



# INDIANA UNIVERSITY

## TRANSPORTATION RESEARCH CENTER

School of Public and Environmental Affairs

222 West Second Street

Bloomington, Indiana 47403-1501

(812) 855-3908 Fax: (812) 855-3537

## SCI/NASS COMBINATION CASE REPORT

CASE NUMBER - NASS-98-79-046A

LOCATION - California

VEHICLE - 1998 CHEVROLET GEO METRO

CRASH DATE - March 1998

Submitted:

June 7, 2000



Contract Number: DTNH22-94-D-17058

Prepared for:

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

## **DISCLAIMERS**

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no responsibility for the contents or use thereof.

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the National Highway Traffic Safety Administration.

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**

1. <i>Report No.</i> NASS-98-79-046A		2. <i>Government Accession No.</i>		3. <i>Recipient's Catalog No.</i>	
4. <i>Title and Subtitle</i> Combination SCI/NASS Air Bag Deployment Investigation Vehicle - 1998 Chevrolet Geo Metro LSi four-door sedan Location - California			5. <i>Report Date:</i> June 7, 1999		
			6. <i>Performing Organization Code</i>		
7. <i>Author(s)</i> Special Crash Investigations Team #2			8. <i>Performing Organization Report No.</i> Task # 0192		
9. <i>Performing Organization Name and Address</i> Transportation Research Center Indiana University 222 West Second Street Bloomington, Indiana 47403-1599			10. <i>Work Unit No. (TRAIS)</i>		
			11. <i>Contract or Grant No.</i> DTNH22-94-D-17058		
12. <i>Sponsoring Agency Name and Address</i> U.S. Department of Transportation (NRD-32) National Highway Traffic Safety Administration National Center for Statistics and Analysis Washington, D.C. 20590-0003			13. <i>Type of Report and Period Covered</i> Technical Report Crash Date: March 1998		
			14. <i>Sponsoring Agency Code</i>		
15. <i>Supplementary Notes</i> Combination SCI/NASS investigation involving a 1998 Chevrolet Geo Metro with manual safety belts and dual redesigned front air bags, and a 1990 Dodge Ram B350 full-size van					
16. <i>Abstract</i> This combination SCI/NASS investigation concerns an air bag deployment crash involving a 1998 Chevrolet Geo Metro (case vehicle) and a 1990 Dodge B350 full-size van (vehicle #2). This case is of special interest because the case vehicle was equipped with redesigned air bags that deployed as a result of the collision events. The case vehicle's unrestrained driver (23-year-old male) and restrained front right passenger (27-year-old female) were both killed. The case vehicle was traveling west at high speed and steering erratically on a five-lane, two-way undivided city street. Vehicle #2 was traveling east in the inside eastbound lane of the same roadway. Witnesses stated they observed the case vehicle weaving back and forth across the entire width of the roadway. The driver of vehicle #2 observed the case vehicle and its erratic maneuvering, braked and steered left. There is no evidence that the driver of the case vehicle attempted any avoidance actions. The crash occurred in the inside westbound lane. The front left corner of the case vehicle impacted the front of vehicle #2, causing the case vehicle's driver and front right passenger air bags to deploy. The two vehicles separated and the case vehicle's right wheels impacted a high barrier curb, causing the case vehicle to roll onto its right side. Police reconstructionists estimated the case vehicle's immediate pre-crash travel speed as 95 km.p.h. [59 m.p.h.]. The driver of vehicle #2 estimated his at-impact travel speed as 32 km.p.h. [20 m.p.h.]. Both vehicles were towed due to disabling damage. The case vehicle driver was transported to a hospital where he was declared dead seven hours post-crash. He sustained closed head injuries including a bilateral subdural hematoma and diffuse white matter shearing, bilateral lung contusions, and various injuries to his extremities. The front right passenger was transported to a hospital where she was declared dead on arrival. She sustained a comminuted basilar skull fracture, lacerations of the heart, lungs, liver and spleen, and numerous broken bones in her thorax and extremities.					
17. <i>Key Words</i> Redesigned Air Bag Deployment			Motor Vehicle Traffic Crash Injury Severity		18. <i>Distribution Statement</i> General Public
19. <i>Security Classif. (of this report)</i> Unclassified	20. <i>Security Classif. (of this page)</i> Unclassified		21. <i>No. of Pages</i> 9	22. <i>Price</i> \$2,500	

