound in the far right lane. As the roadway curved to the left, Vehicle 1 did

¹ As measured by the coroner, this is contrary to DMV data indicated on the police report.

not negotiate the curve and continued straight running up and over the north-east edge concrete curb (see Figure 1). At the vehicle inspection, the front right, front left, and rear right tires were flat. The front right and rear right tire rims were also dented from the impact with the concrete curb. The impact with the curb was not of sufficient magnitude to the deploy the air bags. There was no indication that the driver took any evasive maneuvers after the vehicle struck the curb. Vehicle 1 continued in a northerly direction and collided head-on into a tree (34.0 cm/13.4 in diameter) approximately 20 m (65 ft) from impact with the concrete curb (see Figure 2). Vehicle 1 came to rest heading north on all four wheels and resting with its front end against the tree.



Figure 2. Tree Vehicle 1 struck.

Vehicle 1 sustained major damage to the entire front end. The front axle was displaced rearward approximately 28.0 cm (11.0 in) as a result of the impact with the tree. Event number 4, the front end of Vehicle 1 striking the tree, was the highest delta v event. A CDC of 12FCEN3 has been assigned to the impact with the tree, and maximum crush was measured at C³ and equaled 82.3 cm (32.4 in). The barrier portion of the WinSmash algorithm computed a total delta v of 68.3 km/h (42.4 mph), a longitudinal delta v of - 68.3 km/h (- 42.4 mph), and a latitudinal delta v of 0.0 km/h (0.0 mph). The results fit the collision model and appear reasonable. Vehicle 1 was towed from the scene.



Figure 3. Exterior damage to Vehicle 1.

The police officer that was the first person to arrive on the scene at 0257 hours noted that the driver of Vehicle 1 was seated in the driver's seat slumped over onto the front right passenger's seat and was unconscious. The driver's pelvic area was still in the driver's seat while the upper portion of her body was lying on the front right seat. The driver was not wearing the available manual 3-point lap and shoulder belts.

The police interviewed the brother of the driver of Vehicle 1. He stated that the driver was diagnosed

with breast cancer² a year ago, and that she was taking medication; an empty vial of Vicodin³ was found in the vehicle. The brother had spoken to the driver at midnight, and she sounded drowsy and depressed.

The interior inspection revealed that the driver's seat was adjusted to the mid track position. The rigid plastic cover over the left side knee bolster had been cracked, but the knee bolster itself had not been deformed. The upper half of the steering wheel was deformed forward approximately 14.0 cm (5.5 in), and the lower half approximately 4.0 cm (1.6 in). The left shear capsule was visually observed to have been displaced, but the right shear capsule did not appear to have been displaced. The driver's air bag measured 57.0 cm (22.4 in) in diameter. It had three internal tether straps and two rear vent ports at the 11 and 1 o'clock positions. There were four vertical, and four horizontal folds. There were black linear smudges along the outer top part, and on the back outer mid area of the air bag. These linear smudges are consistent with contact with the module covers as the air bag unfolds. There were grease spots in the center and lower mid part of the air bag. The air bag had a maximum excursion of 30.0 cm (11.8 in). There was no damage to the air bag. The upper and lower module covers were not deformed, but there were oil smudges on the upper cover. The module covers opened in a typical "H" pattern.

The coroner's autopsy report as well as the autopsy photographs were reviewed, and the following injuries were coded from the report:

The driver of Vehicle 1 sustained a diffuse axonal injury, to the pons of brain stem (AIS 5), a cerebellar tonsillar herniation (AIS 5), and scant areas of subdural hemorrhage at the base of the brain, only 1 to 2 cc's in total volume (AIS 4). These injuries are attributed to the air bag.

