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# SCI/NASS COMBINATION SIDE AIR BAG INVESTIGATION

CASE NUMBER - NASS-2004-49-221J
LOCATION - Texas
VEHICLE - 2004 MAZDA RX-8
CRASH DATE - July 2004

Submitted:
April 5, 2005
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Contract Number: DTNH22-01-C-07002

Prepared for:

U.S. Department of Transportation
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National Center for Statistics and Analysis
Washington, D.C. 20590-0003

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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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15. *Supplementary Notes*
SCI/NASS combination investigation of a side air bag deployment crash involving a 2004 Mazda RX-8 that was impacted on its right side by a 1993 Jeep Grand Cherokee

16. *Abstract*

This report covers a SCI/NASS combination investigation of a side air bag deployment crash involving a 2004 Mazda RX-8 (case vehicle) and a 1993 Jeep Grand Cherokee (other vehicle). This crash is of special interest because the case vehicle was equipped with seat back-mounted side impact air bags and roof rail-mounted inflatable curtains that deployed, as well as advanced frontal air bags that did not deploy. The case vehicle's safety belt restrained front right passenger (26-year-old female) sustained severe head injuries and serious abdominal injuries. The case vehicle was traveling northward in the inside northbound lane of a four-lane roadway that was part of a divided local trafficway, approaching a three-leg intersection and intending to turn left to travel west. The other vehicle was traveling southward in the outside southbound lane of the same divided trafficway. The case vehicle turned left across the other vehicle's path. The case vehicle's right side was impacted by the other vehicle's front, causing the case vehicle's front right seat back-mounted side impact air bag and the right roof rail-mounted inflatable curtain to deploy. The case vehicle was pushed in a southwesterly direction and its left rear wheel impacted a barrier curb, causing the left seat back-mounted side impact air bag and left roof rail-mounted inflatable curtain to deploy. The case vehicle came to rest with its rear wheels in the grass beyond the curb and its front wheels in the road at the southwest corner of the intersection, heading northwest. The other vehicle rotated clockwise while sliding northward and came to rest within the intersection. Both vehicles were towed due to damage. The case vehicle's front right passenger sustained her head injuries when the leading edge of the Jeep's hood hit the case vehicle's deployed right inflatable curtain. The impact compressed the inflated curtain and the force was transmitted to her head. She was hospitalized for eleven days. The case vehicle driver sustained police-reported " B" (evident, non-incapacitating) injuries and was not transported via ambulance, but he sought medical attention later and was treated as an outpatient.

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TABLE OF CONTENTS NASS-2004-49-221J

## BACKGROUND



This SCI/NASS combination investigation was brought to the NHTSA's attention in August 2004 by NASS/CDS sampling activities and was designated for SCI on September 28, 2004. This crash involved a 2004 Mazda RX-8 sedan (case vehicle) and a 1993 Jeep Grand Cherokee SUV (other vehicle). The crash occurred in July 2004, at 5:40 p.m., in Texas, 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 impact air bags and roof rail-mounted inflatable curtain air bags that deployed, as well as advanced frontal air bags that did not deploy. The case vehicle's restrained front right passenger (26-year-old female, white, Hispanic) sustained severe head injuries and serious abdominal injuries and was hospitalized for eleven days. The case vehicle's restrained driver (54-year-old male, white, non-Hispanic) sustained police-reported "B" (evident, non-incapacitating) injuries and was not transported, but he presented himself at a hospital later and was treated as a outpatient. There were no other occupants in the case vehicle. This report is based on the coded NASS case and this contractor's evaluation of the evidence.

## CRASH CIRCUMSTANCES

The case vehicle was traveling northward in the inside northbound lane of a four-lane roadway that was part of a divided local trafficway, approaching a three-leg intersection and intending to turn left to travel west. The other vehicle was traveling southward in the outside southbound lane of the same divided trafficway, approaching the same intersection and intending to continue straight. It was daylight, the weather was clear, the concrete road surface was dry and with no apparent defects, there were no traffic controls for north-south traffic, and the speed limit for both vehicles was 56 km.p.h. [35 m.p.h.]. The case vehicle began its intended left turn across the other vehicle's path. It is not known if either vehicle attempted any avoidance actions.