TABLE OF CONTENTS

	<u>Page No.</u>
BACKGROUND .....	1
CRASH CIRCUMSTANCES .....	1
CASE VEHICLE .....	2
CASE VEHICLE DAMAGE .....	2
AUTOMATIC RESTRAINT SYSTEM .....	4
CASE VEHICLE DRIVER KINEMATICS .....	4
CASE VEHICLE DRIVER INJURIES .....	5
CASE VEHICLE FRONT RIGHT PASSENGER KINEMATICS .....	5
CASE VEHICLE FRONT RIGHT PASSENGER INJURIES .....	6
VEHICLE #2 .....	8
SCENE DIAGRAM .....	9
SELECTED PHOTOGRAPHS	
Figure 1: Case vehicle's westbound approach .....	1
Figure 2: Vehicles at approximate final rest positions .....	1
Figure 3: Left view of case vehicle's front damage .....	2
Figure 4: Left front area of case vehicle, showing intrusion from outside .....	2
Figure 5: Case vehicle's entire left side .....	3
Figure 6: Case vehicle's entire right side .....	3
Figure 7: Case vehicle's front seat row and instrument panel, from right .....	3
Figure 8: Case vehicle's steering wheel and driver air bag .....	4
Figure 9: Case vehicle's front right passenger air bag module cover flaps .....	4
Figure 10: Vehicle #2, front and right side .....	8
Figure 11: Vehicle #2, front and left side .....	8
Figure 12: Ladder device mounted on vehicle #2's roof .....	8

This combination SCI/NASS investigation was brought to the NHTSA's attention by NASS/CDS sampling activities and a review of the 1998 Fatality Analysis Reporting System (FARS) in February 1999. The crash involved a 1998 Chevrolet Geo Metro (case vehicle) and a 1990 Dodge Ram B350 van (vehicle #2). The crash occurred in March 1998, at 6:30 a.m., in California, and was investigated by the applicable municipal police department. This case is of special interest because the case vehicle was equipped with redesigned air bags that deployed as a result of collision events. The unrestrained driver (23-year-old male) and the restrained front right passenger (27-year-old female) were both killed. A copy of the NASS electronic case was received in May 2000. This report is based on the Police Crash Report, the death examination reports, police photographs, occupant kinematic principles, the coded NASS case and NASS photographs, and this contractor's evaluation of the evidence. This SCI case report includes footnotes to indicate where this contractor's evaluation of the evidence differs from the NASS case coding.

### CRASH CIRCUMSTANCES

The case vehicle was traveling west at high speed and steering erratically on a five-lane, two-way undivided city street (two lanes east bound, two lanes west bound and a center left turn lane, with a parking lane on each side). Vehicle #2 was traveling east in the inside eastbound lane of the same roadway. It was daylight, the weather was clear, the bituminous surface was dry and there were no roadway defects (**Figure 1**). The speed limit for both vehicles was 56 km.p.h. [35 m.p.h.]. Witnesses stated they observed the case vehicle weaving back and forth across the entire width of the roadway and estimated its speed as 97 - 113 km.p.h. [60 - 70 m.p.h.]. The driver of vehicle #2 observed the case vehicle and its erratic maneuvering at a distance of approximately 120 - 150 meters [400 - 500 feet] and braked. The case vehicle was headed straight toward vehicle #2 in the inside eastbound lane and the driver of vehicle #2 steered left, across the center left turn lane and into the westbound lanes in an attempt to avoid the crash. The case vehicle swerved into the westbound lanes, toward vehicle #2. There is no evidence that the driver of the case vehicle attempted any avoidance actions.