She had a contusion of spinal cord with fracture of the C2 vertebral column (AIS 3). There is a dislocation gap between C1 and C2, but the C2 vertebral body has been shifted anteriorly into the neck, and surrounding the fracture site in the prevertebral space of the neck is abundant hemorrhage and clot. The C2 fracture line is jagged, and forms an upside down V. Associated with the C2 fracture are fractures of the hyoid bone. The right side of the hyoid bone is fractured 2 cm from the tip, and the left horn of the hyoid bone is 0.5 cm (0.3 in) from the tip. This injury is a combination of forward flexion of the cervical spine as a result of the impact with the tree,

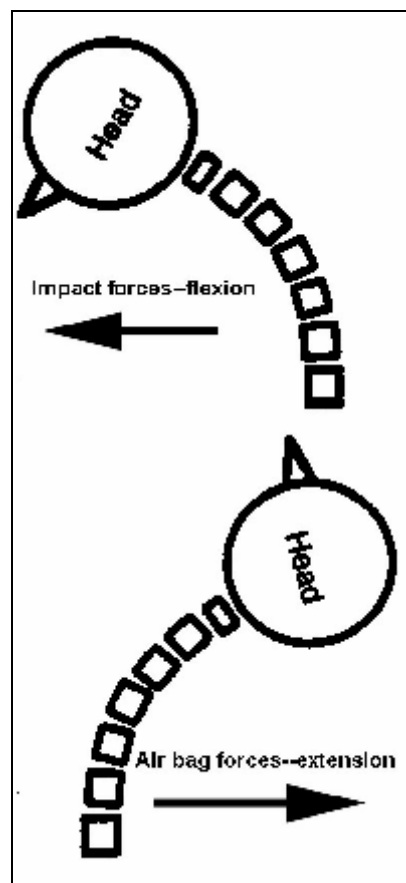


Figure 4. Cervical spine flexion and extension.

² The coroner indicated that there were no areas of malignancy noted on her breast.

³ Vicodin is an opioid analgesic that is used for the relief of moderate to moderately severe pain. Like all narcotics, its use may impair the mental and/or physical abilities required for the performance of potentially hazardous tasks such as driving a car.

and extension of the cervical spine as a result of rearward acceleration of the cervical spine by the deployment of the driver's air bag (see Figure 4).

The driver also sustained acute, bilateral cerebellar infarction (AIS 3), and a slight swelling of the brain with asymmetry of the medial temporal lobes, with the left lobe broadened and flattened very slightly as compared to the right lobe (AIS 3). These injuries are related to the interaction of the driver's air bag.

She had scant retroperitoneal hemorrhage, with scattered hemorrhage in the mesentery of the small and large bowel (AIS 3). She also had fracture of right lateral ribs 4th, 5th, and 6th with displacement of right lateral rib 6 into the right chest cavity (AIS 2). There were Bilateral pleural effusions composed of thin bloody fluid, 500 cc's of fluid is found in each chest cavity (AIS 2). She sustained a hematoma to the spleen covering approximately 3.0 cm (1.2 in) of the capsular surface (AIS 2). There was a contusion of the anterior chest wall, and anterior mediastinum (AIS 1). The majority of the mediastinal hemorrhage had dissected from the level of the spinal column injury. These injuries were attributed to the steering wheel rim/hub.

The driver sustained a contusions of the posterior neck. On the right side measure 5.1 x 2.5 cm (2.0 x 1.0 in), and the left sided contusions measure 5.1 x 5.1 cm (2.0 x 2.0 in) (AIS 1). Possibly non-contact injuries due to cervical spine flexion.

Above the left eyebrow there where scabbed abrasions 1.9 x .6 cm (.75 x .25 in). Lateral to the lateral canthus of the left eye, and just below it, scabbed abrasion 1.3 cm (.5 in) in diameter, and on the left cheek scabbed abrasions found over a 3.8 x 2.5 cm (1.5 x 1.0 in) area. The medial aspect of the left cheek abrasions have a squared off appearance (AIS 1). There was a .6 cm (.25 in) long laceration of the right angle of the mouth, and surrounding the upper frenulum is a 2.5 cm (1.0 in) in diameter contusion (AIS 1). Extending from the lower attachment of the right ear, down onto the upper right neck, is a contusion 7.6 x 5.1 cm (3.0 x 2.0 in) in dimension (AIS 1). These injuries are attributed to the driver's air bag.

