

**TRANSPORTATION SCIENCES
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**VERIDIAN ON-SITE ADULT AIR BAG RELATED FATALITY
INVESTIGATION**

VERIDIAN CASE NO. CA03-016

VEHICLE: 1996 MERCURY SABLE

LOCATION: OHIO

CRASH DATE: FEBRUARY 2003

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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 are 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.

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BACKGROUND

This on-site crash investigation focused on the injury mechanisms and the cause of death for a 78-year old male driver of a 1996 Mercury Sable (**Figure 1**). The Sable was equipped with a frontal air bag system for the driver and right passenger positions that deployed as a result of the crash. The driver either lost control of the vehicle as he attempted to initiate a right turn at a three-leg T-intersection, or he experienced a medical episode that contributed to the causation of the crash. The vehicle departed the T-intersection and overrode a large shrub as it traversed a snow-covered lawn. The Sable



Figure 1. Front right view of the 1996 Mercury Sable

subsequently struck a landscape wall, a sidewalk step, a concrete landscape marker, landscape timbers, and another shrub prior to impacting and coming to rest against a concrete porch. The frontal air bag system probably deployed as a result of the impact with the porch. On-scene police photographs of the crash site identified rotating tire marks across a driveway. The left front tire mark pattern was wide and irregular supporting an aired-out tire. The driver was probably out-of-position forward, which placed him in the path of the deploying front left air bag. Air bag deployment resulted in abrasions of his nose and forehead, a left periorbital contusion, subdural hematoma, intercranial hemorrhage, a small right parietal cerebral contusion, and right pneumothorax. The driver was found in the vehicle devoid of a pulse and was transported to a local hospital where he expired three days following the crash.

The investigating officer notified NHTSA's Special Crash Investigation's (SCI) team of the suspected air bag related fatality. The notification was forwarded to the Veridian SCI team on February 26, 2003 and assigned as an on-site investigative effort. Cooperation was established with the investigating officer who located the vehicle and secured the hospital medical records. The on-site investigation was conducted on March 6-7.

SUMMARY

Crash Site

The crash occurred off-road; however, the critical event occurred at a three-leg T-intersection in a residential area during nighttime hours. The driver approached the crash scene traveling in an easterly direction on a two-lane city street with a 1.5 percent grade, negative to the east. A stop sign regulated eastbound traffic flow onto the cross street. This asphalt-surfaced street was 7.6 m (24'9") in width and was bordered by barrier curbs

with shallow snow banks. Residential driveways intersected the curb lines with snow-covered lawns extending between the driveways. A row of houses was located approximately 15 m (50') east of the east curb line. **Figure 2** is an overall view of the crash scene in the direction of vehicle travel.

The Sable initially impacted and overrode a large shrub that was located 6.2 m (20.5') east of the curb line. The vehicle traversed a lawn and a residential driveway before impacting a retaining wall. This retaining wall bordered the south edge of the driveway and was constructed of 30x46x5 cm (12x18x2") concrete blocks that were stacked and frozen in place due to the cold temperature. The wall was approximately 20.3 cm (8.0") in height in the area of the vehicle's trajectory. A residential sidewalk intersected the driveway with one step (two risers/one tread) that transitioned the change in elevation. This step



Figure 2. Overall view of the crash scene.

was poured concrete that led to a poured concrete sidewalk. Adjacent to the steps were two concrete ornamental markers. These markers were 48 cm (19") square and 28 cm (11") in height. The markers were poured on footers and were frozen in the ground. Southward of the retaining wall and the markers was a three-tier stack of landscape timbers that bordered ornamental shrubs. This landscaped area, adjacent to the house, was positioned 3-7 m (10-23') east of the retaining wall and terminated at a porch. The porch to the house was constructed of a block wall foundation with a 10 cm (4") concrete slab. The slab measured 127x236 cm (50x93") and was 51 cm (20") in height. A lattice panel extended vertically from the porch to the soffit of the house. This panel was displaced by the porch impact; however, the porch was not damaged.

At the time of the crash, the temperature was in the -10 degree Celsius range (15 degree F) with clear conditions and dry paved surfaces. The ground was frozen with approximately 7 cm (3") of snow coverage. The intersection was illuminated by overhead streetlights. The residential speed limit was posted at 48 km/h (30 mph).

