TRANSPORTATION SCIENCES
CRASH DATA RESEARCH CENTER

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VERIDIAN ON-SITE AIR BAG RELATED ADULT DRIVER FATALITY INVESTIGATION

VERIDIAN CASE NO. CA01-038

VEHICLE - 1996 GEO METRO LSI

LOCATION - STATE OF PENNSYLVANIA

CRASH DATE - JUNE, 2001

Contract No. DTNH22-94-D-07058

Prepared for:

U.S. Department of Transportation
National Highway Traffic Safety Administration
Washington, D.C. 20590

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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.

TECHNICAL REPORT STANDARD TITLE PAGE

1. *Report No.* CA01-038	2. *Government Accession No.*	3. *Recipient's Catalog No.*	
4. *Title and Subtitle* Veridian On-Site Air Bag Related Adult Driver Fatality Investigation Vehicle - 1996 Geo Metro LSI Location - State of Pennsylvania		5. *Report Date*: February, 2002 6. *Performing Organization Code*	
7. *Author(s)* Crash Data Research Center		8. *Performing Organization Report No.*	
9. *Performing Organization Name and Address* Veridian Engineering Transportation Sciences Crash Data Research Center P.O. Box 400 Buffalo, New York 14225		10. *Work Unit No.* C01115.0366.(0000-0009) 11. *Contract or Grant No.* DTNH22-94-D-07058	
12. *Sponsoring Agency Name and Address* U.S. Department of Transportation National Highway Traffic Safety Administration Washington, D.C. 20590		13. *Type of Report and Period Covered* Technical Report Crash Date - June, 2001 14. *Sponsoring Agency Code*	
15. *Supplementary Notes* On-site investigation of an acute angle collision that involved a 1996 Geo Metro LSI 2-door hatchback equipped with frontal air bags for the driver and front right passenger positions.			
16. *Abstract* This on-site investigation focused on the injury mechanisms that caused the death of a 78 year old male driver of a 1996 Geo Metro LSI 2-door hatchback. The Geo Metro was equipped with frontal air bags for the driver and front right passenger positions which deployed as a result of an acute angle collision with a 1990 Chevrolet Corvette. The driver of the Chevrolet was operating the vehicle northbound when she failed to observe the eastbound Geo as she turned left (west) at a 3-leg "Y" intersection. As the Chevrolet crossed the eastbound lane, the left front side surface was impacted by the front left area of the Geo resulting in moderate damage to both vehicles. The unrestrained 78 year old male driver of the Geo initiated a forward and slightly lateral trajectory in response to the 1 o'clock impact force as the expanding driver air bag contacted the anterior aspect of both forearms resulting in bilateral contusions. The expanding driver air bag against his chest resulted in soft tissue injury, multiple bilateral rib fractures, and an associated punctured right ventricle of the heart. The Geo driver was transported to a local hospital where he was pronounced deceased. The unrestrained 68 year old male front right passenger of the Geo initiated a forward and slightly lateral trajectory in response to the 1 o'clock impact force and loaded the deployed passenger air bag and glove compartment door. Loading of the glove compartment door resulted in a contusion to the left shin. He also sustained a fractured upper front tooth from contact to food trays held in his lap. The front right passenger was transported to a local hospital for treatment and released.			
17. *Key Words* Collision Deformation Classification (CDC): 01-FYEW-3 WinSMASH damage algorithm: 37.9 km/h (23.6 mph) Expanding driver air bag Punctured right ventricle		18. *Distribution Statement* General Public	
19. *Security Classif. (of this report)* Unclassified	20. *Security Classif. (of this page)* Unclassified	21. *No. of Pages* 8	22. *Price*

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BACKGROUND

This on-site investigation focused on the injury mechanisms that caused the death of a 78 year old male driver of a 1996 Geo Metro LSI 2-door hatchback. The Geo Metro was equipped with frontal air bags for the driver and front right passenger positions which deployed as a result of an acute angle collision with a 1990 Chevrolet Corvette. The driver of the Chevrolet was operating the vehicle northbound when she failed to observe the eastbound Geo as she turned left (west) at a 3-leg "Y" intersection. As the Chevrolet crossed the eastbound lane, the left front side surface was impacted by the front left area of the Geo resulting in moderate damage to both vehicles. The unrestrained 78 year old male driver of the Geo initiated a forward and slightly lateral trajectory in response to the 1 o'clock impact force as the expanding driver air bag contacted the anterior aspect of both forearms resulting in bilateral contusions. The expanding driver air bag against his chest resulted in soft tissue injury, multiple bilateral rib fractures, and an associated punctured right ventricle of the heart. The Geo driver was transported to a local hospital where he was pronounced deceased. The unrestrained 68 year old male front right passenger of the Geo initiated a forward and slightly lateral trajectory in response to the 1 o'clock impact force and loaded the deployed passenger air bag and glove compartment door. Loading of the glove compartment door resulted in a contusion to the left shin. He also sustained a fractured upper front tooth from contact to food trays held in his lap. The front right passenger was transported to a local hospital for treatment and released.

