

**TRANSPORTATION SCIENCES
CRASH RESEARCH SECTION**

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**VERIDIAN ON-SITE REDESIGNED AIR BAG DEPLOYMENT/
INFANT PASSENGER FATALITY INVESTIGATION**

VERIDIAN CASE NO. CA00-007

VEHICLE - 2000 CHEVROLET IMPALA

LOCATION - STATE OF NORTH CAROLINA

CRASH DATE - JANUARY, 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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16. <i>Abstract</i> This on-site investigation focused on the injury mechanisms that caused the death of a two month old infant female front right passenger of a 2000 Chevrolet Impala. The Chevrolet was equipped with redesigned frontal air bags for the driver and right passenger positions which deployed as a result of a frontal collision with a wooden utility pole. The male driver of the Chevrolet Impala was operating the vehicle northbound when he reportedly had fallen asleep and allowed the vehicle to depart the right (east) pavement edge. The vehicle's front wheels/tires made initial contact to the east barrier curb as the front left area impacted a wooden utility pole resulting in severe damage. The vehicle rotated counterclockwise and came to rest in close proximity to the pole facing northwest. The 36 year old male driver of the 2000 Chevrolet Impala was restrained by the available 3-point manual lap and shoulder belt system, seated in an upright posture with the seat track adjusted to the full rearward position. At impact with the pole, he initiated a forward trajectory in response to the 12 o'clock impact force and loaded the manual restraint and deployed redesigned driver air bag. Loading of the manual restraint resulted in contusions to the left neck, shoulder and chest. He also sustained a fractured right ankle from loading to the (intruded) toepan. The driver was transported to the emergency room of a local trauma center for treatment and released. The front right infant passenger was restrained in a rear-facing child safety seat which was installed improperly in a forward facing position (detachable base not used). As the vehicle struck the barrier curb, the child safety seat was probably set in motion by rotating forward. The pole impact further displaced the safety seat in a forward direction and into the path of the expanding redesigned passenger air bag. Her interaction with the expanding air bag resulted in a multitude of injuries which included a cervical spine fracture and cerebral subarachnoid hemorrhage. At this point, the infant rebounded rearward into the safety seat resulting in multiple (posterior) rib fractures. The infant passenger was transported to a local trauma center for treatment and expired within an hour of arrival.			
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**VERIDIAN ON-SITE REDESIGNED AIR BAG DEPLOYMENT/
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VERIDIAN CASE NO. CA00-007
VEHICLE - 2000 CHEVROLET IMPALA
LOCATION - STATE OF NORTH CAROLINA
CRASH DATE - JANUARY, 2000**

BACKGROUND

This on-site investigation focused on the injury mechanisms that caused the death of a two month old infant female front right passenger of a 2000 Chevrolet Impala. The Chevrolet was equipped with redesigned frontal air bags for the driver and right passenger positions which deployed as a result of a frontal collision with a wooden utility pole. The male driver of the Chevrolet Impala was operating the vehicle northbound when he reportedly had fallen asleep and allowed the vehicle to depart the right (east) pavement edge. The vehicle's front wheels/tires made initial contact to the east barrier curb as the front left area impacted a wooden utility pole resulting in severe damage. The vehicle rotated counterclockwise and came to rest in close proximity to the pole facing northwest.

The 36 year old male driver of the 2000 Chevrolet Impala was restrained by the available 3-point manual lap and shoulder belt system, seated in an upright posture with the seat track adjusted to the full rearward position. At impact with the pole, he initiated a forward trajectory in response to the 12 o'clock impact force and loaded the manual restraint and deployed redesigned driver air bag. Loading of the manual restraint resulted in contusions to the left neck, shoulder and chest. He also sustained a fractured right ankle from loading to the (intruded) toepan. The driver was transported to the emergency room of a local trauma center for treatment and released. The front right infant passenger was restrained in a rear-facing child safety seat which was installed improperly in a forward facing position (detachable base not used). As the vehicle struck the barrier curb, the child safety seat was probably set in motion by rotating forward. The pole impact further displaced the safety seat in a forward direction and into the path of the expanding redesigned passenger air bag. Her interaction with the expanding air bag resulted in a multitude of injuries which included a cervical spine fracture and cerebral subarachnoid hemorrhage. At this point, the infant rebounded rearward into the safety seat resulting in multiple (posterior) rib fractures. The infant passenger was transported to a local trauma center for treatment and expired within an hour of arrival.