**Figure 1:** Case vehicle's northbound approach toward left turn across the other vehicle's path

**Figure 2:** Other vehicle's southbound approach; the case vehicle came out from under the overpass and turned left across the other vehicle's path

The crash occurred within the intersection. The case vehicle's right side was impacted by the other vehicle's front, causing the case vehicle's front right seat back-mounted side impact air bag and the right roof rail-mounted inflatable curtain air bag to deploy. The case vehicle was pushed in a southwesterly direction and its left rear wheel impacted a concrete barrier curb,

causing the case vehicle's left seat back-mounted side impact air bag and left roof rail-mounted inflatable curtain air bag to deploy. The case vehicle's rear wheels mounted the curb and it came to rest with its rear wheels in the grass beyond the curb and its front wheels in the road at the southwest corner of the intersection, heading northwest. The other vehicle rotated approximately 100 degrees clockwise while sliding southward and came to rest within the intersection heading slightly north of due west. Both vehicles were towed due to damage.

## CASE VEHICLE

The case vehicle was a 2004 Mazda RX-8 rear wheel drive, four-door, four-passenger sedan (VIN: JM1FE17N940------), equipped with a 1.3 liter rotary gasoline engine and an automatic transmission with a console-mounted selector lever. Four-wheel anti-lock brakes were standard for this model. The case vehicle was fitted with dual-stage frontal air bags and seat back-mounted side impact air bags for the two front seat positions, and with roof rail-mounted inflatable curtain air bags that provided inflatable protection for the front and back outboard seat positions. The front doors opened in the normal manner but the back doors were hinged at the rear and swung open from the front (note, in this arrangement, there is no B-pillar as such; *Automotive News* calls this feature " reverse-open rear-hinged doors"). There were no exterior door handles on the back doors. The odometer reading is unknown due to the non-functional electronic instrument cluster. Its wheelbase was 270 centimeters [106.4 inches]. The case vehicle was towed due to damage.

**Figure 3:** Case vehicle's front and right side

**Figure 4:** Case vehicle's left side; note, left rear wheel damage

The case vehicle sustained heavy direct contact along the right side as a result of the first impact, extending from the A-pillar to the C-pillar, with induced damage extending slightly forward of the front axle and slightly rearward of the rear axle (**Figure 3**). The A-pillar, front door, back door and the C-pillar all sustained direct contact and were crushed inward. The glazing in the two right side windows was shattered. The right A-pillar sustained direct contact above the belt line and the windshield was heavily cracked and separated from its mounting along the right side. There was no other glazing damage. The engine hood was sprung open and displaced. The right roof rail was bent downward and inward. The length of direct plus induced damage was measured as 288 centimeters [113.4 inches]. Maximum crush was measured as 34 centimeters [13.4 inches], on the rearward portion of the front door.

After the first impact, the case vehicle was pushed and slid with the left side leading and the left rear wheel impacted a curb. The wheel was made of a brittle alloy and shattered, leaving the left rear tire dismounted and heavily damaged (**Figure 4**). None of the other wheel/tire assemblies were damaged.

The CDC for the case vehicle's most severe (first) impact was determined to be **02-RYAW-3 (50)**. The WinSMASH reconstruction program, damage only algorithm based on the measured crush profile of both vehicles, was used on the case vehicle's most severe (first) impact. The total, longitudinal and lateral delta Vs for the case vehicle are, respectively: 27 km.p.h. [16.8 m.p.h.], -17 km.p.h. [-10.6 m.p.h.] and -21 km.p.h. [-13.0 m.p.h.]. These results are reasonable and this was an impact of moderate severity (24-40 km.p.h. [15-25 m.p.h.]) for the case vehicle. The CDC for the wheel (second) impact was determined to be **09-LBWN-3 (270)**. The wheel impact is out of scope for the WinSMASH reconstruction program.