The crash notification was provided to NHTSA by the local coroner's office on Friday, July 6, 2001 and assigned to the Veridian SCI team as an on-site investigative effort Monday, July 9, 2001. Although delays were incurred establishing cooperation with the involved parties, the on-site investigator completed field activities on Friday, August 3, 2001.

SUMMARY

Crash Site

This two vehicle crash occurred during the morning hours of June, 2001. At the time of the crash, it was daylight with no adverse conditions as the roads were dry. The crash occurred in the eastbound lane of a (straight) rural 3-leg "Y" intersection with a negative grade for eastbound traffic **(see Figure 10 - page 8)**. A hillcrest was located approximately 55.0 meters (180.5 feet) south of the crash site. Traffic control through the intersection was controlled by a stop sign for northbound traffic. The posted speed limit at the crash site was of 56 km/h (35 mph).

Pre-Crash

The 51 year old female driver of the 1990 Chevrolet Corvette was operating the vehicle northbound **(Figure 1)** when she slowed to a stop in anticipation of a left turn (west) at the 3-leg intersection.

The 78 year old male driver of the 1996 Geo Metro was operating the vehicle eastbound **(Figure 2)** at a (passenger) reported speed of 48 km/h (30 mph) when he crested the hill and observed the Chevrolet cross his path of travel. Upon recognition of the impending harmful event, the Geo driver braked in avoidance, and remained in the eastbound lane prior to the collision.

Figure 1. Northbound approach for the 1990 Chevrolet Corvette.

Figure 2. Eastbound approach for the 1996 Geo Metro LSI.

Crash

As the Chevrolet crossed the eastbound lane of the 3-leg "Y" intersection, the left front side surface was impacted by the front left area of the Geo resulting in moderate damage to both vehicles. Impact resulted in deployment of the frontal air bag systems in each vehicle. The trajectory algorithm of the WinSMASH reconstruction program computed impact speeds of 56.5 km/h (35.1 mph) for the subject vehicle and 15.3 km/h (9.5 mph) for the struck Chevrolet Corvette. Computed velocity changes were 37.9 km/h (23.6 mph) for the subject vehicle and 24.0 km/h (14.9 mph) for the struck Chevrolet. Respective longitudinal components were -35.6 km/h (-22.1 mph) and -15.4 km/h (-9.6 mph). At this point, the Geo rotated 60 degrees counterclockwise and traveled 7.3 meters (24.0 feet) to final rest in the southeast sector of the intersection facing northeast. The Chevrolet rotated 35 degrees counterclockwise and traveled 6.8 meters (22.3 feet) to final rest across the north fog line facing northwest.

Post-Crash

Following the crash, the Geo driver was removed from the vehicle through the left door by rescue personnel due to perceived serious injury (in an unconscious state) as the front right passenger exited through the right door under his own power. The Chevrolet driver exited the vehicle through the left door with some assistance from rescue personnel. All occupants were transported by ambulance to the emergency room of a local hospital for treatment. The Geo driver was pronounced deceased shortly after arrival as the remaining two occupants were treated and released. Both vehicles were towed from the crash site due to disabling damage.

VEHICLE DATA

The 1996 Geo Metro LSI was manufactured in June, 1996 and identified by the vehicle identification number (VIN): 2C1MR2268T6 (production number deleted). The driver-owned vehicle was a 2-door

hatchback equipped with front-wheel drive and a 1.0 liter, I-3 engine. At the time of the crash, the odometer had recorded 37,022 km (23,005 miles). The seating was configured with front bucket and rear bench seats (with folding backs). The passenger and surrogate interviews reported no previous crashes or maintenance on the Geo's frontal air bag system. No cellular phone was present in the vehicle.

