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SCI/NASS COMBINATION CASE REPORT

CASE NUMBER - NASS-99-79-176A
LOCATION - California
VEHICLE - 1996 VOLVO 850
CRASH DATE - December 1999

Submitted:

August 2, 2000

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Contract Number: DTNH22-94-D-17058

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National Highway Traffic Safety Administration
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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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Combination SCI/NASS investigation involving a 1996 Volvo 850 with manual safety belts and pretensioners, dual front air bags and seat back-mounted side air bags, and a 1996 Jeep Cherokee.

16. *Abstract*

This report covers a SCI/NASS combination investigation concerning a 1996 Volvo 850 (case vehicle) and a 1996 Jeep Cherokee (vehicle #2). This case is of special interest because the case vehicle was equipped with seat back-mounted side air bags that deployed as a result of the collision events. In addition, the driver's front air bag deployed but the front right passenger's front air bag did not deploy. The restrained front right passenger (72-year-old female) was killed and the restrained driver (72-year-old female) sustained serious injuries. The case vehicle was traveling west in the westbound left turn lane of a six-lane, two-way undivided local road, approaching a four-leg intersection and intending to turn left to travel south. Vehicle #2 was traveling east in the inside eastbound lane of the same roadway, approaching the same intersection and intending to pass through the intersection and continue east. The case vehicle turned left across the path of vehicle #2. The front of vehicle #2 impacted the right side of the case vehicle, causing the case vehicle's two seat back-mounted side air bags and the driver's front air bag to deploy. The case vehicle rotated approximately 60 degrees clockwise and traveled rearward toward the southeast corner of the intersection. The case vehicle traveled up a mountable curb, across the sidewalk and the back of the case vehicle struck a concrete and brick commercial sign just beyond the sidewalk, where it came to rest heading northwest. Vehicle #2 rotated approximately 160 degrees clockwise and came to rest within the intersection heading southwest. Both vehicles were towed from the scene due to disabling damage. The case vehicle's front right passenger was declared dead at the scene. She was pinned in the case vehicle and had to be extricated. The case vehicle driver was transported to a hospital via ambulance, where she was admitted to intensive care.

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BACKGROUND

NASS-99-79-176A

This combination SCI/NASS crash investigation concerns a 1996 Volvo 850 (case vehicle, vehicle #1) and a 1996 Jeep Cherokee (vehicle #2). The crash occurred in December 1999 at 7:15 p.m., in California, and was investigated by the applicable municipal police department. This crash is of special interest because the case vehicle was equipped with seat back-mounted side air bags and both side air bags deployed as a result of the collision events. The case vehicle's restrained front right passenger (72-year-old female) was killed and the restrained driver (72-year-old female) sustained serious injuries. There were three occupants in vehicle #2, none of whom sustained any injury. The NASS researcher inspected the scene in December 1999, and inspected the case vehicle and interviewed the case vehicle driver in January 2000. Vehicle #2 was not inspected and the driver of vehicle #2 declined to be interviewed. This report is based on the Police Crash Report, the NASS investigator's coded forms and photographs, the interview, the medical records, occupant kinematic principles, and this contractor's evaluation of the evidence.

CRASH CIRCUMSTANCES

The case vehicle was traveling west in the westbound left turn lane of a six-lane, two-way undivided local road, approaching a four-leg intersection and intending to turn left to travel south. Vehicle #2 was traveling east in the inside eastbound through lane of the same roadway, approaching the same intersection and intending to pass through the intersection and continue east. Both roadways were asphalt, dry, straight, level, and with no defects. It was daylight with no adverse weather conditions. The speed limit for both vehicles was 56 km.p.h. [35 m.p.h.]. The intersection was controlled by on-colors automatic signals, with painted lane lines (**Figure 1**). The case vehicle turned left across the path of vehicle #2.