The crash notification was provided to NHTSA by the North Carolina Highway Safety Office on Tuesday, February 22, 2000 and immediately assigned to the Veridian SCI team as an on-site investigative effort. The on-site investigator conducted the investigation on Wednesday, February 23, 2000.

SUMMARY

Crash Site

This single vehicle crash occurred during the afternoon hours of January, 2000. At the time of the crash, it was daylight with no adverse conditions as the roads were dry. The crash occurred off the east pavement edge of a six lane north/south (asphalt) roadway which curved left for northbound traffic (see

Figure 14 - page 9). The urban roadway was bordered by 4.5 cm (1.8 in) high barrier curbs, sidewalks and wooden utility poles located approximately 0.7 meters (2.3 feet) off the east pavement edge. The posted speed limit at the crash scene was 56 km/h (35 mph).

Pre-Crash

The 36 year old male driver of the 2000 Chevrolet Impala reported working two jobs and hadn't slept for 26 hours upon completion of his shift earlier that morning. He dropped the infant's mother off at the hairdresser and proceeded to work to pick up his paycheck. The driver alleged that the infant became irritable (while positioned in the child safety seat) in the rear right seat. He attempted to give the infant a pacifier and "almost struck another vehicle". He pulled into a parking lot and repositioned the child/infant carrier to the front right seat and placed the carrier in a forward facing position. The driver continued northbound (**Figures 1 & 2**) in the outboard lane of the six lane roadway at a (driver reported) speed of 48 km/h (30 mph) when he had fallen asleep and allowed the vehicle to depart the right (east) pavement edge in a forward tracking mode. There were no tire marks within the vehicle's trajectory indicative of driver avoidance maneuvers.



Figure 1. Northbound approach for the 2000 Chevrolet Impala.

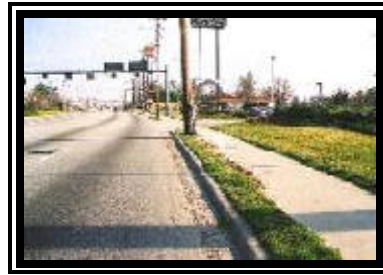


Figure 2. Northbound approach for the 2000 Chevrolet Impala.

Crash

As the Chevrolet exited the east pavement edge of the urban six lane roadway, the front wheels/tires made initial contact to the barrier curb. No rim damage was sustained which would necessitate assignment of another event. The vehicle's trajectory was not altered by the curb as it continued 11.8 meters (38.7 feet) to impact with the 32.0 cm (12.6 in) diameter wooden utility pole (**Figure 3**). The front left area impacted the pole resulting in severe damage, and deployed the Chevrolet's frontal air bag system. Although the impact was classified as out of scope (yielding object), the WinSMASH damage and trajectory algorithm computed an impact speed of 65.8 km/h (40.9 mph) with a (barrier equivalent) velocity change of 58.2 km/h (36.2 mph). The specific longitudinal component was -58.2 km/h (-36.2 mph). The undeformed end width and barrier option were utilized in the WinSMASH computations. The Chevrolet's Sensing and Diagnostic Module (SDM) recorded an impact speed of 83.7 km/h (52.0 mph) with an overall velocity change of 68.9 km/h (42.8 mph). Given the extent of damage to the vehicle, the WinSMASH program may have extrapolated past the range of accuracy; which may explain the variance between the program outputs and recorded vehicle data. During engagement, the pole fractured and was



Figure 3. West view of the struck pole.

displaced forward 30.5 cm (12.0 in). The vehicle rotated counterclockwise 58 degrees and came to rest in close proximity to the pole facing northwest.