VEHICLE DAMAGE

Exterior

The 1996 Geo Metro LSI sustained moderate frontal damage as a result of the impact with the Chevrolet Corvette **(Figure 3)**. The direct contact damage began at the front left bumper corner and extended 93.0 cm (36.6 in) inboard. The impact deformed the entire front end width resulting in a combined direct and induced damage length (Field L) of 103.0 cm (40.6 in). Six crush measurements were documented at the level of the reinforcement bar *(bumper fascia separation)*: C1= 48.0 cm (18.9 in), C2= 49.0 cm (19.3 in), C3= 50.5 cm (19.9 in), C4= 44.5 cm (17.5 in), C5= 20.0 cm (7.9 in), C6= 9.0 cm (3.5 in). The Collision Deformation Classification (CDC) for this impact to the Geo was 01-FYEW-3 with a principal direction of force of (+)20 degrees. The hood was deformed up and rearward from engagement against the side surface of the Chevrolet. The left fender was displaced rearward which restricted/deflated the left front wheel/tire. Induced contact damage produced buckling to the roof area at the left A-pillar and B-pillar. The left lower windshield was fractured from exterior impact forces and the left upper windshield from driver contact. Reduction in the left side wheelbase measured 22.5 cm (8.9 in) as reduction in the right side wheelbase measured 2.0 cm (0.8 in). The left front window was rolled completely down and was undamaged. A blood drip pattern was noted on the left exterior door panel.

Figure 3. Front left damage to the 1996 Geo Metro LSI.

Figure 4. Left front side surface damage to the 1990 Chevrolet Corvette.

The 1990 Chevrolet Corvette sustained moderate left side surface damage as a result of the impact with the Geo Metro **(Figure 4)**. The direct contact damage began 90.5 cm (35.6 in) forward of the left rear axle and extended forward 181.0 cm (71.3 in). The combined direct and induced damage length (Field L) began 39.5 cm (15.6 in) forward of the left rear axle and extended forward 244.0 cm (96.1 in). Although the vehicle's fiberglass exterior compromised accurate crush dimensions, six crush measurements were documented *(approximated)* at the level of the mid-door: C1= 0 cm, C2= 3.0 cm (1.2 in), C3= 2.0 cm

(0.8 in), C4= 0 cm, C5= 12.0 cm (4.7 in), C6= 0 cm. A maximum crush value of 14.0 cm (5.5 in) was documented 13.0 cm (5.1 in) aft of the C4 position. The CDC for this impact to the Chevrolet was 10-LYEW-2 with a principal direction of force of (-)50 degrees. The left (fiberglass) fender was shattered with the crush profile projected to the underlying frame. Direct contact damage was noted to the left front wheel with blue and gray paint transfers extending rearward towards the left door panel. The left front tempered glazing was disintegrated as the windshield was fractured along the left lower A-pillar from exterior impact forces. Reduction in the left side wheelbase measured 11.0 cm (4.3 in).

Interior

Interior damage to the Geo was moderate and was attributed to occupant contact and component intrusions **(Figure 5)**. Indentations and scuff marks were documented on the left knee bolster. Deformation to the lower portion of the steering wheel rim measured 1.0 cm (0.4 in). No sheer capsule movement was identified. A small spider-web fracture pattern was noted on the upper left windshield, and attributed to the driver's left hand. The floor-mounted transmission lever was deformed forward. A heavy concentration of food was found to be splattered across the roof and front occupant space from ice coolers stowed in the rear seating area pre-crash. This cargo shift also deformed the driver seat back from a slightly reclined to an upright position. Scuff marks were documented on the glove compartment door which was also out-of-place. Longitudinal intrusions into the front occupant space involved 14.0 cm (5.5 in) of left toepan, 6.0 cm (2.4 in) of left instrument panel/front left seat back, 4.0 cm (1.6 in) of center instrument panel, and 3.0 cm (1.2 in) of brake pedal intrusion. Lateral intrusions into the driver space involved 14.0 cm (5.5 in) of kick panel and 5.0 cm (2.0 in) of sill intrusion.