She also sustained a contusion just below the tip of the chin, horizontally oriented 5.1 x 1.3 cm (2.0 x .5 in) in dimension (AIS 1), and this was possibly caused by the air bag.

On the right upper shoulder, contusions found over 7.6 x 10.2 cm (3.0 x 4.0 in) area (AIS 1), as well as contusions on the left shoulder, extending onto the left upper chest. These are found over a 17.8 x 10.2 cm (7.0 x 4.0 in) area (AIS 1). On the medial side of the right forearm was a contusion 5.1 cm (2.0 in) in diameter (AIS 1), and located on the ventral right forearm, extending to the wrist is a contusion 7.6 x 5.1 cm (3.0 x 2.0 in) (AIS 1). On the right breast are four punctate scabs (AIS 1). These injuries are attributed to the driver's air bag.

Lateral to the right olecranon is a 3.2 cm (1.25 in) contusion with a central V-shaped 1.3 cm (.5 in) long scab (AIS 1). There were contusions on the dorso lateral aspect of the left forearm. These are found over an 20.3 x 10.2 cm (8 x 4 in) area, with the largest individual contusion 3.8 cm (1.5 in) (AIS 1). The dorsum of the left hand was diffusely contused and edematous. The contusion extends from the wrist onto the metacarpal, and was found over a 7.6 cm (3.0 in) area. Circular areas of contusion

overlie the dorsum of the left thumb, and measure to 2.5 cm (1.0 in). In addition, overlying the PIP's of the right thumb through were small finger contusions, measuring up to 1.9 cm (.75 in) in dimension (AIS 1). There was a palpable fracture of the left hand (AIS2). These upper extremity injuries were probably due to contact with the left instrument panel.

Extending from below the left patella onto the left shin was a contusion measuring 20.3 x 2.5 cm (8.0 x 1.0 in). Extending down the lateral side of the left lower extremity, from the lateral malleolus to the calf, was a 25.4 x 10.2 cm (10.0 x 4.0 in) contusion. Overlying the medial malleolus was a 7.6 cm (3.0 in) in diameter contusion. On the medial left calf was a contusion measuring 12.7 x 6.4 cm (5.0 x 2.5 in), and vertically oriented. Over the left tibia was a vertically oriented, 2.5 cm (1.0 in) long, partially scabbed laceration which extended to a depth of 1.3 cm (.5 in). All AIS 1 injuries and resulted from contact with the left instrument panel and below.

On the medial left thigh, a 10.2 x 7.3 cm (4.0 x 3.0 in) contusion (AIS 1), and overlying the right thigh is a 15.2 x 5.1 cm (6.0 x 2.0 in) contusion (AIS 1) that were probably due to contact with the steering wheel rim. On the right posterior thigh a 15.2 x 7.6 cm (6.0 x 3.0 in) contusion (AIS 1), and on the left posterior thigh were three contusions, measuring to 12.7 cm (5.0 in) in dimension (AIS 1) that were possibly due to contact with the seat cushion.