The crash occurred in the inside westbound lane. The front left corner of the case vehicle impacted the front of vehicle #2, causing the case vehicle's driver and front right passenger air bags to deploy. The force of the impact pushed vehicle #2 counterclockwise as the case vehicle slid to the right (north). The two vehicles separated and the case vehicle's right wheels impacted a high barrier curb, causing the case vehicle to roll onto its right side. Vehicle #2 came to rest headed northeast with its front wheels against the curb (**Figure 2**). Vehicle #2 was equipped with a large extension ladder on a rotating platform ("cherry



**Figure 1:** Case vehicle's westbound approach toward impact, with vehicles at approximate final rest (police photo)



**Figure 2:** Vehicles at approximate final rest; NOTE: ladder device fell from van's roof; rescue workers put case vehicle back on its wheels (police photo)

picker”) mounted on its roof. This device was knocked loose and fell to the ground. Police reconstructionists estimated the case vehicle’s immediate pre-crash travel speed as 95 km.p.h. [59 m.p.h.]. The driver of vehicle #2 estimated his at-impact travel speed as 32 km.p.h. [20 m.p.h.].

### CASE VEHICLE

The case vehicle was a front wheel drive 1998 Chevrolet Geo Metro LSi four-passenger four-door sedan (VIN: 2C1MR5227W6-----) equipped with a 1.3 liter engine and an automatic transmission with column-mounted selector lever. Four wheel anti-lock brakes were an option for this vehicle, but it is not known if the case vehicle was so equipped. The case vehicle’s wheelbase was 236 centimeters [93.1 inches]. The odometer reading is not known. The case vehicle was towed due to disabling damage.

### CASE VEHICLE DAMAGE

The case vehicle sustained underride-type damage at the front left corner resulting in direct contact damage across the left two-thirds of the front and on the left side from the front corner almost to the left B-pillar, including direct contact to the left A-pillar above the belt line and the driver’s door window frame and glazing. The impact involved sustained contact while the two vehicles were rotating, with substantial grinding and tearing of the case vehicle’s body panels. Maximum crush was 69 centimeters [27 inches] at the front left corner (**Figure 3**). The CDC for the case vehicle’s impact with vehicle #2 is **12-FDEW-4** (direction of principal force 350 [-10] degrees). The WinSMASH reconstruction program was used to estimate Delta V based on the measured crush profiles for the two vehicles. This is a complex crash scenario and these results provide a borderline reconstruction. The results seem low for the amount of visually apparent crush. The estimated total, longitudinal and lateral Delta Vs for the case vehicle are, respectively, 67 km.p.h. [42 m.p.h.], -66 km.p.h. [-41 m.p.h.] and 12 km.p.h. [7 m.p.h.].



**Figure 3:** Left view of case vehicle’s front damage

The front bumper and cover were torn away and the hood was folded double and forced rearward into the windshield. The windshield was fractured across its entire width and separated from its mounting along the left A-pillar and along the windshield header on the left. The left front axle was broken with the wheel tilted inward at the top. The wheelbase was shortened to 190 centimeters [75 inches] on the left but was relatively unchanged at 234 centimeters [92 inches] on the right. The left lower A-pillar was forced rearward, the left upper A-pillar sustained direct contact damage above the belt line and the entire A-pillar was



**Figure 4:** Left front area of case vehicle; NOTE: intrusion into driver’s seat area (police photo)

displaced rearward and inward. The left B-pillar was collapsed inward and the left roof rail and left side of the roof were buckled downward in the area of the driver's door opening (**Figure 4**, above). The two door openings on the left were distorted and the glazing in both doors was shattered (**Figure 5**). The right rear wheel was tilted inward at the bottom, resulting from contact with the high barrier curb. There was abrading and red paint transfers on the right rear quarter panel, along the right rocker panel and the lower edges of the two right doors from contact with the curb and sidewalk as the case vehicle rolled to the right upon impacting the curb (**Figure 6**). The CDC for the curb impact, estimated from photographs<sup>1</sup>, is **03-RDLW-2**. (The Police Crash Report indicates that the case vehicle was found lying on its right side but rescue personnel had rolled it back onto its wheels.) The CDC for the rollover is **00-RDAO-2**. The two right doors were forced open during extrication, with pry marks on the doors and adjacent body structures.

The instrument panel was displaced rearward along its entire width, with upward buckling at the middle (**Figure 7**). The driver's instrument cluster and the controls at the center instrument panel were shattered. The lower end of the steering column was forced downward and rearward while the upper end was forced upward and against the instrument panel. The steering wheel rim and spokes were bent and twisted. Longitudinal intrusion by the left A-pillar and lateral intrusion by the left roof rail were each measured as 42 centimeters [17 inches], with 40 centimeters [16 inches] longitudinal intrusion by the left toe pan. There was significant intrusion by the windshield header, instrument panel and floor on the right. The two front bucket seats were forced rearward such that the front seat backs were nearly touching the back seat cushion. There was a child safety seat in the back seat, but there was no child occupant present at the time of the crash.



