

**TRANSPORTATION SCIENCES
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**VERIDIAN ON-SITE AIR BAG RELATED
ADULT DRIVER FATALITY INVESTIGATION
VERIDIAN CASE NO. CA00-022
VEHICLE: 1993 CHEVROLET CORSICA
LOCATION: NEW YORK
CRASH DATE: JUNE 2000**

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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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VERIDIAN ON-SITE AIR BAG RELATED DRIVER FATALITY INVESTIGATION
VERIDIAN CASE NO. CA00-022
VEHICLE: 1993 CHEVROLET CORSICA LT
LOCATION: NEW YORK
CRASH DATE: JUNE 2000

BACKGROUND

This on-site investigation focused on the injury mechanisms that resulted in the death of an 86 year old female driver of a 1993 Chevrolet Corsica. The Corsica was equipped with a frontal air bag for the driver's position that deployed as the vehicle impacted the back wall of a garage. The driver entered her driveway and remotely opened the overhead garage door to her residence. As the vehicle entered the garage, the Corsica sideswiped the left side of the garage door opening and the driver inadvertently depressed the accelerator. The vehicle accelerated across the concrete garage floor and impacted the back wall of the garage. The 12 o'clock direction of force impact resulted in moderate vehicle damage (**Figure 1**) and deployed the driver air bag system. The short stature driver was improperly restrained by the manual belt system and seated with the seat track adjusted to a forward position. The upper air bag module cover flap contacted the chest of the driver. The deploying air bag membrane expanded against the chest and face of the driver, displacing her into the front left seat back support. She sustained soft tissue injuries of the face and occipital scalp, a bi-frontal cerebral contusions, subarachnoid hemorrhage, subdural hemorrhage, and a clivus fracture. She was transported by ambulance to the emergency room of a regional trauma center where her condition was evaluated. The driver was admitted to the intensive care unit where her condition deteriorated and she expired six days following the crash.



Figure 1. Frontal damage to the Chevrolet Corsica.

The crash was identified by a co-worker of the Special Crash Investigation Team at Veridian Engineering on June 26, 2000. The circumstances of the crash, vehicle type, and driver outcome were forwarded to the NHTSA SCI Headquarters and the case was assigned as an on-site investigative effort on June 27. Due to the local nature of the crash, the on-site investigation was initiated immediately following assignment.

SUMMARY

Crash Site

The crash occurred on private property within the garage of the driver's residence in a rural setting. At the time of the crash, it was daylight, clear, and dry. The driver entered her driveway from a two lane county road. The asphalt driveway was 3.1 m (10.2') in width and was a T-configuration. The straight segment of driveway was 18.8 m (61.7') in length. The spur segment that lead to the garage was 3.8 m (12.5') in width and intersected the main driveway at 90 degrees and was located 9.2 m (30.2') from the roadedge. This segment continued 7 m (23.0') to the two car garage. The two car garage was 7.3 m (24.0') in width

and 7.1 m (23.2') in depth. The 2.9 m (16.0') wide garage door was offset to the right of the garage. The overhead door was operated by a mechanical opener with an in-vehicle remote controller.

The garage was added onto the existing house with two separate walls separating the garage from the living area. The back wall of the garage was a double wood framed wall system, constructed of two 5x10 cm (2x4") walls with the stud placing at 41.1 cm (16.0") centers. The inner wall of the garage was covered with two layers of drywall, 12.7 and 15.8 mm (½" and 5/8") in thickness to meet fire code standards. The adjacent wall to the garage was the original exterior wall of the residence. This wall was covered with 12.7 mm (½") foam insulation nailed over the original clapboard siding. The interior (living area) of this wall was covered with plaster and wood lath with an imitation brick veneer glued to the interior wall.

The vehicle impacted the wall and fractured the garage drywall, two 5x10 cm (2x4") studs, split a third stud at the sill plate, and displaced the interior wall of the house, fracturing the brick veneer. The Corsica did not penetrate through the garage wall.