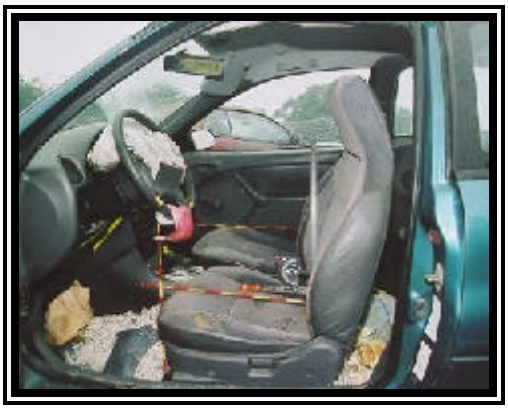

Figure 5. Interior view of the 1996 Geo Metro LSI.

MANUAL RESTRAINT SYSTEMS

The interior of the Geo Metro consisted of a five passenger seating configuration with front bucket and rear bench seats (with folding backs). The driver 3-point manual lap and shoulder belt system consisted of a continuous loop belt webbing with a sliding latchplate and a dual mode retractor (inertial lock/belt sensitive). The front right (and rear outboard) seating position was equipped with a 3-point manual lap and shoulder belt system which consisted of a continuous loop belt webbing with a sliding latchplate and a retractor equipped with an inertial and switchable lock mechanism. The rear center seat was equipped with a 2-point manual lap belt and a locking latchplate. There was no loading evidence identified on the front restraint systems to substantiate usage by either occupant.

SUPPLEMENTAL RESTRAINT SYSTEMS

Figure 6. 1996 Geo Metro LSI deployed frontal air bag system.

The 1996 Geo Metro was equipped with frontal air bags for the driver and front right passenger positions which deployed as a result of the crash **(Figure 6)**. The driver air bag was identified by the following part number: PE5114100-01 with a bar coded lot number of: TBS6135B0113. The air bag was housed in the center of the steering wheel with a horizontally oriented flap tear seam (H-configuration). The flaps were nearly symmetrical in shape as the upper flap measured 15.4 cm (6.1 in) in width and 6.0 cm (2.4 in) in height while the lower flap measured 15.4 cm (6.1 in) in width and 7.8 cm (3.1 in) in height. Although no contact evidence was identified on the exterior surface of the module cover flaps, tissue transfers were documented to the upper right quadrant of the air bag face along with food spattering to the lower right quadrant on the rear aspect. The food spattering was attributed to the trays positioned in the passenger's lap pre-crash. The diameter of the driver air bag measured 63.0 cm (24.8 in) in its deflated state **(Figure 7)**. The bag was tethered by two internal straps and vented by two 4.0 cm (1.6 in) diameter ports located at the 10 o'clock and 2 o'clock sectors on the rear aspect of the air bag. Rearward air bag excursion measured 25.0 cm (9.8 in) from the steering wheel hub.

The front right passenger air bag deployed from the right mid-instrument panel area with a single cover flap design hinged at the top aspect. The cover flap was rectangular in shape and measured 34.5 cm (13.6 in) in width and 15.5 cm (6.1 in) in height. No contact evidence was identified on the exterior surface of the module cover flap. Heavy concentrations of food spattering (attributed to the food trays in the passenger's lap and coolers stowed in the rear seat) were noted across the lower portion of the air bag face along with blood spattering to the upper left quadrant. The passenger air bag measured 47.0 cm (18.5 in) in width and 65.5 cm (25.8 in) in height in its deflated state **(Figure 8)**. No vent ports or internal tether straps were present. Rearward air bag excursion measured 50.0 cm (19.7 in) from the aft portion of the right instrument panel.

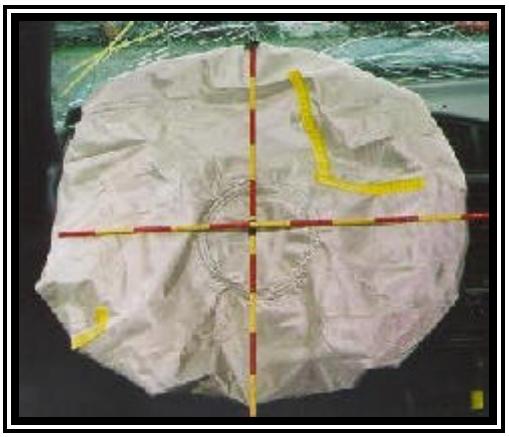

Figure 7. 1996 Geo Metro LSI deployed driver air bag.

Figure 8. 1996 Geo Metro LSI deployed passenger air bag.