**Figure 5:** Case vehicle's entire left side (police photo)



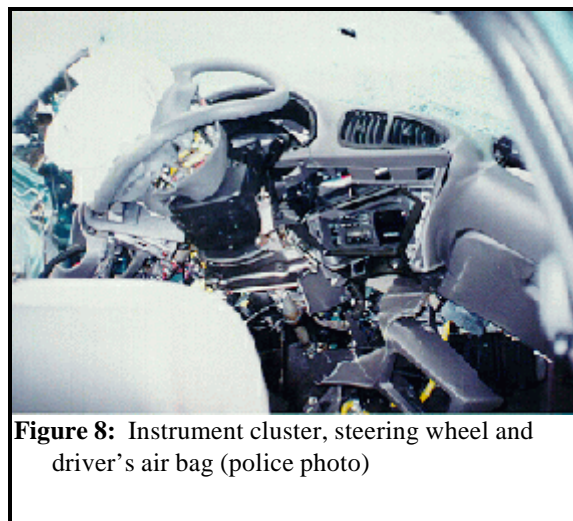
**Figure 6:** Right side of case vehicle showing curb impact and rollover damage (police photo)



**Figure 7:** Case vehicle's front seat row and instrument panel viewed from right

<sup>1</sup>The NASS case coding does not include an event nor a CDC for the curb impact.

The case vehicle was equipped with redesigned air bags for the driver and front right passenger seat positions. The driver's air bag was located in the steering wheel hub (**Figure 8**). The module cover flaps opened along the seams, with no damage to the flaps. The deployed air bag was round, with diameter 60 centimeters [24 inches] and vent ports at the 11 and 1 o'clock positions. It is not known if the driver's air bag was tethered. The back of the air bag was torn, possibly due to contacting the intruding shattered windshield. The NASS case coding indicates the researcher judged the tearing of the air bag as an indication of possible air bag failure. There was some light scuffing on the upper left quadrant of the front of the driver's air bag, but no other evidence of contact was recorded.



**Figure 8:** Instrument cluster, steering wheel and driver's air bag (police photo)

The front right passenger's air bag was located in the top of the instrument panel. The module's single cover flap opened along the seams, with no damage to the flap (**Figure 9**). The deployed air bag was rectangular, 60 centimeters [24 inches] wide and 65 centimeters [26 inches] high, with no tethers or vent ports. There were some spots of blood in the center-left area and several small tears near the top on the front of the air bag, with no other evidence of contact.



**Figure 9:** Front right passenger's module cover flap

#### CASE VEHICLE DRIVER KINEMATICS

The case vehicle driver (23-year-old male, Black, unknown if Hispanic, 173 centimeters, 83 kilograms [68 inches, 183 pounds])<sup>2</sup> was not restrained by his available manual, three-point, lap-and-shoulder safety belt system. He was transported from the scene to a hospital via ambulance and was pronounced dead seven hours post-crash.

The case vehicle driver's pre-crash seated posture and seat adjustments are not known. He was observed by witnesses to be accelerating and steering prior to the crash, so he had at least one hand on the steering wheel and one of his feet on the foot controls. He steered right immediately prior to the impact with vehicle #2 and his body would have shifted to the left in response to this steering maneuver. The impact with vehicle #2 caused the air bags to deploy and caused him to move forward, upward and slightly further leftward, toward the 350 degree direction of principal force. The combination of his unrestrained

---

<sup>2</sup>The description of the driver's physical characteristics is based on the official death examination report. The NASS case coding gives his height as 180 centimeters and weight as 70 kilograms.



forward momentum plus the opposite motion of the intruding steering assembly caused the air bag to deflate and he contacted the steering wheel hub and spokes, causing bilateral lung contusions. His head contacted the intruding left A-pillar, windshield and windshield header and he sustained closed head injuries consisting of a bilateral subdural hematoma and diffuse axonal injury (white matter shearing). The floor and toe pan intruded, causing comminuted fractures of his right tibia and fibula. The driver's door intruded and impacted the driver's left side, causing a fracture of his left humerus and a contusion on his left buttock.