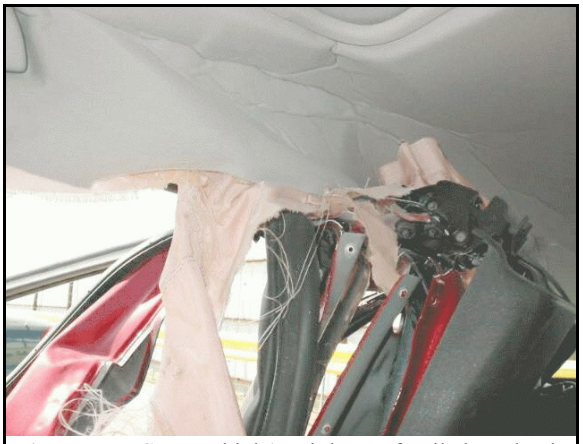


**Figure 5:** Case vehicle's right roof rail door latch mechanism; note, striker pulled out of roof rail and latch pulled partially out of door structure

**Figure 6:** Case vehicle's undamaged left reverse-open rear-hinged door; note, vertically oriented latch that engages the striker in the roof rail

The reverse-open rear-hinged back doors had vertically oriented upper and lower latch-and-striker mechanisms in the leading edge of the back door, with the latches in the door and the strikers in the roof rail (**Figure 6**) and sill, respectively. The right upper latch mechanism was torn out of the door structure and separated from the upper striker, with the door structure intruding laterally (**Figure 5**). Note, there is no B-pillar as such in this arrangement.

The case vehicle sustained major intrusion on the right side, including the front door panel (28 centimeters [11.0 inches]), the roof side rail (19 centimeters [7.5 inches]), the front door sill (18 centimeters [7.0 inches]) and the A-pillar (16 centimeters [6.3 inches]). The front right seat back and seat cushion were deformed inward approximately 22 centimeters [8.7 inches] and the right side of the instrument panel was crushed inward 20 centimeters [7.9 inches]. In addition, the leading edge of the Jeep's hood broke through the right doors' window glazing and intruded into the passenger compartment, penetrating an estimated 20 centimeters [7.9 inches]. (Note: this intrusion by the Jeep's hood is not documented in the coded NASS case data.)

The case vehicle was equipped with frontal air bags and seat back-mounted side impact air bags for the driver and front right passenger seats, and roof rail-mounted inflatable curtain air bags that provided inflatable protection for the front and back seat outboard positions, for a total of six air bags. The two seat back-mount side impact air bags and the two roof rail-mounted inflatable curtain air bags all deployed. The two frontal air bags did not deploy.

The front right passenger's seat back-mounted side impact air bag was installed behind a trim panel in the outboard edge of the front right seat back. The single air bag module cover flap was centered in this panel. The cover flap measured 20 centimeters [7.9 inches] vertically and 7 centimeters [2.6 inches] horizontally. The front right seat back was deformed and partially obscured by the intruding components but it appears that the module cover flap opened along the tear points and was not damaged during the deployment. The deployed air bag was approximately oval in shape (**Figure 7**), measuring 27 centimeters [10.6 inches] vertically and 30 centimeters [11.8 inches] horizontally. There was a single vent port, of unknown diameter, located near the forward edge on the outboard surface, and no tether. There was no evidence of occupant contact on the air bag, but the outboard surface showed scuffing from the intruding front door panel. There was no evidence of damage to the front right passenger's seat back-mounted side impact air bag.

**Figure 7:** Front right passenger's seat back-mounted side impact air bag, inboard surface

**Figure 8:** Forward portion of right inflatable curtain air bag, cut apart during rescue efforts

**Figure 9:** Aft portion of right inflatable curtain air bag, cut part during rescue efforts

The right roof rail-mounted inflatable curtain air bag was installed along the junction where the headliner meets the roof rail and provides inflatable protection for the front and back seat positions (**Figures 8** and **9**). There is no cover flap as such. Rather, as the inflatable curtain air bag expands it causes the headliner joint to separate and the air bag emerges through this opening.

The entire vertical profile of the case vehicle's right side was heavily damaged and the right inflatable curtain air bag was cut apart during rescue operations such that it was not possible to measure the deployed air bag or otherwise evaluate the tattered remains. The left inflatable curtain air bag also deployed and was undamaged (see **Figures 10 - 12**). The fragments of the right curtain suggest that the left and right inflatable curtain air bags were very similar. The left inflatable curtain air bag measured 100 centimeters [39.4 inches] horizontally and 29 centimeters [11.4 inches] vertically. The air bag was constructed from inner and outer panels of fabric that were stitched together. The pattern of the stitching was such that it defined two separate pillow-like areas that inflate. The forward pillow area was approximately egg-shaped and was large enough that it covered the entire distance from the instrument panel to the front seat back. The rear pillow area was U-shaped and relatively narrow. There were no interior tethers and no vent ports. There was copious blood staining on the right inflatable curtain fabric fragments near the front right seat position.