Vehicle Data

The 1996 Mercury Sable GS four-door sedan was purchased by the driver as a used vehicle on April 9, 1998. At the time of purchase, the odometer reading was 45,820 km (28,472 miles). The current odometer reading at the time of the SCI inspection was 135,326 km (84,090 miles). Previous (repaired) damage was noted to the leading edge of the lower left front door panel and the trailing edge of the left front fender. A subtle variance in the paint color was noted to the front bumper fascia and to these repaired body components. Superficial previous damage that included paint transfers and abrasions was noted to all four corners of the Sable and along the left body side molding.

The Sable was manufactured on 10/95 and was identified by vehicle identification number 1MELM50U4TG (production number deleted). The Sable was powered by a 3.0

liter V-6 transverse mounted gasoline engine with Electronic Fuel Injection (EFI) linked to a 4-speed automatic overdrive transmission with a column mounted transmission selector lever. The braking system consisted of power-assisted front disc/rear drum brakes without anti-lock. The Sable was equipped with all season radial tires mounted on OEM alloy wheels. The manufacturer’s recommended tire pressure was 228 kPa (33 PSI). The tire and wheel data is provided in the following table:

Position	Tire/Size	Pressure	Tread Depth	Damage
LF	Firestone Affinity Touring T2/P195/65R15 89T M&S	0 kPa	3.2 mm (4/32”)	Aired out, debeaded; no visible damage
RF	Firestone Affinity Touring T2/P195/65R15 89T M&S	202.3 kPa (29.5 psi)	4.0 mm (5/32”)	No damage
LR	Firestone Affinity Touring T2/P195/65R15 89T M&S	113.1 kPa (16.5psi)	4.0 mm (5/32”)	No damage
RR	Firestone Affinity Touring T2/P195/65R15 89T M&S	222.9 kPa (32.5 psi)	4.8 mm (6/32”)	No damage

The interior of the Sable was configured with front bucket seats with a flip and fold center armrest that converted into a center front seated position. At the time of the crash, the unit was folded into the center armrest configuration. The front seat backs had adjustable head restraints that were adjusted to the full down position. The rear seat was a three-passenger bench seat with split forward folding seat backs. The Sable was equipped with power accessories that included windows, door locks, 6-way driver’s seat, outside mirrors, and an aftermarket alarm system.

Crash Sequence

Pre-Crash

The 78-year old male driver of the 1996 Mercury Sable departed his residence on the evening of the crash, reportedly to visit a friend. Following his departure from the friend’s residence, the driver of the Sable was traveling in an easterly direction on a two-lane city street, apparently en route to his residence. As he approached the three-leg T-intersection, the driver may have experienced a medical episode. He had a reported health history of diabetes mellitus, chronic atrial fibrillation, severe tricuspid regurgitation with right ventricular failure, and rheumatic heart disease. Due to his religious beliefs, the driver did not take his prescribed medications.

The driver initiated a wide right turn at the three-leg intersection and departed the east (left) edge of the intersecting street at a private driveway. The vehicle traversed the mouth of the driveway and entered a lawn area in a tracking mode. Light snow covered the grass and private driveways. The crash schematic is attached as **Figure 15**, Page 12.

Crash

The front left area of the Mercury Sable impacted and overrode a large shrub that was located in the lawn area between two driveways (**Figure 3**). The shrub impact apparently resulted in a rapid air out of the left front tire. The Sable continued forward on a slight clockwise arc, traveling on a path that was nearly parallel to the intersecting street. The vehicle traversed another private driveway and impacted a retaining wall (**Figure 4**) that was constructed of 30x46x5 cm (12x18x2”) concrete blocks. The front center and right area of the Sable impacted the retaining wall that was approximately 20 cm (8.0”) in height.



Figure 3. Trajectory of the Mercury Sable and the struck shrub (Impact #1).



Figure 4. Struck retaining wall and sidewalk steps.