Figure 1: Case vehicle's westbound approach to left turn and initial impact

The crash occurred within the intersection (see **SCENE DIAGRAM**, below). The front of vehicle #2 impacted the right side of the case vehicle, causing the case vehicle's two seat back-mounted side air bags and the driver's front air bag to deploy (the front right passenger's front air bag did not deploy). The case vehicle rotated approximately 60 degrees clockwise and traveled rearward toward the southeast corner of the intersection. Moving rearward, the case vehicle traveled up a mountable curb, across the sidewalk and the back of the case vehicle struck a concrete and brick commercial sign just beyond the sidewalk

Figure 2: Case vehicle's backward path of travel to second impact and final rest

(**Figure 2**), where it came to rest heading northwest. Vehicle #2 rotated approximately 160 degrees clockwise and came to rest within the intersection heading southwest.

CASE VEHICLE

The case vehicle was a rear wheel drive 1996 Volvo 850 five-passenger, four-door sedan (VIN: YV1LS5540T2------), equipped with a 2.4 liter I-5 gasoline engine and an automatic transmission with console-mounted selector lever. Four-wheel anti-lock brakes were standard for this model. The wheelbase was 266 centimeters [104.9 inches]. The odometer reading was reported as 51,761 kilometers [32,164 miles]. The case vehicle was towed from the scene due to disabling damage.

CASE VEHICLE DAMAGE

The case vehicle sustained heavy direct contact damage centered approximately on the right B-pillar (**Figure 3**), with direct contact above the belt line, including both right doors and extending forward of the right A-pillar into the right fender. The imprint of vehicle #2's bumper is plainly apparent along the midline of the right side doors. The right sill was overridden until vehicle #2's front had penetrated the case vehicle such that vehicle #2's undercarriage components caused direct contact on the case vehicle's sill (i.e., the case vehicle sustained right side override and vehicle #2 sustained front underride[1]). The B-pillar and the doors collapsed inward, causing major lateral intrusion into the front right seat area (**Figure 4**). The right roof rail and roof were buckled downward, causing vertical intrusion. All glazing on the right side was shattered (kernelized). The right A-pillar was also pushed inward, pulling the windshield header down, and the windshield was shattered across its entire width. The CDC was determined to be **61-RYAW-4**, with direction of principal force 30 degrees [one o'clock] and reflecting the NASS investigator's judgement that the vehicle sustained bowing of the frame with end shift to the right. Maximum crush was 65 centimeters [26 inches] at the B-pillar. The

Figure 3: Case vehicle's right side damage; note, right front door in foreground

Figure 4: Case vehicle's front right seat position; note, relatively undamaged seat cushion

[1]Note that the side override/front underride aspect of this collision is not reflected in the NASS case coding because side override/underride is not defined for light vehicles. The NASS definition of override/underride is limited to end plane impacts for light vehicles and when an impact involves a side plane of a light vehicle, the override/underride variables must be coded "no override/underride".

winSMASH ROLDMIS reconstruction program was used to calculate Delta V based on the crush profile of the case vehicle because vehicle #2 was not inspected. The results for the case vehicle indicate Total, Longitudinal and Lateral Delta V, respectively: 43 km.p.h [27 m.p.h.], -37 km.p.h. [-23 m.p.h.] and -21 km.p.h. [-13 m.p.h.]. This is a borderline reconstruction and these results appear somewhat high, but this was certainly a crash of high severity for the case vehicle.

The case vehicle rolled backwards, up a mountable curb and across the sidewalk at the southeast corner of the intersection and the back hit a concrete and brick commercial sign. The CDC for this second impact was **06-BZLW-1**, with direction of principal force 180 degrees. The case vehicle came to rest against the sign structure. No reconstruction was attempted for this minor second impact.

Virtually all components on the right side caused intrusion into the right side seating areas, including the A- and B-pillars, the roof side rail, the roof, the interior surfaces of the two doors and the floor pan. The front right seat position sustained very heavy intrusion. The seat back of the front right bucket seat was pushed laterally such that it was compressed between the collapsed right B-pillar and the driver's seat back, and was bent and folded (**Figure 5**). It appears that the front right seat cushion was essentially undamaged (the available photos do not permit a complete evaluation due to debris). This configuration of damage to the seat back but not to the seat cushion reflects the side override component of the impact. The right front door interior panel intruded beyond the right third into the middle third of the front seat row, for a measured total intrusion of 56 centimeters [22 inches] laterally. The right side front and back doors were jammed shut.