The left roof rail-mounted inflatable curtain air bag was installed along the junction where the headliner meets the roof rail and provides inflatable protection for the front and back seat positions (**Figures 10 - 12**). There is no cover flap as such. Rather, as the inflatable curtain air bag expands it causes the headliner joint to separate and the air bag emerges through this opening. The left inflatable curtain air bag measured 100 centimeters [39.4 inches] horizontally and 29 centimeters [11.4 inches] vertically. The air bag was constructed from inner and outer panels of fabric that were stitched together. The pattern of the stitching was such that it defined two separate pillow-like areas that inflate. The forward pillow area was approximately egg-shaped and was large enough that it covered the entire distance from the instrument panel to the front seat back. The rear pillow area was U-shaped and relatively narrow. There were no interior tethers and no vent ports.

**Figure 10:** Exterior view, whole left side inflatable curtain air bag

**Figure 11:** Rear portion, left side curtain air bag

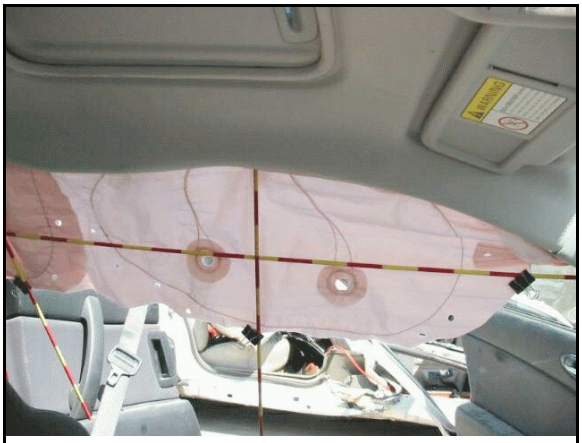


**Figure 12:** Forward portion, left side curtain air bag

**Figure 13:** Inboard surface of driver' s seat back-mounted side impact air bag

The driver's seat back-mounted side impact air bag was installed behind a trim panel in the outboard edge of the driver's seat back (**Figure 13**). The single air bag module cover flap was centered in this panel. The cover flap measured 20 centimeters [7.9 inches] vertically and 7 centimeters [2.6 inches] horizontally. The module cover flap opened along the tear points and was not damaged during the deployment. The deployed air bag was approximately oval in shape, measuring 27 centimeters [10.6 inches] vertically and 30 centimeters [11.8 inches] horizontally. There was a single vent port, of unknown diameter, located near the forward edge on the outboard surface, and no tether. There was no evidence of occupant contact on the air bag, but the outboard surface showed scuffing and two small tears which the NASS investigator attributed to the use of a pry bar to open the jammed driver's door.

## CASE VEHICLE FRONT RIGHT PASSENGER'S KINEMATICS

The case vehicle's front right passenger (26-year-old female, white, Hispanic, 175 centimeters, 77 kilograms [69 inches, 170 pounds]) was restrained by the available manual, three-point, lap-and-shoulder safety belt system. The front right seat adjustments and the passenger's posture at the time of the crash are not known. At the time of the inspection, the front right bucket seat's folding back was found adjusted in a slightly reclined position and the seat track was adjusted at the middle position.