DRIVER DEMOGRAPHICS

Age/Sex:	78 year old male
Height:	170 cm (67 in)
Weight:	82 kg (180 lb)
Seat Track Position:	Mid-to-forward position
Manual Restraint Use:	None
Usage Source:	Vehicle inspection, passenger interview
Eyeware:	Prescription glasses
Type of Medical Treatment:	Transported to a local hospital and pronounced deceased

Driver Injuries

Injury	***Severity (AIS 90)***	***Injury Mechanism***
*Punctured right ventricle (2cm - endocardium exposed with interstitial hemorrhage)	Critical (441012.5,4)	Expanding driver air bag
*Multiple bilateral rib fractures (mid-clavicular line involving ribs 3-5)	Moderate (450220.2,3)	Expanding driver air bag
^Laceration over right eye (below eyebrow)	Minor (297602.1,1)	Eyeglasses (indirect air bag contact injury)
^Laceration over left eye (below eyebrow)	Minor (297602.1,2)	Eyeglasses (indirect air bag contact injury)
*Laceration bridge of nose (left side - 2cm)	Minor (290602.1,4)	Eyeglasses (indirect air bag contact injury)
*Bilateral chest contusions (surrounding rib fracture site)	Minor (490402.1,3)	Expanding driver air bag
*Bilateral contusions to anterior forearms	Minor (790402.1,3)	Expanding driver air bag

Sources: autopsy report/surrogate interview^*

Driver Kinematics

The unrestrained 78 year old male driver of the 1996 Geo Metro LSI was seated in an upright posture with his hands placed at the 10 o'clock and 2 o'clock sectors on the steering wheel rim. The seat track was adjusted to a mid-to-forward position with the seat back angled 18 degrees off vertical. The passenger stated the driver was not belted, further evidenced by the lack of loading evidence to the front left restraint and contact points within the vehicle.

Figure 9. Indentations to the driver knee bolster.

At impact, the driver initiated a forward and slightly lateral trajectory in response to the 1 o'clock impact force as the expanding air bag contacted the anterior aspect of the forearms resulting in bilateral

contusions. This injury mechanism was evidenced by the location of the injury relative to the driver's pre-crash placement of the hands on the steering wheel rim. His left arm was propelled vertically upward as the posterior aspect of the left hand struck the upper windshield with no resulting injury reported. This air bag "fling" movement of the extremity was evidenced by the small fracture pattern documented on the left upper windshield area. Interaction with the expanding air bag resulted in contusions to the chest, multiple bilateral rib fractures and an associated punctured right ventricle of the heart, evidenced by the type/severity of the injury in conjunction with the deformation identified to the lower portion of the steering wheel rim. The driver loaded the knee bolster as evidenced by the indentations documented on this component **(Figure 9)**, however, no injury was reported as a result. He also sustained bilateral lacerations above the eyes (below the brow) from bag compression against the driver's eyeglasses, evidenced by the nature of the injury relative to the tissue transfers documented on the upper right quadrant of the air bag face. Conflicting information was obtained regarding the post-crash exit status of the driver, however, he probably remained in the vehicle due to the severity of the injuries sustained. Following the crash, he was removed through the left door by rescue personnel due to perceived injuries (in an unconscious state) and transported by ambulance to the emergency room of a local hospital. Although death was probably immediate, the driver was pronounced deceased approximately 24 minutes following the crash.

FRONT RIGHT PASSENGER DEMOGRAPHICS

Age/Sex:	68 year old male
Height:	178 cm (70 in)
Weight:	84 kg (185 lb)
Seat Track Position:	Full rearward position
Manual Restraint Use:	None
Usage Source:	Vehicle inspection, passenger interview
Eyeware:	Prescription glasses
Type of Medical Treatment:	Transported to the emergency room of a local hospital and released

Front Right Passenger Injuries

Injury	*Severity (AIS 90)*	*Injury Mechanism*
^Fractured front upper tooth	Minor (251404.1,8)	Food tray in lap
^Contusion left lower leg (below knee)	Minor (890402.1,2)	Glove compartment door

*Source: passenger interview^*

Front Right Passenger Kinematics

The unrestrained 68 year old male front right passenger of the 1996 Geo Metro LSI was seated in an upright posture with the seat track adjusted to the full rearward position and the seat back angled 18 degrees off vertical. The passenger stated he was not belted, further evidenced by the lack of loading evidence to the front right restraint and contact points within the vehicle. It should be noted that the passenger was holding two trays of food in his lap prior to the crash.

At impact, the passenger initiated a forward and slightly lateral trajectory in response to the 1 o'clock impact force and loaded the deployed front right passenger air bag and glove compartment door.