Figure 5: Back of front seats; note, front right seat back compressed between B-pillar and driver's seat, and driver's seat pressed against left side

AUTOMATIC RESTRAINT SYSTEM

The case vehicle was equipped with dual front air bags and seat back-mounted side air bags at the two front seat positions, for a total of four air bags, and was also equipped with safety belt pretensioners for the two front seats. All of the air bags deployed except the front right passenger's front air bag, and the two pretensioners actuated. The original equipment automatic restraint system for this model vehicle includes three sensors. One sensor, sensitive to longitudinal deceleration, controls the two front air bags. The side air bags are controlled by separate individual sensors for each of the two side air bags. The sensors for the side air bags are located on the outboard surface of the seat cushion frame, near the junction of the seat back and the seat cushion. These sensors are linked directly to the air bag module (i.e., they are not part of the vehicle's wiring harness). These independent side sensor devices are triggered by any manner of physical compression.

The driver's front air bag was located in the steering wheel hub with the cover flaps in the H-configuration. The deployed air bag was round with diameter 54 centimeters [21 inches], with four tethers and two vent ports. There was no indication of any problem with the driver's front air bag. There were numerous blood spots all over the front of the air bag and scuffing on the back (**Figure 6**).

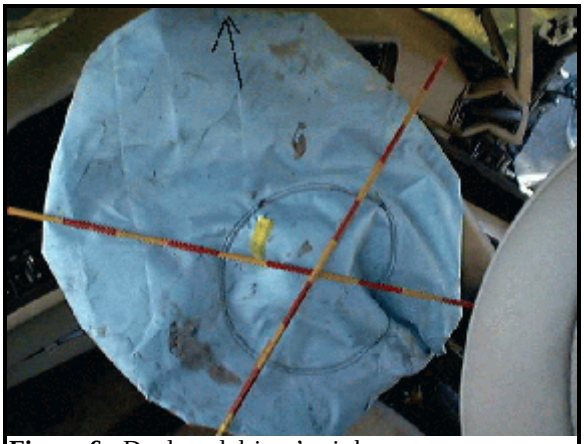


Figure 6: Deployed driver's air bag

The front right passenger's front air bag was located in the top of the instrument panel and did not deploy. The center-right area of the instrument panel was bent sharply upward along the inboard edge of the air bag module cover flap, where the instrument panel is molded to form the center console. The outboard edge of the instrument panel was bent downward and crushed against the intruded A-pillar (**Figure 7**). Although the longitudinal Delta V was sufficient to deploy the driver's front air bag, the passenger's front air bag did not deploy.

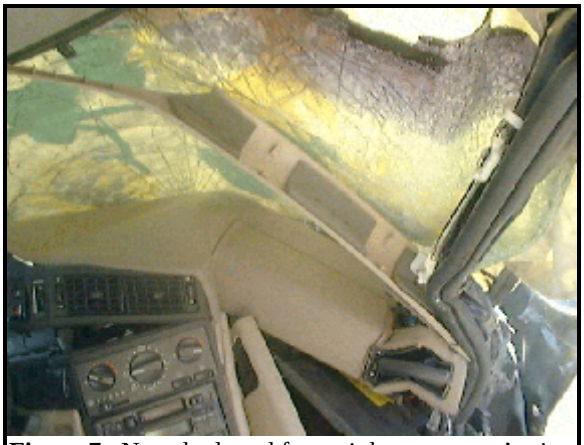


Figure 7: Non-deployed front right passenger's air bag module cover

The driver's and front right passenger's side air bags were both mounted in the outboard edge of the respective seat backs. Both of these air bags deployed through a pre-stressed seam in the vinyl upholstery (**Figure 8**). Both side air bags were rectangular, 21 centimeters [8 inches] long and 27 centimeters [11 inches] high. The side air bags each had two vent ports and no tethers. There was no indication of any problem with either of the side air bags, except the right side air bag had a hole near the top where it was probably pinched by the intruding B-pillar. The right side air bag deployed as a result of the direct compression of the right side sensor by the impact with vehicle #2 (**Figure 9**, below). The left side air bag deployed when the massive lateral intrusion forced the outboard edge of the driver's seat against the left side interior surface, resulting in compression of the left side air bag sensor.