It is not known if the case vehicle driver attempted any avoidance maneuvers prior to the impact. The case vehicle was in the midst of executing a left turn and the front right passenger was probably leaning slightly to the right in response to this turning maneuver. The case vehicle's right front door was impacted by the other vehicle's front, causing the case vehicle's front right seat back-mounted side impact air bag and the right roof rail-mounted inflatable curtain air bag to deploy. The front right passenger moved forward and rightward, parallel and opposite to the 50 degree (2:00 o'clock) direction of force. The other vehicle's front bumper crushed the case vehicle's door inward and the leading edge of its engine hood broke out the case vehicle's right front door glazing and intruded into the case vehicle's interior as the passenger was moving rightward. The passenger's head was cushioned by the inflatable curtain air bag and she did not make direct physical contact with the other vehicle, but the impact compressed the inflated curtain and the force was transmitted to her head. She sustained a right cerebral subdural hemorrhage, a left cerebral subarachnoid hemorrhage and was knocked unconscious. The case vehicle's right side was crushed inward and the front right seat was deformed by the intruding right side components. The right side interior surface contacted the passenger's right hip/abdomen area, causing a rupture of her bladder and fractures of the inferior and superior pubic rami bilaterally. As a result of the intrusion by the right side components (**Figure 14**, see also **Figure 7**), the

passenger was pushed leftward and was compressed between the center console and the intruding right side components, causing a fracture on the left side of her sacrum. The intruding components also contacted her legs, causing contusions on her knees and distal thighs, bilaterally. As the case vehicle slid leftward, the front right passenger was held in place by the safety belt system and probably remained compressed between the intruded right side components and the center console as the case vehicle's left rear wheel impacted the curb. Her posture at final rest is not known.

**Figure 14:** Right front seating area; note, door panel intrusion, deformed seat cushion and seat back, and close proximity of center console

## FRONT RIGHT PASSENGER'S INJURIES

The front right passenger was transported via ground ambulance to a hospital, where she was admitted for eleven days for treatment of her injuries.

The following table of specific injuries is reproduced from the NASS case data (vehicle #1, occupant #2). The NASS injury coding schema that was in use for a 2004 case does not include attributes that can represent the scenario where the force of other vehicle's impact is transmitted through the inflated curtain to the victim's head. The NASS data indicate the Injury Source for the head/brain injuries as " the hood of the other vehicle" but the hood did not actually contact the victim's head. In addition, the NASS injury coding indicates that the victim's head injuries are not related to an intrusion, but her head injuries are the result of the Jeep's hood intruding into her seating area.

| Injury Number | Injury Description (including Aspect) | NASS Injury Code & AIS 90 | Injury Source (Mechanism) | Source Confidence | Source of Injury Data |
|---|---|---|---|---|---|
| 1. | Subdural hemorrhage, right cerebrum | severe 140652.4,1 | Hood of other vehicle | Certain | Hospitalization Records |
| 2. | Subarachnoid hemorrhage, left cerebrum | serious 140684.3,2 | Hood of other vehicle[1] | Certain | Hospitalization Records |
| 3. | Ruptured bladder, NFS | serious 540640.3,8 | Right side interior surface | Certain | Hospitalization Records |
| 4. | Displaced fractures, bilateral superior and inferior pubic rami | serious 852604.3,5 | Right side interior surface | Certain | Hospitalization Records |
| 5. | Closed fracture, left sacrum | moderate 852602.2,6 | Center console | Certain | Hospitalization Records |

[1]The NASS data show this as an " indirect" injury, but that is a coding error.

| Injury Number | Injury Description (including Aspect) | NASS Injury Code & AIS 90 | Injury Source (Mechanism) | Source Confidence | Source of Injury Data |
|---|---|---|---|---|---|
| 6. | Non-anatomic brain injury, unconscious, moaning, GCS= 9, inappropriate movements | critical 160824.5,0 | Hood of other vehicle | Certain | Emergency Room |
| 7. | Laceration, right forearm, NFS | minor 790602.1,1 | Right side hardware/armrest | Certain | Emergency Room |
| 8. | Contusions, bilateral distal thighs and knees | minor 890402.1,3 | Right side interior surface | Certain | Emergency Room |

## CASE VEHICLE DRIVER'S KINEMATICS

The case vehicle's driver (54-year-old male, white, non-Hispanic, 183 centimeters, 91 kilograms [72 inches, 200 pounds]) was restrained by the available manual, three-point, lap-and-shoulder safety belt system. His seat adjustments and seated posture is not known, but he had at least one hand on the steering wheel and was operating the foot controls. At the time of the vehicle inspection, his seat back was found adjusted to a slightly reclined position and the seat track was adjusted at the middle position.