Vehicle Data

The 1993 Chevrolet Corsica was purchased by the driver as a used vehicle approximately four years prior to this crash. The long term history of the vehicle was unknown, however, the exterior of the Corsica appeared to have been repainted. The Corsica was manufactured on 2/93 and was identified by vehicle identification number 1G1LT53T3PY (production number deleted). The power train consisted of a 3.1 liter, multi-point fuel injected, transverse mounted V-6 engine linked to a three-speed automatic transmission. The brake system consisted of power-assisted front disc/rear drum brakes with anti-lock (ABS). Additional vehicle equipment included front bucket seats with reclining seat back supports and adjustable head restraints, and a rear bench seat with a fixed backrest, power-assisted steering, power door locks, and manually operated windows and seat tracks.

Crash Sequence

Pre-Crash

The driver of the Chevrolet Corsica had completed errands and was returning to her residence. She approached her driveway from an easterly direction and initiated a left turn from the two-lane county road. The driver proceeded into her driveway at a slow rate of speed and traveled the 9.2 m (30.2') before turning 90 degrees on her approach to the garage (**Figure 2**). At this time, the driver probably activated the remote to open the overhead door to the garage. The crash schematic is attached as **Figure 12**, Page 12.



Figure 2. Trajectory of the Corsica into the garage.

Crash

As she entered the garage, the left front side area of the Corsica sideswiped the left side of the garage door opening. The 12 o'clock direction of force impact produced superficial damage to the rub strip on the left front fender, forward of the side marker light. As the vehicle continued forward, the left outside rear view

mirror impacted the opening which abraded and displaced the mirror rearward. Superficial abrasions were also noted to the left rear quarter panel below the level of the rub strip. This impact abraded and dented the aluminum trim on the garage door jamb.

As the driver sideswiped the garage opening, she probably inadvertently depressed the accelerator pedal as evidenced by acceleration marks from the front tires on the concrete garage floor. The left front tire acceleration mark began 0.7 m (2.3') inboard of the garage door while the right front began 1.3 m (4.3') inboard of the door opening. The location of these marks and the subsequent impact location with the back wall of the garage identified a slight diagonal trajectory of the vehicle as it entered the garage.

The acceleration marks continued 5.8 m (19.0') and 5.5 m (18.0') respectively for the left and right tires to impact against the back wall of the garage. Due to the angled trajectory of the vehicle, the front right area of the Corsica impacted the wall (**Figure 3**) resulting in a 12 o'clock direction of force impact. The front bumper of the Corsica crushed to a maximum depth of 18.4 cm (7.25") located at the right corner. Although the wall yielded, the WinSMASH program was utilized to compute a total velocity change of 17.0 km/h (10.6 mph). The specific longitudinal and lateral components were -17.0 km/h (-10.6 mph) and 0 km/h respectively. The impact induced deceleration was sufficient to deploy the frontal driver air bag. Due to the yielding wall, the air bag probably deployed late in the crash sequence.



Figure 3. Impact damage to the garage wall.

Post-Crash

The vehicle came to rest engaged against the struck wall of the garage. At rest, the engine continued to run with full power applied to the front-wheel-drive vehicle. It was unknown if the driver continued to depress the accelerator pedal post-crash or if the throttle and/or linkage jammed during the crash.

The front tires spun on the concrete floor for an unknown period of time. The left front tire was spun bald and remained inflated with fragments of rubber tread compound fused to the inner fender. The right front tire was spun bald with the steel belts exposed and the tire deflated. Large amounts of rubber tread compound were fused to the inner fender. In addition, the serpentine belt on the engine was fragmented and the outer third of the belt was disintegrated.

An adult male arrived at the driver's residence approximately two hours post-crash for a scheduled appointment. As he entered the driveway, this witness observed the garage door was open and the Corsica positioned slightly diagonal in the garage with anti-freeze pooled under the vehicle. As he exited his vehicle, the witness observed rubber fragments on the garage floor and noted the smell of burned rubber in the garage. He observed that the Corsica was not running.