The case vehicle was also equipped with safety belt pretensioners for the two front seat positions. The NASS researcher indicated that both pretensioners did actuate.

Figure 8: Driver's deployed side air bag

The case vehicle driver (72-year-old female, White, unknown if Hispanic, 155 centimeters, 59 kilograms [61 inches, 130 pounds]) was restrained by her available manual lap-and-shoulder safety belt system. She was transported via ambulance to a hospital, where she was admitted and released after seven days to a rehabilitation facility.

Figure 9: Deployed front right passenger's side air bag; note, tear at upper corner

The case vehicle driver was probably seated in a normal driving posture, with her back against the seat back, her feet on the floor or foot controls and her hands on the steering wheel. Her seat track adjustment is not known, the seat back was slightly reclined and the tilt steering wheel was adjusted in the full up position. It is not known if she made any avoidance maneuvers. Her at-impact posture is not known, but it was probably unchanged. The impact with vehicle #2 caused the air bags to deploy and the safety belt pretensioners to actuate, and caused the driver to move forward and rightward, toward the 30 degree direction of principal force. The combination of safety belt use and pretensioner actuation limited her movement, but she sustained contusions and abrasions in the central chest from the safety belt webbing. She encountered the deployed driver's front air bag, sustaining contusions and abrasions on her nose. The force of the massive right-to-left intrusion caused the front right passenger to strike the driver's thorax, causing fractured ribs on the right and a contusion to her right lung. Her right hand flailed, striking the front right passenger and causing a contusion on her right wrist. The force of the impact caused her to load against her seat back, causing a fracture of her sacrum, contusions to her bladder and mesentery and a contusion on her lower back. She also sustained a fracture of her pelvis and one ankle, both of which are not further described in the available medical records. Her posture at final rest is not known. She was removed from the case vehicle by rescue workers and transported to a hospital via ambulance, where she was admitted to the intensive care ward.

CASE VEHICLE DRIVER INJURIES

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1.	Fracture, right ribs 2, 3 and 4, with hemothorax	450222.3 serious	Other occupant	Probable	Post E.R. med. rec.
2.	Contusion, right lung	441406.3 serious	Other occupant	Probable	Post E.R. med. rec.
3.	Contusion, bladder	540610.2 moderate	Seat, back support	Possible	Emergency Room

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
4.	Contusion, mesentery	542010.2 moderate	Seat, back support	Possible	Emergency Room
5.	Fracture, sacrum (posterior pelvis)	852602.2 moderate	Seat, back support	Possible	Post E.R. med. rec.
6.	Fracture, pelvis NFS	852602.2 moderate	unknown	unknown	Post E.R. med. rec.
7.	Fracture, ankle NFS	852000.2 moderate	unknown	unknown	Post E.R. med. rec.
8.	Abrasion, nose	290202.1 minor	Other occupant	Probable	Emergency Room
9.	Contusion, nose	290402.1 minor	Other occupant	Probable	Emergency Room
10.	Abrasion, central chest	490202.1 minor	Belt restraint webbing	Probable	Emergency Room
11.	Contusion, central chest	490402.1 minor	Belt restraint webbing	Probable	Emergency Room
12.	Contusion, posterior right wrist	790402.1 minor	Other occupant	Possible	Interviewee
13.	Contusion, lower back	690402.1 minor	Seat, back support	Probable	Interviewee

CASE VEHICLE FRONT RIGHT PASSENGER

The case vehicle front right passenger (72-year-old female, White, unknown if Hispanic, 168 centimeters, 68 kilograms [66 inches, 150 pounds]) was restrained by the available manual lap-and-shoulder safety belt system. She was declared dead at the scene, approximately 15 minutes post-crash, and transported directly to the morgue.