As the Sable began to mount the wall, the leading edge of the front left frame rail impacted the concrete steps that led to a paved sidewalk. The Sable continued forward, impacting a concrete marker that was 48 cm (19”) square and 28 cm (11.0”) in height with the front right area of the bumper. The impact fractured this marker and displaced the fragments across the front lawn of the private residence. The Sable continued forward and overrode a three-tier stack of landscape timbers that bordered the front of the house. As the Sable continued forward, the vehicle impacted two ornamental shrubs prior to impacting the concrete slab of the front porch (**Figure 5**).



Figure 5. Struck porch.

The impact involved the front left area of the bumper and rotated the vehicle approximately 15 degrees in a counterclockwise direction. The frontal air bag system probably deployed as a result of the impact with the porch. The prior impacts did not alter the vehicle’s trajectory. The damage algorithm of the WinSMASH program computed a barrier equivalent speed of 10.4 km/h (6.5 mph) for the porch impact using the CDC and damage locators as inputs.

Post-Crash

The Mercury Sable came to rest engaged against the front porch. Police and fire department personnel arrived on-scene within three minutes of the crash. The driver was found in the vehicle slumped over the steering assembly and the deployed air bag. He was unconscious and without a pulse. The driver was removed from the vehicle and rapid resuscitation efforts were performed (CPR). He was loaded into an ambulance and transported to a local hospital. En route, an IV was attempted and the driver was bagged and intubated. He arrived at the hospital approximately 30 minutes following the crash. On arrival, he remained pulseless. Blood pressure and pulse were restored at the hospital. The driver was diagnosed with a severe closed head injury and was supported by a ventilator. Three days following the crash, the driver's family submitted a previously authorized Do Not Resuscitate (DNR) order to the hospital. The driver was removed from the ventilator and immediately expired.

Vehicle Damage

Exterior

The Mercury Sable sustained moderate frontal and undercarriage damage as a result of the multiple impact crash sequence. The initial impact with the large shrub produced superficial abrasions and scratches to the front left area of the bumper fascia. The left front tire sustained a rapid air out, apparently as a result of this shrub impact. This was based on the tire marks that were visible in the on-scene police photographs.

The lower air dam aspect of the bumper fascia (**Figure 6**) impacted the retaining wall that paralleled the private driveway. This impact, which abraded and fractured the composite component, began 29.2 cm (11.5") left of center and extended 90.2 cm (35.5") to the right. This impact was below the level of the bumper beam. The lower radiator support engaged the retaining wall as the Sable overrode the block wall, however, there was no residual crush.



Figure 6. Impact damage to the bumper fascia and air dam.

The left front tire and wheel of the Sable overrode the concrete stairs and the vehicle continued forward. The front right and center aspect of the front bumper impacted the square concrete decorative marker that was positioned beyond the retaining wall. The impact involved the bumper face and the structural beam of the bumper system. The direct contact damage began 2.5 cm (1.0") left of center and extended 48.3 cm (19.0") to the right, terminating inboard of the corner (**Figure 6**).

The front left corner area of the Sable subsequently impacted two ornamental shrubs that were located in the front landscaping adjacent to the house. These minor impacts did not produce significant residual damage. The minor damage was masked by the initial shrub impact and the subsequent impact with the porch.

The front left corner (**Figure 7**) area of the Sable impacted the corner of the porch. The porch consisted of a concrete block foundation that was capped with a 10 cm (4") thick concrete slab that measured 127x236 cm (50x93"). The slab was covered with indoor/outdoor carpeting. The impact abraded the bumper fascia and chipped the paint from the corner area of the fascia as the fascia flexed and rebounded to its original form. The direct contact damage began 59.7 cm (22.5") left of center and extended 10.2 cm (5.0") to the corner. The leading edge of the front left frame rail was crushed rearward (**Figure 8**) to a maximum depth of (1.0").



Figure 7. Front left corner damage from porch impact.



Figure 8. Crushed leading edge of the left frame rail and separation of the lower control arm.

The lower control arm separated (**Figure 8**) from the outboard aspect of the left frame rail. It appeared that rust and deterioration contributed to the separation. It was unknown if this separation occurred from the vehicle's impact with the sidewalk steps, or resulted from tire/wheel contact against the porch foundation.