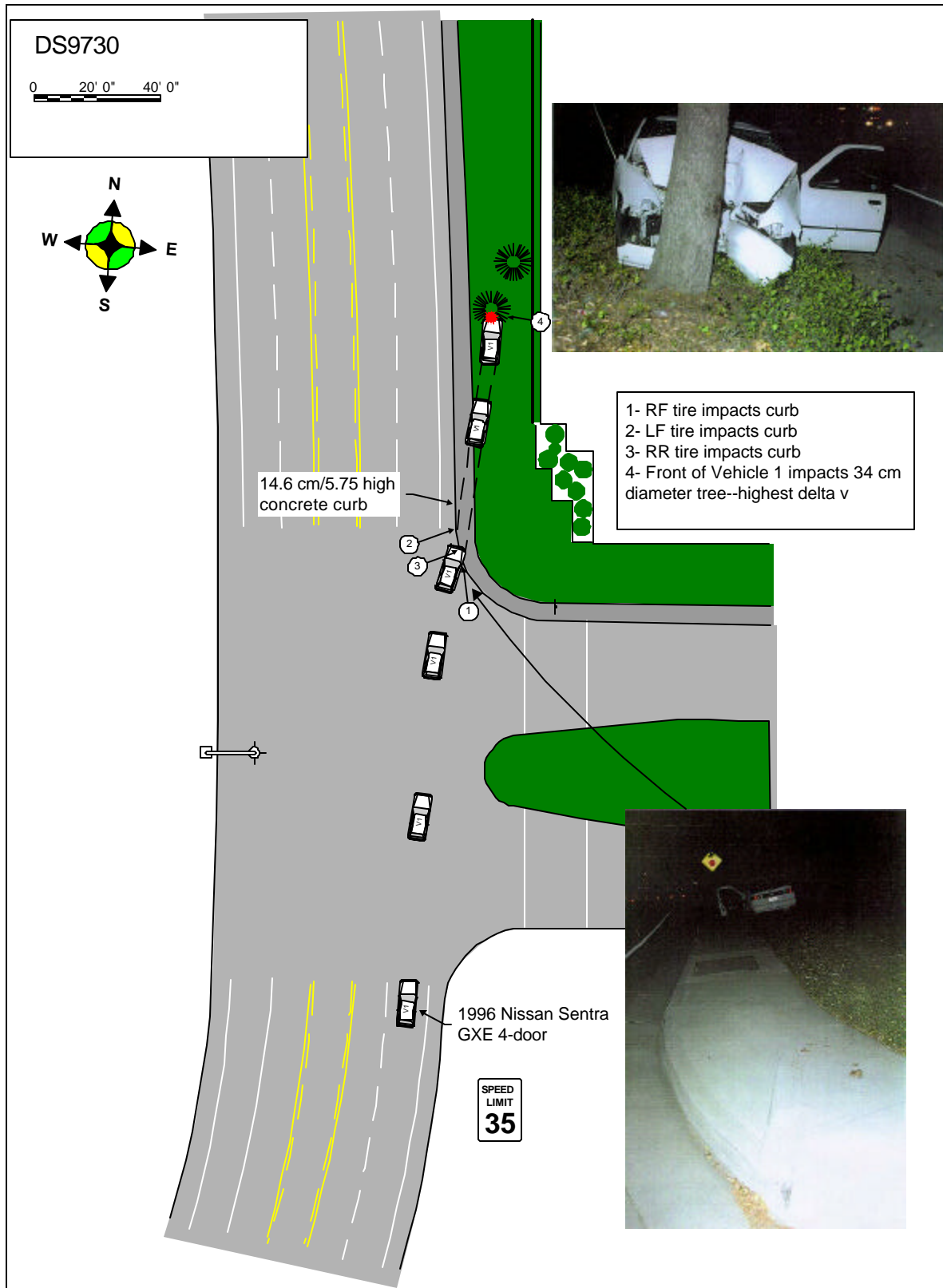
Medial to the right patella a 7.6 cm (3.0 in) diameter contusion with a central 1.3 cm (.5 in) scab. Covering the lateral right distal extremity, extending from the knee to the lateral malleolus, a band of contusion, measuring 33.0 x 10.2 cm (13.0 x 4.0 in). Surrounding the medial malleolus, and extending upward onto the calf is a 17.8 x 10.2 cm (7 x 4 in) contusion. On the medial side of the right shin a 3.8 x 1.3 cm (1.5 x 0.5 in) abrasion. All were AIS 1 type injuries to the lower extremities that were caused by contact with the left instrument panel and below. On the dorsum of the right great toe is a 5.1 x 2.5 cm (2.0 x 1.0 in) contusion (AIS 1) and possibly caused by the accelerator pedal as the toe pan intruded.