It is not known if the driver attempted any avoidance actions. The case vehicle was in the midst of executing a left turn and the driver was probably leaning slightly to the right in response to this turning maneuver. The case vehicle's right side was impacted by the other vehicle's front. The driver probably moved forward and rightward, toward the 2:00 o'clock direction of force, but was held in place by his safety belt. Subsequently, the left rear wheel/tire assembly impacted a curb, causing the left seat back-mounted side impact air bag and the left roof rail-mounted inflatable curtain air bag to deploy. The driver probably moved slightly leftward in response to the wheel impact and probably encountered the inflatable curtain air bag with his head, and the seat back-mounted air bag with his thorax. He sustained an unknown lung injury. His position at final rest is not known.

## DRIVER'S INJURIES

The driver was treated at the scene and not transported via ambulance to a medical facility. He presented himself at a hospital emergency department later and was treated as an outpatient.

| Injury Number | Injury Description (including Aspect) | NASS Injury Code & AIS 90 | Injury Source (Mechanism) | Source Confidence | Source of Injury Data |
|---|---|---|---|---|---|
| 1. | Lung injury, NFS | serious 441499.3,9 | unknown | unknown | interviewee |

The other vehicle was a 1993 Jeep Grand Cherokee four-wheel-drive, four-door, five-passenger SUV (VIN: 1J4GZ58Y9PC------), equipped with a 5.2 liter V8 gasoline engine. Four-wheel anti-lock brakes were an option for this model, but it is not known if this vehicle was so equipped. The Cherokee was equipped with a driver-only air bag that did deploy. Its odometer reading was recorded as 227,961 kilometers [141,652 miles]. Its wheelbase was 269 centimeters [105.9 inches]. The Cherokee was towed due to disabling damage.

The Cherokee sustained direct contact damage across the entire front (**Figures 15** and **16**). The grille and both headlamp/turn signal assemblies were shattered and broken away, and the bumper cover was torn off. There was direct contact damage on the leading edge of the hood, with the hood buckled and displaced rearward. The leading edges of both fenders were crushed rearward, with slight left-to-right displacement of the fenders. The wheelbase was shortened by 4 centimeters [1.6 inches] on the left and stretched by 1 centimeter [0.4 inches] on the right. The right front wheel was restricted by the crushed fender but the tire was not deflated, and there was no other wheel or tire damage. Maximum crush was measured as 25 centimeters [9.8 inches] at the front right corner. There was slight cracking of the windshield at the lower left corner, from the hood being forced rearward, and no other glazing damage.

The CDC for the Cherokee's single impact was determined to be **11-FDEW-2 (340)**. The WinSMASH reconstruction program, damage only algorithm based on the measured crush profile of both vehicles, was used on the Cherokee's impact. The total, longitudinal and lateral delta Vs for the Cherokee are, respectively: 24 km.p.h. [14.9 m.p.h.], -23 km.p.h. [-14.3 m.p.h.] and + 8 km.p.h. [+ 5.0 m.p.h.]. These results are reasonable and this was an impact of moderate severity (24-40 km.p.h. [15-25 m.p.h.]) for the Cherokee.