The following table identifies the Collision Deformation Classifications (CDC) for each damage producing event in this crash.

Event No.	Object Struck	CDC
1	Large shrub	12-FYEW-1
2	Concrete block retaining wall	12-FZEW-1
3	Concrete marker	12-FZEW-1
4	Ornamental shrub	12-FLLE-1
5	Ornamental shrub	12-FLEE-1
6	Porch	12-FLLE-1

Interior Damage

The interior of the Mercury Sable sustained minor severity damage that resulted from air bag deployment and minimal occupant related damage. There was no intrusion of the passenger compartment. The driver of the Sable was restrained by the manual safety belt system; however, due to his forward position at impact, he did not adequately load the restraint system to produce loading evidence. His left knee contacted the knee bolster (**Figure 9**) which scuffed the left aspect of the bolster panel. Multiple body fluid

transfers were observed to the driver's air bag. These transfers resulted post-deployment as the driver came to rest slumped against the steering assembly. There was no damage to the four-spoke steering wheel rim or compression of the energy absorbing steering column. **Figure 10** is a view of the shear capsule brackets that show no displacement.

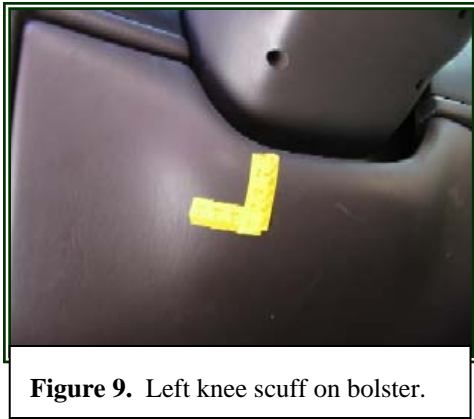


Figure 9. Left knee scuff on bolster.

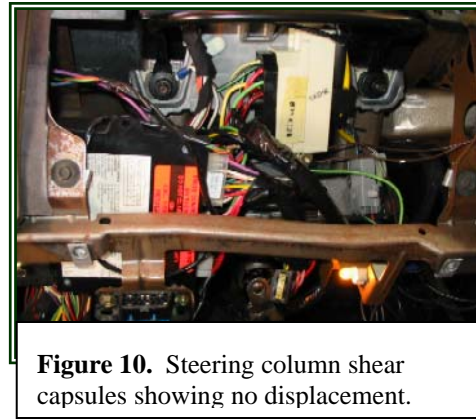


Figure 10. Steering column shear capsules showing no displacement.

The deployment of the front right passenger air bag resulted in windshield damage as a result of cover flap contact. The tethered flap impacted the laminated glazing and fractured the right two-thirds of the windshield. A 21.6 cm (8.5") laceration of the laminate was noted in the area of the flap contact. The cover flap was cracked and the leading edge abraded from the windshield contact. The expanding front right air bag contacted and cracked the rear view mirror glass and displaced the mirror to the left. The right upper A-pillar jacket was fractured by the expansion of the air bag membrane.

Manual Restraint Systems

The Sable was manufactured as a six-passenger vehicle. The four outboard and center rear seat positions were equipped with 3-point lap and shoulder belt systems. The center front position was equipped with a fixed length adjustable lap belt.

The four outboard safety belt systems consisted of continuous loop webbings with sliding latch plates. The front left retractor was an Emergency Locking Retractor (ELR) with a belt sensitive locking mode. The front right and three rear positions were equipped with dual mode ELR and switchable Automatic Locking Retractors (ALR), with the belt sensitive feature. The center rear shoulder belt was detachable from the lap belt. The front outboard belt systems also utilized adjustable D-rings. The front left was adjusted to the full down position while the front right was adjusted 2.5 cm (1.0") below the full-up position. Both D-rings had 8.6 cm (3.375") of vertical adjustment.

The driver's belt system yielded heavy routine usage indicators that included abraded webbing edges and surface scratches on the latch plate. There was no crash related loading evidence on the belt webbing. The driver was observed in the vehicle post-crash with the belt system buckled around his body. The remaining belt systems had minimal

routine wear marks, indicating infrequent use. The Sable was seldom used to transport additional passengers during this driver's ownership.