Fire paramedics arrived at the scene and treated the driver of Vehicle 1. She was transported via ground ambulance to a county hospital. Three days after the crash, life support systems were suspended at the request of her family and she expired at 0825 hours.

The driver of Vehicle 1 fell asleep or was under the influence of medication. Her posture is not known but it appears that she was initially seated upright and when she fell asleep she may have slumped forward with her head and upper body in close proximity to the driver's air bag. Her left hand was probably on the steering wheel, and she was not wearing the available 3-point manual lap and shoulder belts. She was seated in a fabric covered bucket seat with a folding back. The seat was slightly reclined at a 13 degree angle and adjusted to the mid track position. The vehicle did not negotiate the curve on the roadway, and it ran up and over the concrete curb. The impact with the curb was not of sufficient magnitude to the deploy the air bags. There were no indication that the driver took any evasive maneuvers after the vehicle struck the curb. Vehicle 1 continued moving forward, and struck a tree head on. The curb impact placed the driver forward, out of position and within the path of the deploying air bag. At impact with the tree, the driver went forward and both knees struck the lower instrument panel. The driver engaged the air bag, loaded thru the air bag and then the steering wheel

rim; deforming the upper and lower portion of the rim. Basically wrapping herself around the steering wheel. The driver sustained a fractured cervical spinal column, with a spinal cord contusion which were the cause of death. The neck injury appears to have been caused by both the forward movement of the driver as she wrapped around the steering wheel—flexion of her cervical spine, and the rearward acceleration as the air bag deployed and rotated her head backwards—extension of her cervical spine (see Figure 4). There were abrasions to either side of the neck indicating that the air bag was engaged at some point.

SCENE DIAGRAM



DETAILED INFORMATION

Vehicles

Vehicle 1

Description:	1996 Nissan Sentra GXE 4-door	
VIN:	1N4AB41D5TCXXXXXX	
Odometer:	8,267 km (25,973 miles)	
Engine:	1.6 L V4	
Reported Defects:	None reported	
Cargo:	None	
Damage Description:	Severe/total front end damage, hood, grille area, and both front fenders. The frame around the driver's door buckled, as did the roof top. The front right and left tires were restricted, and the front axle was damaged.	
CDC (4 th event–highest Delta V):	12FCEN3	
Delta V ⁴ :	Total	68.3 km/h (42.4 mph)
	Longitudinal	-68.3 km/h (-42.4 mph)
	Latitudinal	0 km/h (0 mph)
	Energy	205,609 joules (151,750 ft-lb)



Figure 6. Exterior damage to vehicle.

⁴ Calculated using the barrier options of WinSmash. NCAP Test #2298 were used to calculate d_1 and d_0 values.

Supplemental Restraint System (Air Bag):

Vehicle 1 was equipped with a driver's air bag and a top-mounted front right passenger's air bag. The steering wheel hub mounted driver's air bag was circular and measured 57.0 cm (22.4 in) in diameter. It had three tethers and two rear vent ports at the 11 and 1 o'clock positions. There were four vertical, and four horizontal folds. There were black linear smudges along the outer top part, and on the back outer mid area of the air bag. These linear smudges are consistent with contact with the module covers as the air bag unfolds. There were grease spots in the center and lower mid part of the air bag. The air bag had a maximum excursion of 30.0 cm (11.8 in). There was no damage to the air bag. The dual module covers opened in a typical "H" configuration, and the upper and lower module covers were not deformed, but there was an oil smudge on the upper cover. The passenger side air bag is rectangular in shape and measures 56.0 cm (22.0 in) high by 37.0 cm (14.6 in) wide; it was not tethered and had two vent holes at the rear and outboard part of the air bag. It was not damaged, and there was food found on the lower left corner of the air bag. The single module cover is rectangular in shape and there were no indications of damage or occupant contact.