Loading of the glove compartment door resulted in a contusion just below the left knee as evidenced by the deformation documented to this component. He also sustained a fractured front upper tooth as a result of striking the food trays which were propelled up and forward from the impact force. Following the crash, the front right passenger exited the vehicle under his own power through the right door, and sat adjacent to the final rest position of the vehicle until police/rescue arrived within minutes. He was subsequently transported by ambulance to the emergency room of a local hospital for treatment and released.

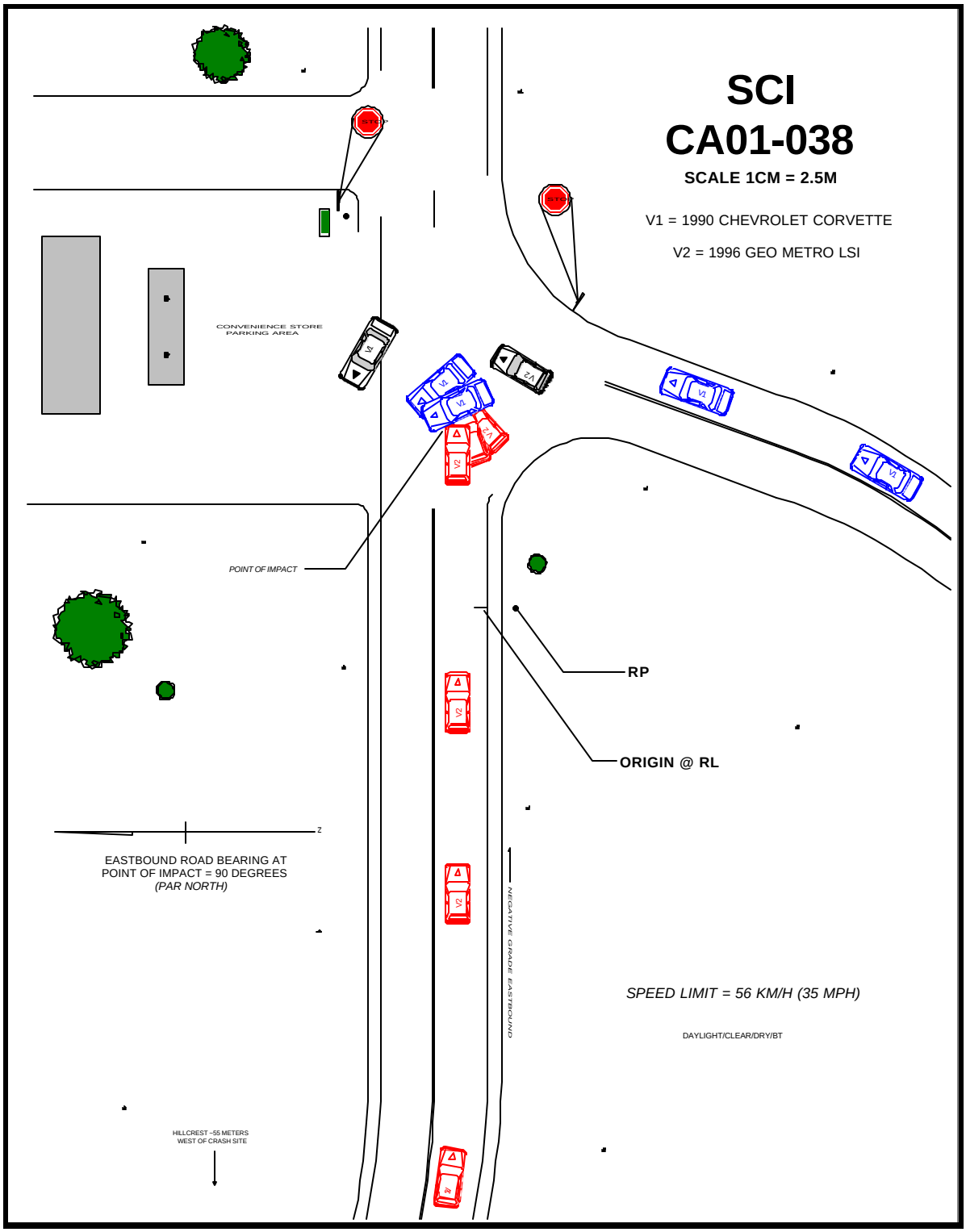

Figure 10. Scene Diagram.