Frontal Air bag System

The Mercury Sable was equipped with a frontal air bag system for the driver and right passenger positions. The system consisted of two crash sensors that were mounted to the upper radiator support panel, a diagnostic control module that was mounted on the center tunnel under the mid instrument panel, the steering wheel mounted driver's module, and the front passenger module that was mounted in the top of the right instrument panel. The frontal air bag system probably deployed (**Figure 10**) as a result of the frontal impact with the porch.



Figure 10. Deployed frontal air bags.



Figure 11. Expansion transfers on the bag membrane.

The front left driver's air bag was concealed by asymmetrical H-configuration module cover flaps. The upper flap measured 7.6 cm (3.0") in height and 14.0 cm (5.5") in width at the horizontal tear seam. The lower flap was the same width as the upper and was 5.7 cm (2.25") in height. There was no damage or contact evidence to the cover flaps.

The driver's air bag membrane measured 61 cm (24") in its deflated state and was tethered internally by two internal tethers located at the 3 and 9 o'clock positions. The tethers were sewn to the face of the bag membrane with a 16.5 cm (6.5") diameter tether reinforcement with two rows of external stitching. The bag was not directly vented into the passenger compartment. There was no direct driver contact evidence on the bag membrane. Several body fluid (blood) stains were present on the bag in the center tether reinforcement, and above and below the reinforcement circle. These stains occurred post-crash as the driver bled from his facial injuries.

The air bag membrane did yield evidence of expansion transfers (**Figure 11**) from the inside surface of the module. A 15.8x5.1 cm (6.25x2.0") area of black striations was noted on the membrane at the 9 o'clock sector, forward of the peripheral seam. A second area of black striations was present on the bag at the 6 o'clock sector, extending in both directions of the peripheral seam. These transfers possibly resulted from an impeded

deployment due to a forward positioned driver. The driver air bag membrane was stamped with the following manufacturer nomenclature:

(12 o'clock sector)

139 324

P116487-03D

TAC273J23546

(6 o'clock sector)

809 329 767

387

The front right passenger air bag was concealed by a single cover flap that was mounted to the top of the right instrument panel. The cover flap was reinforced with a sheet metal backer panel and was shaped in a tri-oval design. The maximum width of the flap was 43.8 cm (17.25") with a height of 29.2 cm (11.5"). The flap was tethered to the instrument panel by two 2.9 cm (1.125") wide tether straps that were 24.8 cm (9.75") in length (**Figure 12**). At deployment, the flap completely separated from the top right instrument panel and was restrained by the tethers. The flap impacted and fractured the right two-thirds (66 percent) of the windshield. In addition, the flap impact lacerated 21.6 cm (8.5") of the plastic laminate. The leading edge of the cover flap was abraded from the windshield contact.



Figure 12. Tethered front right air bag module cover flap.



Figure 13. Fractured right A-pillar trim from air bag expansion.

The front right passenger air bag was folded into the module and wrapped with a band of bag material. At deployment, the expansion of the air bag membrane split the band to allow the deployment of the bag. This band material was fragmented with strands snagged in the right sun visor clip and headliner. The expanding air bag membrane, although not restricted, contacted and fractured the plastic trim (**Figure 13**) on the right upper A-pillar. The bag also expanded against the rear view mirror, fracturing the mirror glass and displacing the mirror to the left.

The front right passenger air bag membrane was tethered internally by a wide band tether that was sewn to the bag face with a 62.2 cm (24.5”) horizontally oriented seam. There were no vent ports in the fabric of the bag. The face of the front right air bag was 62.2 cm (24.5”) in width and 54.6 cm (21.5”) in height. The top panel of the bag extended 58.4 cm (23.0”) rearward of the inflator. There was no damage or contact evidence on the passenger air bag membrane.