Post-Crash

Following the crash, the driver of the Chevrolet (*climbed over the infant passenger and safety seat*) exited the vehicle through the right front door under his own power. The infant passenger was subsequently removed from the vehicle by a witness and placed on the ground (still in the child seat) adjacent to the final rest position of the vehicle until rescue personnel arrived on-scene within ten minutes of the crash. The witness reportedly told the driver that the infant was conscious and breathing. Treatment was rendered at the scene by fire department personnel and emergency medical technicians (EMTs). The driver was transported by ambulance to a the emergency room of local trauma center for treatment and released. The infant passenger was transported by ambulance to a local trauma center for treatment and expired within an hour of arrival. The Chevrolet was towed from the scene with disabling damage.

VEHICLE DATA

The 2000 Chevrolet Impala was identified by the vehicle identification number (VIN): 2G1WF55E7Y9 (production number deleted). This rental vehicle was acquired by the driver two days prior to the crash. The vehicle was a 4-door sedan equipped with front wheel drive and a 3.4 liter, V-6 engine. The Chevrolet was also equipped with power windows, door locks, steering and front disc/rear drum (ABS) brakes. At the time of the crash, the odometer had recorded approximately 29,772 km (18,500 miles). The seating was configured with front (split) and rear bench seats (with separate/folding backs). The rental company reported no previous crashes or maintenance on the Chevrolet's air bag system. No cell phone was present or in use at the time of the collision.

VEHICLE DAMAGE

Exterior

The Chevrolet Impala sustained severe frontal damage as a result of the impact with the wooden utility pole (**Figure 4**). The direct contact damage began 37.0 cm (14.6 in) to the right of the front left bumper corner and extended 32.0 cm (12.6 in) inboard. The impact deformed the full frontal width resulting in a combined direct and induced damage length (Field L) of 88.0 cm (34.6 in). Six crush measurements were documented at the level of the bumper: C1= 21.0 cm (8.3 in), C2= 76.0 cm (29.9 in), C3= 90.0 cm (35.4 in), C4= 94.0 cm (37.0 in), C5= 37.0 cm (14.6 in), C6= 0 cm. A maximum crush value of 101.0 cm (39.8 in) was documented 12.5 cm (4.9 in) inboard of the C3 position. The Collision Deformation Classification (CDC) for this impact to the Chevrolet was 12-FYEN-4 with a principal direction of force of 0 degrees. The left portion of the bumper fascia fractured and separated from the reinforcement bar during the collision sequence. Both headlamp assemblies detached from their respective mounts undamaged. The hood was deformed up and rearward from engagement against the pole. The left fender was deformed rearward which restricted the left front door opening and wheel/tire (not deflated). No wheel damage was found



Figure 4. Frontal damage to the 2000 Chevrolet Impala.

attributed to the initial curb contact. Reduction in the left side wheelbase measured 19.0 cm (7.5 in). Induced buckling was noted to the roof area at the left B-pillar. The windshield fractured from exterior impact forces and the interior front right air bag module cover flap.

Interior

Interior damage to the Chevrolet identified through the vehicle inspection was severe and was attributed to component intrusion and occupant contact (**Figures 5 & 6**). Multiple scuff marks and indentations were documented on the left knee bolster (rigid plastic type) and instrument panel area. Additional scuff marks and indentations were found on the left front door panel. The driver's seat cushion was heavily scrubbed and torn. Induced buckling of the floor displaced the driver's seat cushion upward 4.0 cm (1.6 in) and 15.0 cm (5.9 in) forward to an upright position. The rear-view mirror fractured and separated from the windshield. No column compression or loading to the steering wheel rim was identified (tilt column set to the full up position). Longitudinal intrusions into the front driver/passenger space included 29.0 cm (11.4 in) of left toepan intrusion, 16.0 cm (6.3 in) of right toepan intrusion, 11.0 cm (4.3 in) of left instrument panel intrusion, 16.0 cm (6.3 in) of center instrument panel intrusion and 6.0 cm (2.4 in) of right instrument panel intrusion.