This witness approached the Chevrolet Corsica and observed the driver in the vehicle, seated upright in a normal driving posture, conscious and alert. Due to her small stature, the witness stated she was obscured from the rear of the vehicle by the seat back support and the head restraint. He conversed with the driver and observed blood oozing from two large lacerations on her posterior scalp. The witness immediately called 911 on his cellular telephone to request medical attention for the driver.

He proceeded to open the left front door and observed the ignition key was in the run position. He further noted the driver's seat belt system was buckled, however, the shoulder belt webbing was positioned behind her back. The driver attempted to swing her legs out from the vehicle and recline the seat back support. The witness instructed her to remain in the vehicle and wait for medical personnel to arrive on-scene. During this time frame, the witness continued to converse with the driver.

Paramedics arrived to the rural location within 10-15 minutes of the 911 call and began to assess the driver in the vehicle. She responded appropriately to all questions relating to her name, age, address, and social security number. She could not recall the circumstances of the crash. The paramedics cut the lap belt webbing and removed the driver from the vehicle for ambulance transport to the emergency room of a regional trauma center. The driver attempted to refuse medical treatment, requesting a band-aid for her scalp injury.

She was transported to the emergency room of a regional trauma center where she was evaluated. Following the results of a CT scan of the head, the driver was admitted to the intensive care unit of the hospital. Over the next six days, her condition deteriorated and she expired.

Vehicle Damage

Exterior

The Chevrolet Corsica sustained minor left sideswipe damage from contact against the left jamb of the garage door opening and moderate front right damage from impact against the back wall of the garage. Additional damage was incurred to the front tires of the vehicle as the throttle remained opened post-crash which allowed the tires to spin bald on the concrete garage floor.

The initial sideswipe damage from the door jamb began on the rub strip on the side surface of the left front fender, forward of the wheel opening over the side marker light. The protruding left outside rearview mirror contacted the jamb which abraded the mirror and displaced the assembly approximately 2.5 cm (1.0") rearward. Superficial abrasions were also noted to the left rear quarter panel below the rub strip. There was no residual crush associated with this impact sequence. The Collision Deformation Classification (CDC) for this event was 12-LDES-1.

The frontal damage that resulted from the impact with the garage wall began 29.5 cm (11.6") right of center and extended 34.5 cm (13.6") to the right bumper corner (**Figure 4**). Maximum crush was 18.4 cm (7.25") located at the right corner of the bumper system. The corner impact deflected the full width of the bumper resulting in a combined direct and induced damage length of 124.5 cm (49.0"). The crush profile at bumper level was as follows: C1 = 3.2 cm (1.25"), C2 = 7.0 cm (2.75"), C3 = 10.2 cm (4.0"), C4 =

12.9 cm (5.1 cm), C5 = 16.5 cm (6.5"), C6 = 18.4 cm (7.25"). The CDC for this impact was 12-FREE-1. The depth of crush is depicted in **Figure 5**.



Figure 4. Frontal damage to the Corsica.



Figure 5. Profile view documenting the extent of crush.

Post-crash, the engine was running at a presumed full throttle position with the frontal area of the Corsica engaged against the back wall of the garage. Due to the high engine RPMs, the front tires broke traction of the concrete floor surface and spun to a point of deterioration. The right front tire was spun bald with cord exposed through the casing of the tire (**Figure 6**). The tire was flat with fragments of rubber tread fused to the inner fender of the vehicle. The left front tire was spun bald, however, the tire remained inflated. Fragments of the rubber tread compound were fused to the inner fender. Tire fragments from both front tires were reportedly scattered across the garage floor. The front tires were identified as Sears SuperGuard 60 P185/75R14.



Figure 6. Damage to the right front tire.