Driver Demographics

Age/Sex: 78-year old male
 Height: *165.1 cm (65.0”)
 Weight: *65.7 kg (145.0 lb)
 Eyewear: Prescription eyeglasses
 Seat Track Position: Unknown, seat found in full rear track position at time of the SCI inspection
 Manual Restraint Usage: 3-point lap and shoulder belt system
 Usage Source: Vehicle inspection, observations of first responders
 Mode of Transport
 From Scene: Ambulance
 Type of Medical Treatment: Admitted to a local hospital where he expired three days following the crash

** Note: The driver’s license listed his height at 165.1 cm (65.0”) and his weight at 65.7 kg (145.0 lb). There was no official documentation of his current height and weight in the medical records. The funeral director estimated his height and weight at 183 cm (72.0”) and 82-86 kg (180-190 lb), which is considerably different from the license data.*

Driver Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanism
Subdural hematoma	Severe (140650.4,9)	Expanding front left air bag
Intracranial hemorrhage, NFS	Severe (140629.4,9)	Expanding front left air bag
Small cerebral contusion in the right parietal area	Serious (140606.3,1)	Expanding front left air bag
Right pneumothorax	Serious (442202.3,1)	Expanding front left air bag
Scattered abrasions over the brow on the forehead	Minor (290202.1,7)	Expanding front left air bag
Scattered abrasion of the nose	Minor (290202.1,4)	Expanding front left air bag
Left periorbital contusion	Minor (297402.1,2)	Expanding front left air bag

Source – Hospital medical records; no autopsy was performed

Driver Kinematics

The 78-year old male driver of the Mercury Sable was seated in an unknown track position. The seat track was found in a full rear position at the time of the SCI inspection with the seat back reclined 21 degrees. Based on the height and weight discrepancy

between the driver's license data and the funeral director, it was unknown if the driver at 165 cm (65") could comfortably operate the vehicle from a full rear track position. In the full rear track position, the horizontal distance between the center of the steering wheel air bag module cover and the seat back was 67.3 cm (26.5"). The driver was reported by first responders at the crash scene as restrained by the 3-point lap and shoulder belt system. There was no loading evidence on the belt system; however, the system did yield historical usage indicators that were consistent with the vehicle mileage.

The police suspected that the driver of the Mercury Sable sustained a medical event that contributed to the causation of this run-off-road crash. It should be noted that the hospital medical data did not identify evidence of such an event. He did have a medical history of diabetes mellitus, chronic atrial fibrillation, severe tricuspid regurgitation with right ventricular failure, and rheumatic heart disease. The departure of the vehicle from the three-leg T-intersection suggested that the driver relinquished control of the vehicle due to a possible medical event, or possibly by falling asleep. There was no alcohol involvement.



Figure 14. Driver's position and the deployed front left air bag.

The frontal air bag system deployed during the multiple event crash. The system probably deployed as result of the impact with the porch. At the time of deployment, the driver was probably slumped in a forward direction with his face in close proximity to the steering wheel mounted air bag module (**Figure 14**). As the air bag deployed, the expanding bag membrane impacted the driver's face resulting in abrasions of the nose, forehead, and a left periorbital contusion. The continued expansion of the bag against the driver's head produced a subdural hematoma, intracranial hemorrhage, and a small cerebral contusion of the right parietal lobe. The driver also sustained a right pneumothorax that probably resulted from air bag expansion against his chest. Although he would have initiated a forward trajectory in response to the frontal crash forces, there was no evidence of steering wheel deformation or compression of the energy absorbing steering column. A small scuff was noted to the left was aspect of the knee bolster. No injury occurred from this contact.

The expanding air bag would have displaced the driver rearward. He subsequently slumped forward against the steering assembly and the deflated air bag. He was found by the first responders unconscious and without a pulse.

Medical Treatment

The driver was removed from the vehicle by fire department personnel. He was placed on the ambulance cot and administered CPR. Attempts to intubate the driver were unsuccessful. CPR activities continued as the driver was transported by ambulance to a local hospital. The unit arrived at the hospital approximately 30 minutes following the crash. The driver remained pulseless for this time period.

At the hospital emergency room, the staff physician intubated the driver. Blood pressure and pulse were restored; however, the driver could not support breathing. He was placed on a mechanical ventilator. The driver was subsequently diagnosed by CT scan with closed head injuries. He was maintained on the ventilator for a period of approximately three days. During this time frame, numerous physicians evaluated the status of the driver. It was concluded that the driver's prognosis for recovery was poor. The family produced a previously signed Do Not Resuscitate (DNR) order and the driver was removed from the ventilator. He immediately expired three days following the crash. No autopsy was performed.