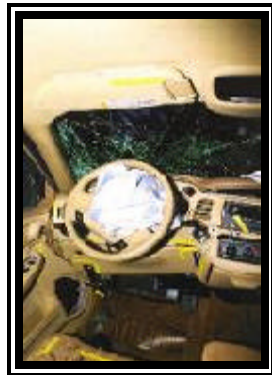


Figure 5. Interior view of the driver space.

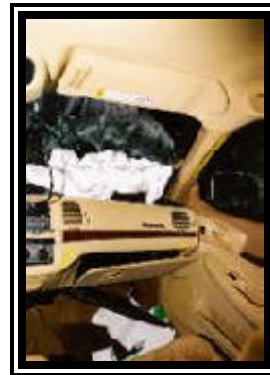


Figure 6. Interior view of the passenger space.

MANUAL RESTRAINT SYSTEMS

The interior of the Chevrolet consisted of a six passenger seating configuration with front (split) and rear bench seats (with separate/folding backs). The driver 3-point manual lap and shoulder belt system consisted of a continuous loop belt webbing with a semi-locking latchplate and dual mode retractors (inertial lock/belt sensitive). Loading evidence consisted of deep abrasions to the D-ring (**Figure 7**) and an associated transfer to the shoulder portion of the webbing (**Figure 8**) which measured 20.5 cm (8.1 in) in length. In addition, multiple "white" fabric transfers were identified to the belt webbing which was attributed to the driver's shirt. Stretched stitching was also noted at the lower attachment point of the front left restraint (no pretensioner/energy management loop present). The front right 3-point manual lap and shoulder belt system consisted of a continuous loop belt webbing with a semi-locking latchplate and retractors equipped with inertial and switchable lock mechanisms. Loading evidence consisted of plastic "shavings" embedded into the webbing which was attributed to the child safety seat (**Figure 9**). The rear seated positions were equipped with 3-point manual lap and shoulder belt systems which consisted of continuous loop belt webbings with semi-locking latchplates that retracted into dual mode locking retractors.

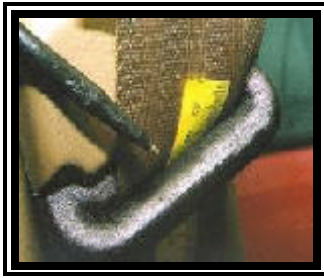


Figure 7. Abrading to the front left D-ring.



Figure 8. Loading mark to the front left restraint.



Figure 9. Loading transfers to the front right restraint.

CHILD SAFETY SEAT

The infant passenger of the 2000 Chevrolet Impala was positioned in a rear-facing child safety seat (RFCSS) in the front right seat of the vehicle. The child safety seat was manufactured by Century Products on 09/03/99 and was identified as a Smartfit Plus (**Figure 10**) with a model number of 4529MYT. The RFCSS consisted of a molded plastic shell with a folding carrying handle, fabric covered padding, and an integral 3-point harness system (**Figure 11**). A detachable base was provided with the RFCSS, however, this base was not in use at the time of the crash. Warning labels were affixed to the shell of the seat with additional warning labels found on the vehicle sunvisors and restraint systems. There was no residual damage to the RFCSS. The shell did not yield evidence of contact (i.e., abrasions, fracture sites); although the RFCSS *was* positioned within the deployment path of the front right air bag.



Figure 10. Century Smartfit Plus child safety seat.

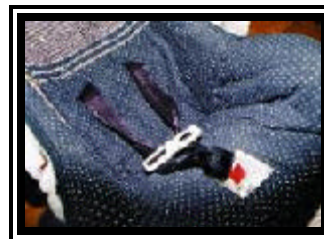


Figure 11. Child safety seat integral 3-point harness.

SUPPLEMENTAL RESTRAINT SYSTEMS

The Chevrolet Impala was equipped with redesigned frontal air bags for the driver and right passenger positions. The air bags deployed as a result of the crash. The driver air bag module was identified by the General Motors part number: *16824055-00* with a bar coded lot number of: *TRCA90087757*. The air bag was housed in the center of the steering wheel with a vertically oriented flap tear seam (I-configuration). The flaps were symmetrical in shape and measured 8.0 cm (3.1 in) in width and 11.0 cm (4.3 in) in height. Although no contact evidence was identified on the exterior surface of the module cover flaps, skin oil was documented to the lower right quadrant of the air bag along with eyelash strands to the upper (centered) section. The diameter of the driver air bag measured 64.0 cm (25.2 in) in its deflated state (**Figure 12**). The bag was tethered by four internal straps and vented by two ports located at the



Figure 12. 2000 Chevrolet Impala redesigned driver air bag.