**Figure 15:** Cherokee's front, straight on

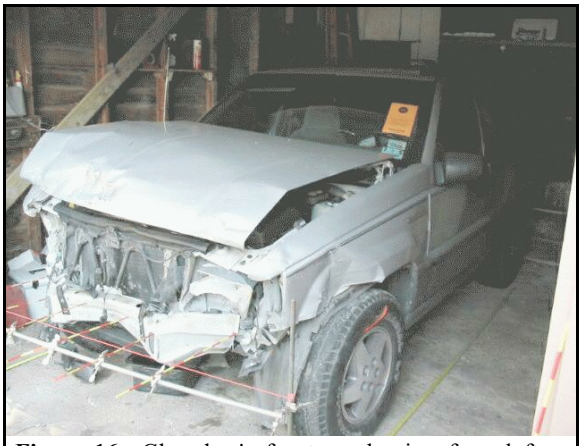
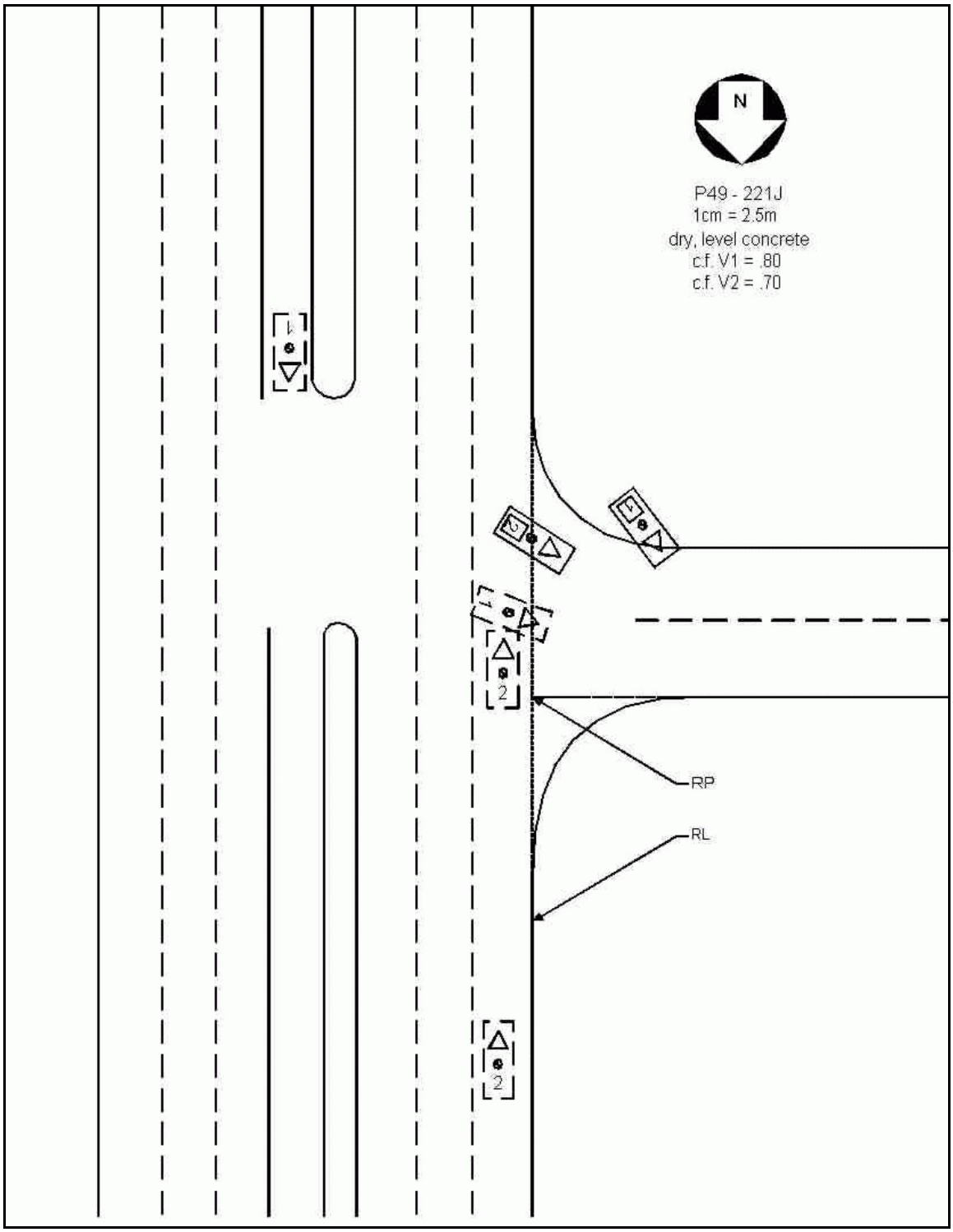


**Figure 16:** Cherokee's front, angle view from left

The other vehicle's driver (39-year-old male, white, Hispanic) was restrained by the available manual, three-point, lap-and-shoulder safety belt system and the driver's steering wheel-mounted air bag deployed. The driver sustained police-reported " C" (possible) injuries and was not transported. There was no other occupant in the Cherokee.


N
P49 - 221J
1cm = 2.5m
dry, level concrete
c.f. V1 = .80
c.f. V2 = .70
RP
RL