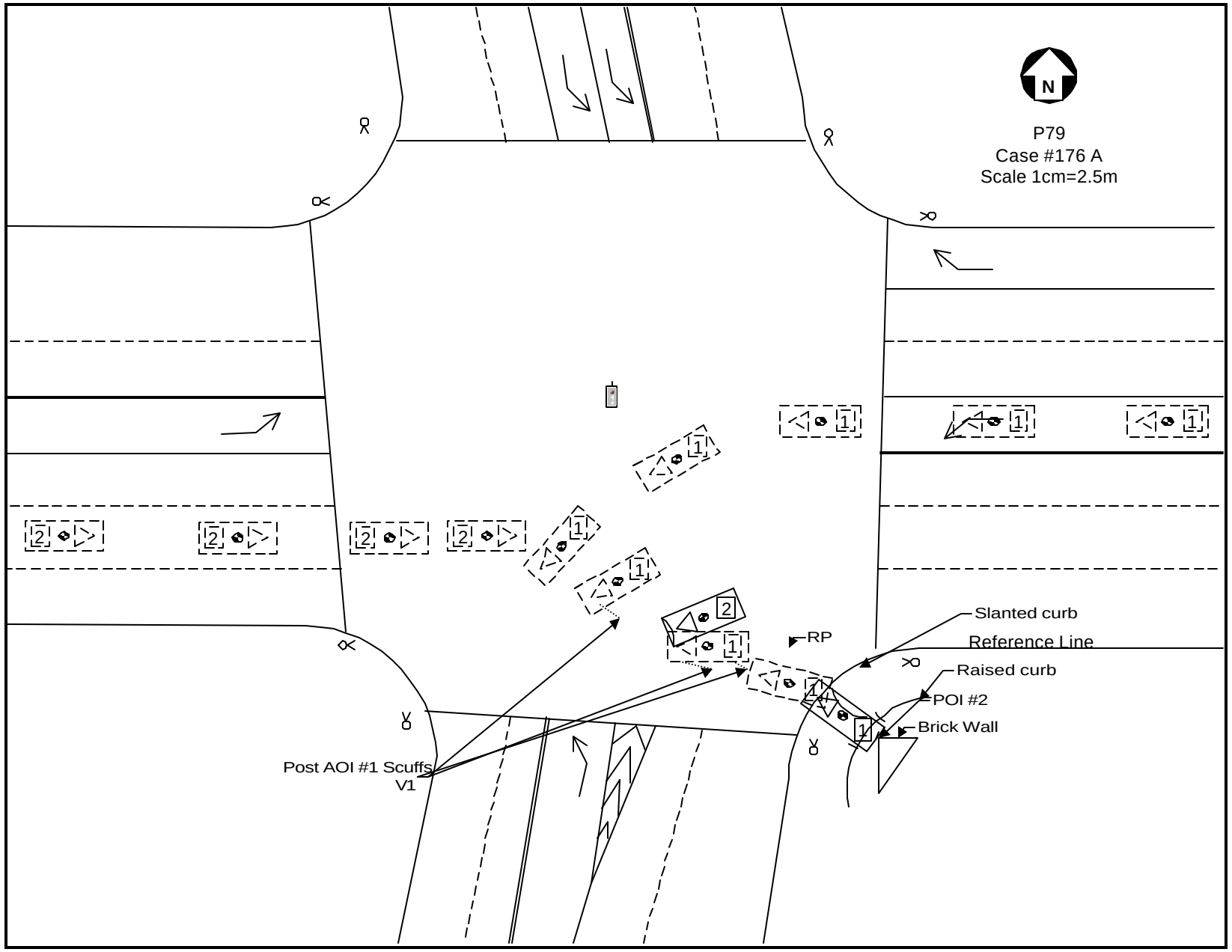
The case vehicle front right passenger was probably seated in a normal posture, with her back against the seat back, her feet on the floor and her hands on her lap. Her seat track adjustment is not known and her seat back was slightly reclined. Her at-impact posture is not known, but it was probably unchanged. The impact with vehicle #2 caused the air bags to deploy and the safety belt pretensioners to actuate, and caused the front right passenger to move forward and rightward, toward the 30 degree direction of principal force. The combination of safety belt use and pretensioner actuation limited her movement, but she sustained an abrasion on the right side of her neck from the safety belt webbing. She immediately encountered the intruding right side components, sustaining multiple fractures of ribs 1 through 8 on the right, a ruptured diaphragm, a laceration of the pericardial sac and a contusion to her heart. She also sustained contusions and abrasions on her right arm and hand, contusions and abrasions on the outer surface of her right thigh, and a laceration on her right wrist. Her legs flailed and she sustained contusions