11 o'clock and 1 o'clock sectors on the rear aspect of the air bag.



Figure 13. 2000 Chevrolet Impala redesigned passenger air bag.

The front right air bag module was identified by the General Motors part number: *10288227* with a bar coded lot number of: *AL822718168V0913*. The front right passenger air bag deployed from the right mid-instrument panel area with a module design recessed into the instrument panel. This configuration did not utilize a conventional flap as the instrument panel separated to allow the bag to expand. Although no contact evidence was identified on the exterior surface of the module cover flap, black vinyl transfers were noted to the right upper quadrant of the air bag from expansion within the module. The passenger air bag measured 37.0 cm (14.6 in) in width and 53.0 cm (20.9 in) in height in its deflated state (**Figure 13**). No contact

evidence was found on the air bag. The bag was tethered by two internal straps sewn to the top seam and vented by two ports located at the 10 o'clock and 2 o'clock sectors on the side aspect of the air bag.

DRIVER DEMOGRAPHICS

Age/Sex:	36 year old male
Height:	185 cm (73 in)
Weight:	119 kg (263 lb)
Seat Track Position:	Full rearward position
Manual Restraint Use:	3-point lap and shoulder belt system
Usage Source:	Vehicle inspection, police report
Eyewear:	None
Type of Medical Treatment:	Transported to the emergency room of a local trauma center and released

Driver Injuries

<i>Injury</i>	<i>Severity (AIS 90)</i>	<i>Injury Mechanism</i>
*Fracture right ankle	Moderate (852002.2,1)	Intruded toepan (<i>indirect</i>)
*Contusion left neck	Minor (390402.1,2)	Shoulder belt webbing
*Contusion left shoulder	Minor (790402.1,2)	Shoulder belt webbing
*Contusion chest (whole area)	Minor (490402.1,0)	Shoulder belt webbing
*Contusion right knee	Minor (890402.1,1)	Knee bolster

* Source - driver

Driver Kinematics

The 36 year old male driver of the 2000 Chevrolet Impala was restrained by the available 3-point manual lap and shoulder belt system, seated in an upright posture with the seat track adjusted to the full rearward position. Restraint usage was confirmed by the loading evidence documented on the 3-point manual lap and shoulder belt system. At impact with the pole, he initiated a forward trajectory in

response to the 12 o'clock impact force and loaded the manual restraint and deployed redesigned driver air bag. He also loaded the seat cushion as the buttocks slid forward resulting in the removal of fabric from the leading edge of the cushion. Loading of the manual restraint resulted in contusions of the left neck, shoulder and chest as evidenced by the D-ring abrading and associated loading marks identified on the shoulder belt webbing. Contact to the deployed driver air bag was confirmed by the skin oil and eyelashes found on the face of the air bag. He also sustained a contusion to the right knee from contact to the bolster, evidenced by the scuff marks and indentations documented to this component. His right foot loaded the (intruded) toepan which resulted in a fractured right ankle. Following the collision, the driver observed "smoke" (venting air bag gases) and quickly exited the vehicle through the right front door (*climbed over the infant passenger and RFCSS*). He was transported by ambulance to the emergency room of a local trauma center for treatment and released. The combination of restraint options provided additional protection against further contact to the steering wheel hub/rim, thus preventing serious injury or death.