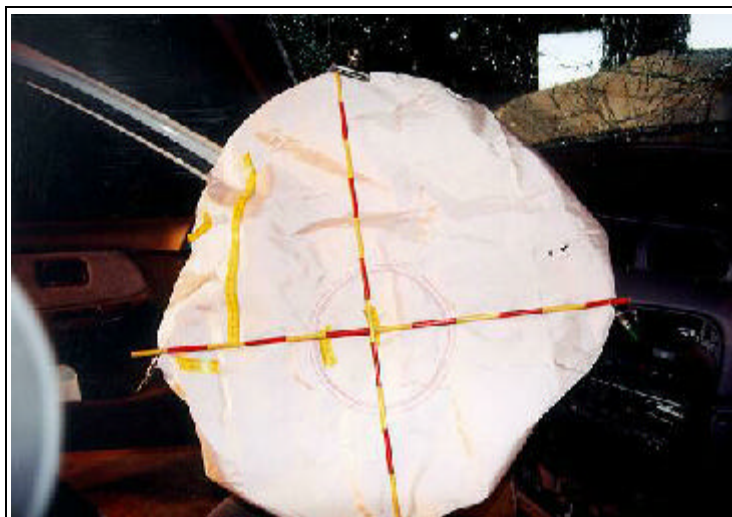


Figure 7. Driver's air bag.

Occupants

<u>Vehicle 1</u>	Occupant 1
Age/Sex:	35/Female
Seated Position:	Front left
Seat Type:	Bucket
Height:	168.9 cm (66.5 in)
Weight:	78.5 kg (173 lb)
Occupation:	Unknown
Pre-existing Medical Condition:	Breast cancer
Alcohol/Drug Involvement:	Toxicological test were negative for alcohol, but positive for opiate and benzodiazepine; probably related to the vial of Vicodin found in the vehicle
Driving Experience:	Presumed >17 years
Body Posture:	Out of position with her head slumped forward in close proximity to driver's air bag and steering wheel
Hand Position:	Unknown due to being unconscious at the time of collision. Injuries to the left hand suggest that it was probably on the steering wheel.
Foot Position:	Right foot probably on accelerator pedal, and left foot on toe pan.
Restraint Usage:	Lap and shoulder belt not used
Air bag:	Driver's and front right passenger's air bag deployed

Injuries and Injury Mechanisms

Vehicle 1

	<u>INJURY</u>	<u>OIC CODE</u>	<u>ICD-9</u>	<u>SOURCE</u>
Driver:	Diffuse axonal injury, pons of brain stem	140206.5, 8	851.4	Air bag
	Cerebellar tonsillar herniation (neuropathology)–brain stem injury	140202.5, 8	348.4	Air bag
	Scant areas of subdural hemorrhage at the base of the brain, only 1 to 2 cc's in total volume. Slight swelling of the brain with asymmetry of the medial temporal lobes, with the left lobe broadened and flattened very slightly as compared to the right lobe.	140684.3, 3	432.1	Air bag
	Contusion of spinal cord with fracture of the C2 vertebral column, dislocation gap between C1 and C2, but the C2.	640208.3, 6	806.01	Steering wheel
	Fractures of the hyoid bone. The right side of the hyoid bone is fractured 2 cm from the tip, and the left horn of the hyoid bone is 0.5 cm (0.3 in) from the tip.	350200.2, 5	807.5	Steering wheel
	Acute, bilateral cerebellar infarction	140676.3, 9	434.9	Air bag
	Retroperitoneal hemorrhage.	543800.3, 8	863.0	Steering wheel rim/hub
	Fracture of right lateral ribs 4 th , 5 th , and 6 th with displacement of right lateral rib 6 into the right chest cavity–hemothorax.	450222.3, 1	807.03	Steering wheel rim/hub
	Contusion, mediastinum	442299.7, 9	862.2	Steering wheel rim/hub
	Hematoma to the spleen covering approximately 3 cm (1.2 in) of the capsular surface.	544212.2, 2	865.00	Steering wheel rim/hub
	Contusion of the anterior chest wall.	490402.1, 0	922.1	Steering wheel rim/hub
	Contusions of the posterior neck. On the right side measure 5.1 x 2.5 cm (2.0 x 1.0 in), and the left sided contusions are 5.1 x 5.1 cm (2.0 x 2.0 in).	390402.1, 6	920	Unknown, possibly non-contact (spine flexion)