During the post-crash running of the engine, the outboard third of the serpentine engine belt fragmented. Several large strands of fabric and belt cord were present in the engine compartment. The fragmented belt cut through the hood insulation in the area directly above the belt location. Engine oil and anti-freeze were present on the garage floor and within the engine compartment post-crash and at the time of the SCI inspection of the Corsica.

All four doors of the vehicle remained closed during the crash and were operational post-crash. There was no glazing damage.

The Chevrolet Corsica was initially left at the scene of the crash by the investigating police agency. The vehicle was subsequently claimed by the insurance company and towed to a salvage yard for auction.

Interior

Interior damage to the Corsica was minor and was associated with air bag deployment and driver contact. There was no intrusion of interior components or damage resulting from the exterior deformation.

The left aspect of the upper air bag module cover flap contacted the chest of the driver as the air bag system deployed. A vertically oriented abrasion was noted to the flap which extended 8.2 cm (3.25") laterally and 3.8 cm (1.5") vertically. The upper right aspect of the module cover was partially displaced from the steering assembly due to the restricted bag expansion against the forward positioned driver. The combination of air bag expansion against the driver, and the driver's forward motion in response to the crash forces, resulted in 0.9 cm (0.375") of steering column shear capsule compression (**Figure 7**).

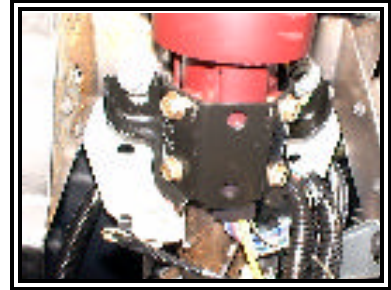


Figure 7. Steering column shear capsule displacement.

The driver was displaced rearward by the expanding air bag into the seat back support. Her head compressed the padding and loaded the structure of the seat that resulted in lacerations of the occipital scalp. A large amount of blood was absorbed by the seat back.

Rescue personnel subsequently cut the lap belt webbing as they removed the driver from the vehicle. The shoulder belt webbing retracted into the left B-pillar of the vehicle.

Driver Air Bag System

The 1993 Chevrolet Corsica was equipped with a frontal air bag for the driver's position. The driver air bag deployed (**Figure 8**) as a result of frontal impact with the back wall of the garage. The system consisted of single front mounted crash sensor affixed to the upper radiator support panel, an interior mounted safeing sensor that was located in the forward aspect of the center mid instrument panel, a Diagnostic Energy Reserve Module (DERM) that was located in the right instrument panel area, and the steering wheel mounted driver air bag module. Although the DERM did contain minimal crash related data, the module was not downloaded for this SCI investigation.



Figure 8. Deployed driver's air bag.

The driver air bag deployed from a module that was housed within the two-spoke steering wheel rim. The spokes were positioned at the 4 and 8 o'clock sectors. The module was concealed by H-configuration flaps that were nearly symmetrical in shape with a horizontal width of 20.9 cm (8.25") at the tear seam and vertical dimensions of 5.7 cm (2.25") and 5.1 cm (2.0") for the upper and lower



Figure 9. Vertically oriented abrasion of the upper cover flap.



Figure 10. Deployed non-tethered driver air bag.

flaps respectively. The left aspect of the upper flap contacted the chest of the driver. A vertically oriented abrasion that measured 3.8x8.3 cm (1.5x3.25") evidenced the contact point (**Figure 9**). The expanding air bag was restricted by the forward positioned driver. As the bag began to deploy, the membrane expanded within the module cover and partially separated the upper right quadrant of the cover from the steering wheel. The bag continued to deploy from the H-configuration flaps.

The diameter of the air bag was 67.3 cm (26.5") in its deflated state. The driver air bag was not tethered (**Figure 10**) and was vented by two 1.3 cm (0.5") diameter ports located the 10 and 2 o'clock sectors. There was no evidence of driver contact to the air bag (i.e., tissue or fabric transfers). A bar coded label was affixed to the air bag adjacent to the module at the 12 o'clock sector and was as follows: PUT1057-01N. A second label was affixed to the 6 o'clock sector and read as follows: TBF226111486.