and abrasions on both lower legs from the knee bolster. She also sustained an abrasion on her left forearm and a contusion on her left thigh. At final rest, she was pinned in the car by the intruding components and her body had to be extricated by rescue personnel.

CASE VEHICLE FRONT RIGHT PASSENGER INJURIES

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1.	Multiple fractures, right ribs 1 - 8	450252.4 severe	Right side interior surface	Probable	Autopsy
2.	Ruptured diaphragm	440604.3 serious	Right side interior surface	Probable	Autopsy
3.	Laceration, pericardial sac	441602.2 serious	Right side interior surface	Probable	Autopsy
4.	Contusion, heart	441004.3 moderate	Right side interior surface	Probable	Autopsy
5.	Abrasion, right neck	390202.1 minor	Belt restraint webbing	Probable	Autopsy
6.	Lacerations, right wrist and left palm (bilateral)	790602.1 minor	Right side hardware	Probable	Autopsy
7.	Abrasion, left forearm	790202.1 minor	Right instrument panel	Possible	Autopsy
8.	Contusion, right upper arm	790402.1 minor	Right side interior surface	Probable	Autopsy
9.	Abrasion, right forearm	790202.1 minor	Right side interior surface	Probable	Autopsy
10.	Contusion, dorsum of right hand	790402.1 minor	Right side interior surface	Probable	Autopsy
11.	Abrasions, bilateral lower legs	890202.1 minor	Knee bolster	Probable	Autopsy
12.	Contusions, bilateral lower legs	890402.1 minor	Knee bolster	Probable	Autopsy
13.	Contusion, right foot	890402.1 minor	Floor	Probable	Autopsy
14.	Abrasion, right outer thigh	890202.1 minor	Right side hardware	Probable	Autopsy
15.	Contusion, right outer thigh	890402.1 minor	Right side hardware	Probable	Autopsy
16.	Contusion, distal left thigh	890402.1 minor	Right side hardware	Possible	Autopsy

Vehicle #2 was reported as a 1996 Jeep Cherokee (VIN: unknown). Vehicle #2 was not inspected, the driver of vehicle #2 declined to be interviewed, and there is no knowledge of vehicle #2's body style or equipment except that, according to the Police Crash Report, it had dual front air bags that did deploy. There were three occupants in vehicle #2, all between 15 and 20 years old, none of whom sustained any injury. The basic 1996 Jeep Cherokee, as described in the vehicle specification references, was configured for five passengers, either two-door or four-door, either rear wheel drive or four wheel drive, with a wheelbase of 258 centimeters [101.4 inches] and equipped with a 4.0 liter I-6 gasoline engine. Vehicle #2 was towed from the scene due to disabling damage. The winSMASH ROLDMIS algorithm was used to calculate Delta V based on the case vehicle's crush profile. The results for vehicle #2 indicate Total, Longitudinal and Lateral Delta V, respectively: 37 km.p.h. [23 m.p.h.], -37 km.p.h. [-23 m.p.h.] and 6 km.p.h. [4 m.p.h.]. This is a borderline reconstruction, but the results appear reasonable.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P79
Case #176 A
Scale 1cm=2.5m
RP
Slanted curb
Reference Line
Raised curb
POI #2
Brick Wall
Post AOI #1 Scuffs
V1