Above the left eyebrow are scabbed abrasions found over a 1.9 x .6 cm (.75 x .25 in) area. Lateral to the lateral canthus of the left eye, and just below it, is a 1.3 cm (.5 in) in diameter scabbed abrasion. Left cheek, are scabbed abrasions, possibly just related to tape (probably related to air bag), but found over a 3.8 x 2.5 cm (1.5 x 1.0 in) area. The medial aspect of the left cheek abrasions have a squared off appearance.	290202.1, 7	910.0	Air bag
	290202.1, 2	918.0	
	290202.1, 2	910.0	
A .6 cm (.25 in) long laceration of the right angle of the mouth. Surrounding the upper frenulum is a 2.5 cm (1 in) in diameter contusion.	290602.1, 1 290600.1, 8	873.4 920	Air bag
Contusion just below the tip of the chin, horizontally oriented 5.1 x 1.3 cm (2.0 x 0.5 in) in dimension.	290402.1, 8	920	Air bag
Extending from the lower attachment of the right ear, down onto the upper right neck, is a contusion 7.6 x 5.1 cm (3.0 x 2.0 in) in dimension. Two zones of skin slip are found on the right neck, with the largest 1.3 cm (.5 in) in dimension.	390402.1, 1	920	Air bag
Right upper shoulder contusions, 7.6 x 10.2 cm (3.0 x 4.0 in) area.	790402.1, 1	923.00	Air bag
Contusions, left shoulder, extending onto the left upper chest. These are found over a 17.8 x 10.2 cm (7.0 x 4.0 in) area.	790402.1, 2	923.0	Air bag
On the medial side of the right forearm is a contusion 5.1 cm (2.0 in) in diameter.	790402.1, 1	923.10	Possibly air bag
Located on the ventral right forearm, extending to the wrist is a contusion 7.6 x 5.1 cm (3.0 x 2.0 in).	790402.1, 1	923.10	Possibly air bag
Lateral to the right olecranon is a 3.2 cm (1.25 in) contusion with a central V-shaped 1.3 cm (.5 in) long scab.	790402.1, 1	923.11	Possibly the left instrument panel
On the right breast are four punctate scabs.	490602.1, 1	875.0	Possibly air bag

Contusions on the dorso lateral aspect of the left forearm. These are found over an 20.3 x 10.2 cm (8.0 x 4.0 in) area, with the largest individual contusion 3.8 cm (1.5 in).	790402.1, 2	923.10	Possibly the left instrument panel
The dorsum of the left hand is diffusely contused and is edematous. The contusion extends from the wrist onto the metacarpals, and is found over a 7.6 cm (3.0 in) area. Circular areas of contusion overlie the dorsum of the left thumb, and measure to 2.5 cm (1.0 in). In addition, overlying the proximal interphalangeal of the right thumb through small finger contusions, measuring up to 1.9 cm (.75 in) in dimension.	790402.1, 2	923.20	Probably the left instrument panel
There is a palpable fracture of the left hand, which likely involves the metacarpal bones of the left long, and possibly left ring fingers.	752500.2, 2	815.09	Probably the left instrument panel
Extending from below the left patella onto the left shin is a contusion, measuring 20.3 x 2.5 cm (8.0 x 1.0 in). Extending down the lateral side of the left lower extremity, from the lateral malleolus to the calf, is a 25.4 x 10.2 cm (10.0 x 4.0 in) contusion. Overlying the medial malleolus a 7.6 cm (3.0 in) in diameter contusion. On the medial left calf is a contusion measuring 12.7 x 6.4 cm (5.0 x 2.5 in), and vertically oriented. This consists of closely spaced, vertically oriented lines of a contusion.	890402.1, 2	924.1	Left instrument panel
	890402.1, 2	924.10	
	890402.1, 2	924.10	
On the medial left thigh, a 10.2 x 7.3 cm (4.0 x 3.0 in) contusion. On the left posterior thigh are three contusions, measuring to 12.7 cm (5.0 in) in dimension.	890402.1, 2 890402.1, 2	924.00 924.00	Probably the steering wheel rim Posterior possibly seat cushion
Over the left tibia is a vertically oriented, 2.5 cm (1.0 in) long, partially scabbed laceration which extends to a depth of 1.3 cm (.5 in).	890602.1, 2	891.0	Left instrument panel and below
Overlying the right thigh is a 15.2 x 5.1 cm (6.0 x 2.0 in) contusion.	890402.1, 1	924.00	Probably the steering wheel rim