Manual Restraint Systems

The Chevrolet Corsica was equipped with 3-point lap and shoulder belts for the four outboard seated positions and a center rear lap belt. The front belt systems consisted of continuous loop webbings with locking latchplates (cinch bars) and emergency locking retractors positioned in the lower B-pillars. The upper D-rings were fixed.

The driver's belt system yielded evidence of historical usage (wear on the belt edges and abrasions on the latchplate). There was no loading evidence on the belt system. Rescue personnel cut the lap belt webbing approximately 4.4 cm (1.75") above the vinyl sleeve at the outboard anchorage point. The remainder of the belt webbing retracted into the B-pillar.

Driver Demographics

Age/Sex: 86 year old female
 Height: 147.3 cm (58.0")
 Weight: 45.4 kg (100.0 lb)
 Manual Restraint
 Use: Improper use of the manual 3-point lap and shoulder belt; shoulder belt was positioned behind the driver's back
 Usage Source: Witness observations, vehicle inspection
 Seat Track Position: Forward position (presumed to be in the full forward position, however, the seat track was moved prior to SCI inspection)
 Eyewear: Unknown
 Mode of Transport
 From Scene: Ambulance to the emergency room of a regional trauma center
 Type of Medical
 Treatment: Admitted to the intensive care unit of a regional trauma center where her condition deteriorated. She expired six days following the crash.

Driver Injuries

<i>Injury</i>	<i>Injury Severity (AIS90/Update 98)</i>	<i>Injury Mechanism</i>
Bilateral subdural hygromas with acute subdural hemorrhage anterior to the frontal lobe	Critical (140654.5,3)	Acceleration injury from air bag expansion
Subdural hemorrhage in the posterior fossa	Severe (140438.4,6)	Acceleration injury from air bag expansion
Small contusion on the roof of the 3 rd ventricle	Severe (140678.4,9)	Acceleration injury from air bag expansion
Small amount of subarachnoid hemorrhage over the occipital lobe	Serious (140466.3,6)	Seat back support
Small bi-frontal contusions of 0.5 cm in size, predominately in the right frontal lobe	Serious (140606.3,1)	Air bag expansion

<i>Injury</i>	<i>Injury Severity (AIS90/Update 98)</i>	<i>Injury Mechanism</i>
Subarachnoid hemorrhage within the sulci along the high convexity of both cerebral hemispheres	Serious (140620.3,3)	Acceleration injury from air bag expansion
Small hemorrhagic contusions along the cortical surface	Serious (140620.3,3)	Acceleration injury from air bag expansion
Bone fragment anterior to the clivus, appeared to be detached from the clivus Supplemental Note: The hospital radiology identified an atlanto-occipital dislocation with degenerative joint disease at C2-C6 with narrowing of the disc at C3-C4 and C5-C6. The atlanto-occipital dislocation was ruled out in the autopsy	Moderate (150402.2,6)	Driver air bag expansion that resulted in hyper-extension of the neck
Two 3 cm laceration of the occipital scalp	Minor (190602.1,6)	Seat back support
Contusion of the posterior neck	Minor (390402.1,6)	Seat back support
Bilateral periorbital contusions	Minor (297402.1,1; 297402.1.2)	Driver air bag expansion that resulted in hyper-extension of the neck
Contusion of the left face	Minor (290402.1,2)	Expanding driver air bag membrane
Abrasions of the upper and lower lips	Minor (290202.1,8)	Expanding driver air bag membrane
Chest contusion	Minor (490402.1,9)	Upper air bag module cover flap