FRONT RIGHT PASSENGER DEMOGRAPHICS

Age/Sex: 2 month old female
 Height: 56 cm (22 in)
 Weight: 7 kg (16 lb)
 Seat Track Position: Full rearward position
 Child Safety Seat Use: Century Smartfit Plus Model #4529MYT (*improper usage*)
 Manual Restraint Use: 3-point lap and shoulder belt system (*improper usage*)
 Usage Source: Vehicle inspection, driver interview
 Eyeware: None
 Type of Medical Treatment: Transported to a local trauma center (expired within an hour of arrival)

Front Right Passenger Injuries

<i>Injury</i>	<i>Severity (AIS 90)</i>	<i>Injury Mechanism</i>
*Cervical spine fracture with spinal cord laceration and instability between c1/c2 vertebrae	Maximum (640272.6,6)	Expanding front right air bag
*Cerebral subarachnoid hemorrhage (cerebral cortex, left frontoparietal lobe, right frontal lobe, left inferior/posterior temporal lobe)	Serious (140684.3,2)	Expanding front right air bag
*Bilateral posterior rib fractures (right #1-8 / left #2&3)	Serious (450230.3,3)	Child safety seat
*Bilateral lung contusions (w/ hemothorax)	Severe (441410.4,3)	Expanding front right air bag
*Diaphragm contusion	Moderate (440602.2,8)	Expanding front right air bag
*Liver laceration	Moderate (541820.2,1)	Expanding front right air bag
*Liver contusion	Moderate (541810.2,1)	Expanding front right air bag
*Bilateral back contusion	Minor (490402.1,3)	Child safety seat

* Source - autopsy report

Front Right Passenger Kinematics

The 2 month old infant female front right passenger of the 2000 Chevrolet Impala was positioned in a Century Smartfit Plus child safety seat (CSS). This child restraint was designed exclusively as a rear-facing restraint and was engineered with a detachable base. The driver elected not to use the base and allegedly secured the restraint shell with the vehicle's manual 3-point lap and shoulder belt system in the rear right seat. It should be noted that this restraint can be used with or without the detachable base. He further noted that the infant was restrained within the CSS by the integral 3-point harness system. The harness utilized a plastic harness positioning clip that should have been positioned at the level of the armpits. Furthermore, the integral harness should have been adjusted to fit the infant with no more than a finger's thickness of slack in the straps at the shoulder level. Although the adjustment of these features could not be verified during this follow-up investigation, the driver probably had these features adjusted incorrectly.

As the infant became irritable in the rear right seat, the driver repositioned the CSS in the front right seat of the vehicle. He placed the rear facing CSS in a forward facing position and routed the manual lap belt webbing through the appropriate loops in the shell of the CSS. Belt usage was confirmed by the plastic "shavings" embedded into the front right lap belt webbing. The shoulder belt webbing would have extended over the top of the restraint. The switchable locking retractor was not placed in the locking mode, therefore, the emergency locking retractor was required to secure the CSS. This mode does not secure the restraint properly during normal pre-crash vehicle operation. With the CSS placed in this position, the CSS would likely have rotated forward due to the contour of the shell and the attachment point of the vehicle's belt system.

The driver noted that the carrying handle was adjusted to an upright position while in the front right position of the Impala. This was incorrect as the handle should have been pivoted and locked over the top of the CSS shell. In this upright position, the handle posed a hazard to the safety of the child.

As the vehicle struck the barrier curb, the CSS was probably set in motion by rotating forward. The pole impact further displaced the CSS in a forward direction and into the path of the expanding redesigned passenger air bag. Due to the presumed loose fit of the CSS integral harness and the improper adjustment of the chest clip, the infant began to eject from the CSS into the path of the expanding front right air bag. Her interaction with the expanding air bag resulted in a multitude of internal injuries which included a cervical spine fracture and cerebral subarachnoid hemorrhage. Additional bag related trauma included a contusion of the diaphragm, laceration/contusion of the liver and bilateral contusions of the lungs.

The infant was accelerated into the shell of the CSS by bag expansion. She came to rest in the CSS. This trajectory resulted in multiple posterior rib fractures and an associated bilateral soft tissue contusion of the back. She was removed from the vehicle by a witness and placed on the ground (still in the child seat) adjacent to the final rest position of the vehicle until rescue personnel arrived on-scene within ten minutes of the crash. The driver reported no visible injury to the infant (conscious and breathing) as she was transported by ambulance to a local trauma center and expired within an hour of arrival. Given the improper placement and usage of the child safety seat, death or serious injury would have occurred in any deployment event.