#### 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.	Unconscious with neurological deficit	160804.4 severe	Windshield and left A-pillar <sup>3</sup>	Certain	Emergency Room
2.	Contusion, left buttock	890402.1 minor	Left side interior surface <sup>4</sup>	Probable	Post-ER Med. Records
3.	Contusion of the lungs, bilateral	441410.4 severe	Steering wheel hub and spokes	Certain	Post-ER Med. Records
4.	Subdural hematoma, bilateral	140654.5 critical	Windshield and left A-pillar	Certain	Post-ER Med. Records
5.	Diffuse axonal injury (white matter shearing)	140628.5 critical	Windshield and left A-pillar	Probable	Post-ER Med. Records
6.	Open fracture, distal right tibia	853422.3 serious	Floor	Certain	Post-ER Med. Records
7.	Open fracture, distal right fibula	851606.2 moderate	Floor	Certain	Post-ER Med. Records
8.	Fracture, distal left humerus	752600.2 moderate	Left side interior surface <sup>5</sup>	Probable	Post-ER Med. Records

#### CASE VEHICLE FRONT RIGHT PASSENGER KINEMATICS

The case vehicle front right passenger (27-year-old female, Black, unknown if Hispanic, 157 centimeters, 59 kilograms [62 inches, 130 pounds])<sup>6</sup> was restrained by her available manual three-point lap-and-shoulder safety belt system. She was transported via ambulance to a hospital, where she was declared dead on arrival.

The front right passenger's seat adjustments and seated posture are not known. In light of the high

<sup>3</sup>The NASS case coding attributes this injury to the steering wheel hub and spokes.

<sup>4</sup>The NASS case coding attributes this injury to the seat back.

<sup>5</sup>The NASS case coding attributes this injury to the left instrument panel.

<sup>6</sup>The description of the passenger's physical characteristics is based on the official death examination report. The NASS case coding gives her height as 170 centimeters and her weight as 50 kilograms.

speed and erratic steering reported by witnesses, it is not reasonable to make any presumptions about the passenger’s posture, except that she was in the front right position and was probably facing approximately forward. The driver steered right immediately prior to the first impact and the front right passenger probably shifted slightly to the left in response to this steering maneuver. The impact with vehicle #2 caused the front right passenger to move forward, upward and slightly further leftward, toward the 350 degree direction of principal force. The impact caused the air bag to deploy and also caused the retractor in her safety belt system to lock. She encountered the deployed air bag with her face and torso, causing abrasions to her forehead and left cheek. She loaded the safety belt system, which anchored her right shoulder and abdomen as her momentum caused her to tend to move upward and forward, resulting in the left side of her torso pivoting further forward. The pressure of the torso portion of the safety belt system caused fractures of her right clavicle, sternum and right ribs 1 through 4. In addition, her chest was compressed causing lacerations of the pericardial sac and the intraventricular septum. As she pivoted, the lap portion of the safety belt pressed against her abdomen, causing lacerations of her spleen and a contusion in the right lower quadrant of her abdomen. The case vehicle rotated counterclockwise as the air bag deflated and her head and torso struck the instrument panel as it intruded. As result of striking the instrument panel, she sustained a basilar skull fracture with subgaleal hemorrhage, a fracture of the left clavicle and left first rib. She also sustained lacerations of the liver and a fracture of her right humerus. Her left leg flailed and impacted the underside of the instrument panel, causing a major laceration of her lower left leg and a fracture of her left femur.

**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.	Abrasions of the forehead	290202.1 minor	Passenger’s air bag <sup>7</sup>	Possible	Emergency Room
2.	Fracture of the manubrium sternum	450804.2 moderate	Safety belt webbing	Possible	Autopsy
3.	Fractured ribs, left <sup>8</sup> 1 & right 1-4, with bilateral hemothorax	450232.4 severe	Safety belt webbing <sup>9</sup>	Possible	Autopsy
4.	Abrasion, left cheek	290202.1 minor	Passenger’s air bag <sup>10</sup>	Possible	Autopsy
5.	Contusion, lower right quadrant of the abdomen	590402.1 minor	Safety belt webbing	Possible	Autopsy
6a.	Fracture of right clavicle, at the sternal end	752200.2 moderate	Safety belt webbing	Possible	Autopsy <sup>11</sup>

<sup>7</sup>The NASS case coding attributes this injury to the windshield.