<i>Injury</i>	<i>Injury Severity (AIS90/Update 98)</i>	<i>Injury Mechanism</i>
Contusion of the lateral aspect of the right upper arm	Minor (790402.1,1)	Probable fling injury into the front right seat back support
Bilateral forearm contusions	Minor (790402 .1,3)	Expanding driver air bag membrane
Left knee contusion	Minor (890402.1,2)	Knee bolster
Bilateral lower leg contusions	Minor (890402.1,3)	Knee bolster

* *Source of Injuries - Hospital records and autopsy report*

Driver Kinematics

The 86-year old female driver of the 1993 Chevrolet Corsica was seated in a presumed upright driving posture with the seat track adjusted to a near full forward position and the seat back set to a near vertical position (**Figure 11**). She was restrained by the manual belt system, however, the system was used improperly. Due to her short stature, her seated height was low, therefore the driver positioned the shoulder belt behind her back to prevent contact against her neck and face. This was observed by the witness who arrived at the residence approximately two hours post-crash. He further noted that the driver's head was barely visible over the top of the seat back support. This, in combination with her forward position, placed her face in a close proximity to the steering assembly and the driver air bag module.



Figure 11. Driver's forward seated position.

The frontal impact with the studded garage wall deployed the driver air bag system. Due to the minor severity crash and the displacement of the wall system, the air bag probably deployed late in the crash sequence. The driver initially responded to the 12 o'clock direction of force impact by moving forward. Her pelvic region loaded the lap belt webbing, however, due to her forward seated position, her left knee and lower legs contacted the knee bolster resulting in a soft tissue contusions. Her upper torso and head moved forward as the air bag system deployed. The left aspect of the upper air bag module cover flap contacted the chest of the driver. A vertically oriented scuff mark was present on the vinyl flap. The driver sustained a contusion of the chest that was associated with the cover flap contact. The expanding driver air bag membrane contacted the anterior aspects of the driver's forearms, resulting in bilateral forearm contusions. This contact probably separated her hands from the steering wheel rim. Her right arm was flung to the right, probably impacting the right front seat back support. The driver sustained a contusion of the lateral aspect of the right upper arm from the probably seat back contact.

The expanding air bag membrane contacted the driver's face. The initial contact abraded her lips and contused her left face. The continued expansion of the air bag accelerated the driver's head rearward which produced a slight hyper-extension motion of the neck. The acceleration allowed the brain to move within the skull which produced bilateral subdural hygromas with acute subdural hemorrhage anterior to the frontal lobe, subdural hemorrhage on the posterior fossa, a small contusion on the roof of the third ventricle, small bi-frontal contusions, a small amount of subarachnoid hemorrhage over the occipital lobe, subarachnoid hemorrhage within the sulci along the high convexity of both cerebral hemispheres, and small hemorrhagic contusions of the cortical surface. The extension component of the head acceleration fractured the clivus. It should be noted that this injury was initially diagnosed as an atlanto-occipital (AO) separation by radiology, however, the AO separation was ruled out by the autopsy.

The driver's head was accelerated into the seat back support by the expanding driver air bag. The occipital aspect of her scalp compressed the padded seat back support against the internal structure of the seat frame. This contact resulted in two 3 cm (1.2") lacerations of the occipital scalp and a contusion of the posterior neck.

The driver came to rest in her seated position, restrained by the manual lap belt. It was unknown if she was rendered unconscious post-crash as she had no recollection of the crash details. The driver either maintained pedal pressure on the accelerator or the linkage jammed as a result of the crash. The engine continued to run post-crash at a high RPM level. This was confirmed by the subsequent spinning of the front tires on the concrete garage floor.

A witness to the post-crash condition of the driver arrived on-scene approximately two hours following the crash. He observed the driver seated in the front left position of the vehicle with the lap belt buckled around her pelvis and the shoulder belt positioned behind her back. The driver was conscious and alert and was asking for assistance from the vehicle. She was bleeding heavily from the occipital lacerations.