SCENE SCHEMATIC

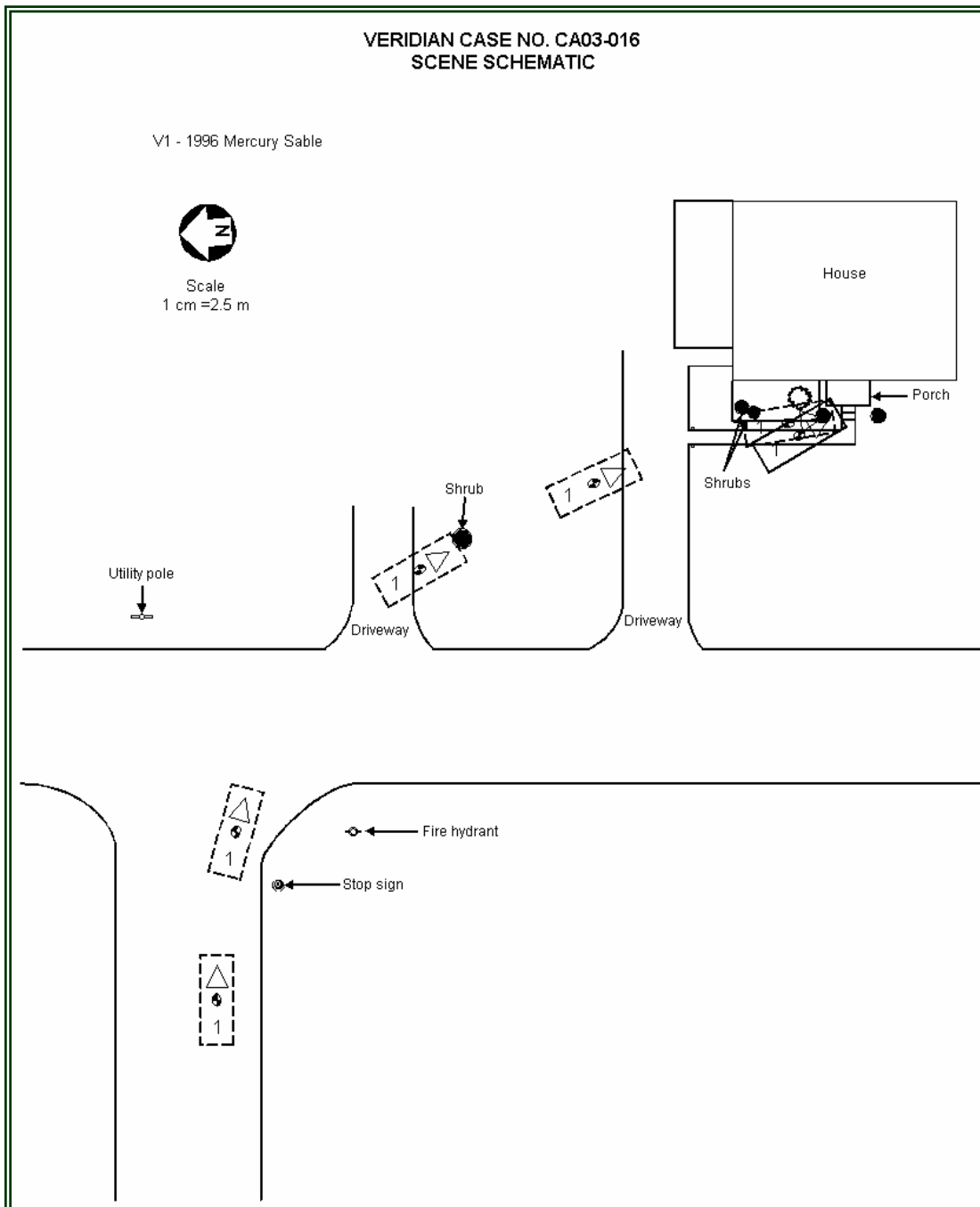


Figure 15. Crash Schematic.