<sup>8</sup>The left rib fracture was probably not caused by the safety belt, but rather was caused by contact with the instrument panel. The NASS injury coding protocols require that all rib fractures must be combined as one injury.

<sup>9</sup>The NASS case coding attribute these injuries to the right instrument panel.

<sup>10</sup>The NASS case coding attributes this injury to the windshield.

<sup>11</sup>The autopsy report states, “fracture of both sternoclavicular joints.” The autopsy diagram depicts fracture lines at the sternal end of both clavicles. The NASS case coding is limited to one sternoclavicular

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
6b.	Fracture of the left clavicle, at the sternal end	752200.2 moderate	Center instrument panel	Possible	Autopsy <sup>11</sup>
7.	Basilar skull fracture, through left and right petrous ridges and posterior stella turcica ("hinge" fracture)	150206.4 severe	Center instrument panel	Possible	Autopsy
8.	Laceration of the intraventricular septum	441300.5 critical	Safety belt webbing	Possible	Autopsy
9.	Multiple lacerations of the liver, NFS	541820.2 moderate	Right instrument panel	Possible	Autopsy
10.	Multiple lacerations of the spleen, NFS	544220.2 moderate	Safety belt webbing	Possible	Autopsy
11.	Fracture, shaft of left femur	851814.3 serious	Center instrument panel	Possible	Autopsy
12.	Fracture, shaft of right humerus	752600.2 moderate	Right instrument panel	Possible	Autopsy
13.	Unconscious, no response to painful stimuli	168024.5 critical	Center instrument panel	Possible	Emergency Room <sup>12</sup>
14.	Major laceration, left lower leg, 20 cm./8 in. long, deep to bone	890604.2 moderate	Center instrument panel	Possible	Autopsy <sup>13</sup>
15.	The pericardial sac is torn	441602.2 moderate	Center instrument panel	Possible	Autopsy <sup>13</sup>
16.	Subgaleal hemorrhage, bilateral parietal and occipital regions	190402.1 minor	Center instrument panel	Possible	Autopsy <sup>13</sup>

dislocation, with aspect coded as right.

<sup>12</sup>The NASS case coding indicates the autopsy as the source of data for this injury, but an autopsy cannot be the source for non-anatomic brain injury data based on observations of the patient's behavior.

<sup>13</sup>The NASS case coding does not include this injury.

Vehicle #2 was a 1990 Dodge B350 cargo van (VIN: 2B7KB31Z4LK-----) with extended rear overhang (the “Maxi Van” model). Vehicle #2's damage consisted of direct contact across the left two-thirds of the front, with direct contact to the bumper, grille, hood and the front axle and suspension on the left (**Figures 10 & 11**). The left front wheel and tire were forced rearward, against the trailing edge of the wheel well. The left front fender and door sustained induced damage and the windshield separated from its gasket/mounting around most of its perimeter. The windshield did not fracture or crack and there was no other glazing damage. The CDC for vehicle #2's impact with the case vehicle is **01-FDEW-4**, with direction of principal force 20 degrees. Vehicle #2 was equipped with an extension ladder on a rotating platform (“cherry picker”) mounted on its roof (**Figure 12**). This device was broken loose during the collision and fell to the ground without making contact with the case vehicle. The WinSMASH reconstruction program was used to estimate Delta V based on the measured crush profiles for the two vehicles. This is a complex crash scenario and these results provide a borderline reconstruction. The results appear low for the visually apparent amount of crush. The estimated total, longitudinal and lateral Delta Vs for vehicle #2 are, respectively, 31 km.p.h. [19 m.p.h.], -30 km.p.h. [-18 m.p.h.] and -11 km.p.h. [-7 m.p.h.].



**Figure 10:** Front and right side of vehicle #2



**Figure 11:** Front and left side of vehicle #2



**Figure 12:** Ladder device that was fixed to the top of vehicle #2

SCENE DIAGRAM

NASS-98-79-046A