This witness used his cellular telephone to request police and rescue assistance. The driver was removed from the vehicle and transported by ambulance to the emergency room of a regional trauma center. She was admitted for treatment of her injuries. Her condition deteriorated over the proceeding six days and she expired. An autopsy was performed on the body. The medical examiner listed the primary cause of death as pre-existing arteriosclerotic coronary artery disease with the secondary factor listed as head injury. The arteriosclerotic coronary artery disease was a pre-existing condition.

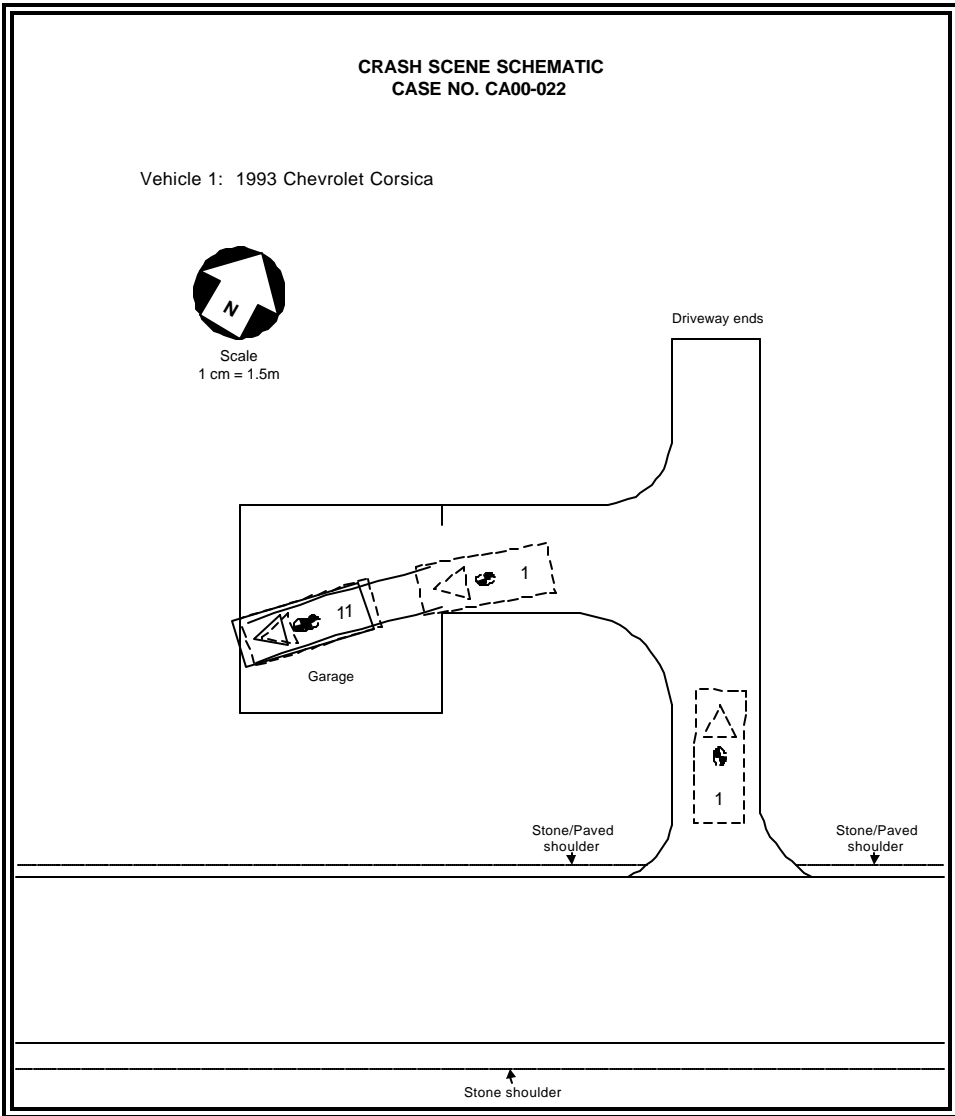


Figure 12. Crash Schematic