On the right posterior thigh is a 15.2 x 7.6 cm (6.0 x 3.0 in) contusion.	890402.1, 1	924.00	Possibly seat cushion
Medial to the right patella is a 7.6 cm (3.0 in) diameter contusion with a central 1.3 cm (.5 in) scab. Covering the lateral right distal extremity, extending from the knee to the lateral malleolus, is a band of contusion, measuring 33.0 x 10.2 cm (13.0 x 4.0 in). Surrounding the medial malleolus, and extending upward onto the calf is a 17.8 x 10.2 cm (7.0 x 4.0 in) contusion.	890402.1, 1	924.11	Left instrument panel and below
	890402.1, 1	924.1	
	890402.1, 1	924.10	
On the medial side of the right shin is a 3.8 x 1.3 cm (1.5 x .5 in) abrasion.	890202.1, 1	916.0	Left instrument panel and below
On the dorsum of the right great toe is a 5.1 x 2.5 cm (2.0 x 1.0 in) contusion.	890402.1, 1	924.3	Possibly accelerator pedal

Occupant Kinematics

The driver of Vehicle 1 fell asleep or was under the influence of medication. Her posture is not known but it appears that she was initially seated upright and when she fell asleep she may have slumped forward with her head and upper body in close proximity to the driver's air bag. She was not wearing the available 3-point manual lap and shoulder safety belt. Her left hand was probably on the steering wheel. She was seated in a fabric covered bucket seat with a folding back. The seat was slightly reclined at a 13 degree angle and adjusted to the mid track position. Vehicle 1 did not negotiate the curve on the roadway, and it ran up and over the concrete curb. The impact with the curb was not of sufficient magnitude to deploy the air bags. There were no indication that the driver took any evasive maneuvers after the vehicle struck the curb. Vehicle 1 continued moving forward, and struck a tree head on. The curb impact placed the driver forward, out of position and within the path of the deploying air bag. At impact with the tree, Vehicle 1 experienced a rapid deceleration. The driver went forward and both knees struck the lower instrument panel. The driver engaged the air bag, loaded thru the air bag and then the steering wheel; deforming the upper and lower portion of the steering wheel rim. Basically wrapping herself around the steering wheel. The driver sustained a fractured cervical spinal column, with a spinal cord contusion which were the cause of death. The neck injury appears to have been caused by both the forward movement of the driver as she wrapped around the steering wheel—flexion of her cervical spine, and the rearward acceleration as the air bag deployed and rotated her head backwards—extension of her cervical spine (see Figure 4). There were abrasions to either side of the neck indicating that the air bag was engaged at some point. The air bag pushed the driver back and she probably struck the seat back. She was found seated in the driver's seat slumped over onto the front right passenger's seat and unconscious. The driver's pelvic area was still in the driver's seat while the upper portion of her body was lying on the front right seat.