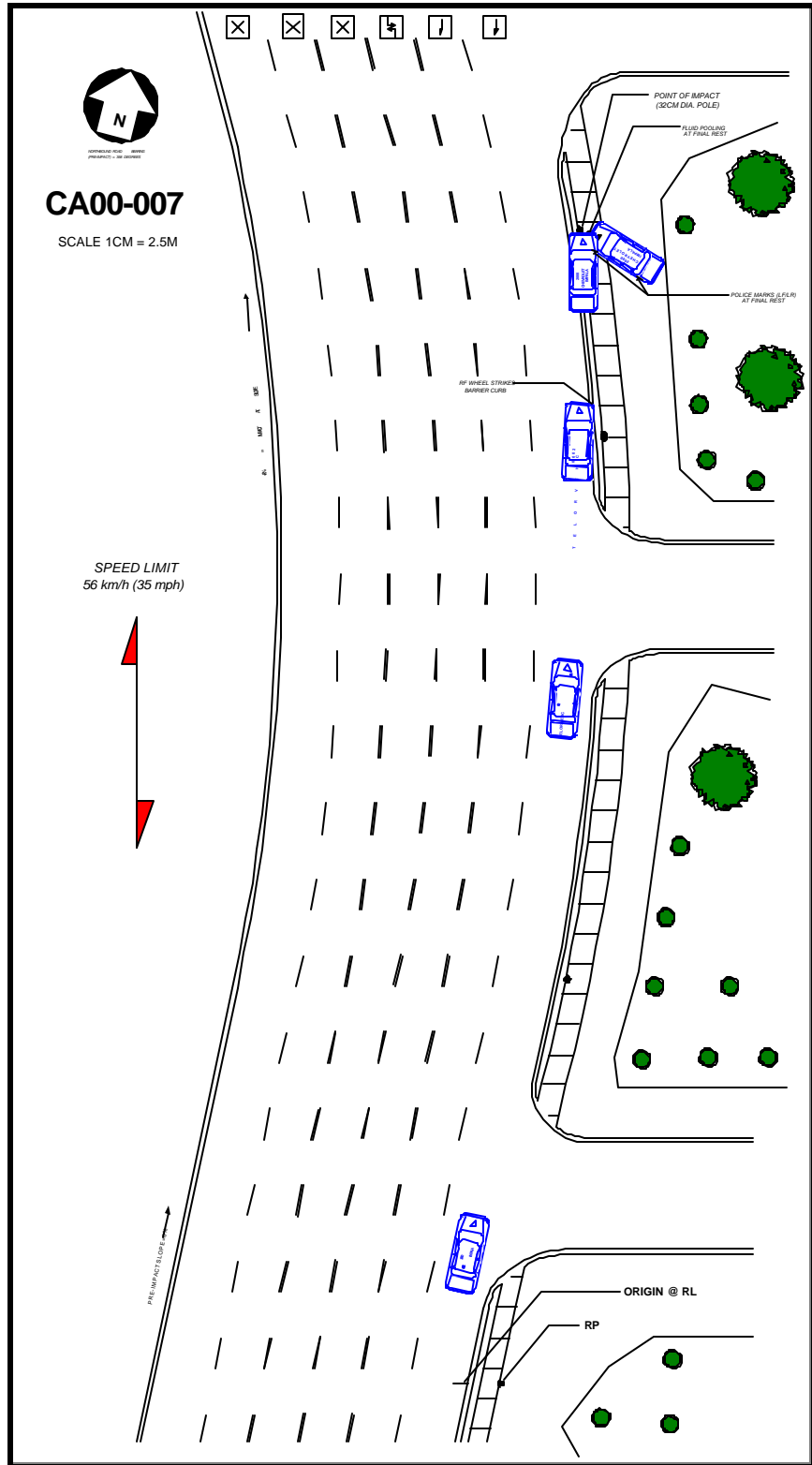


Figure 14. Scene Diagram