

CRASH DATA RESEARCH CENTER

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CALSPAN ON-SITE CERTIFIED ADVANCED 208-COMPLIANT VEHICLE

CRASH INVESTIGATION

SCI CASE NO: CA08006

VEHICLE: 2006 KIA SPECTRA

LOCATION: GEORGIA

CRASH DATE: JANUARY 2008

Contract No. DTNH22-07-C-00043

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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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TABLE OF CONTENTS

BACKGROUND 1

SUMMARY 2

CRASH SITE 2

VEHICLE DATA - 2006 KIA SPECTRA 2

CRASH SEQUENCE 3

PRE-CRASH 3

CRASH 3

POST-CRASH 3

VEHICLE DAMAGE 4

EXTERIOR 4

CERTIFIED ADVANCED 208-COMPLIANT FRONTAL AIR BAG SYSTEM 5

MANUAL SAFETY BELT SYSTEMS 6

OCCUPANT DEMOGRAPHICS/DATA 7

DRIVER 7

DRIVER INJURIES 7

DRIVER KINEMATICS 7

CHILD PASSENGER 8

CHILD PASSENGER INJURIES 9

CHILD PASSENGER KINEMATICS 9

SCENE SCHEMATIC 11

**CALSPAN ON-SITE CERTIFIED ADVANCED 208-COMPLIANT VEHICLE
CRASH INVESTIGATION
SCI CASE NO.: CA08006
VEHICLE: 2006 KIA SPECTRA
LOCATION: GEORGIA
CRASH DATE: JANUARY 2008**

BACKGROUND

This investigation focused on the Certified Advanced 208-Compliant (CAC) frontal air bag system, the fatal injury sources, and the cause of death for a 2-month-old female that was positioned on the lap of a restrained 20-year-old female driver in a 2006 Kia Spectra (**Figure 1**). The Kia was equipped with a Certified Advanced 208-Compliant (CAC) frontal air bag system that included safety belt pretensioners with buckle switches, seat track positioning sensors, and a front right occupant presence sensor. In addition to the frontal air bag system, the Kia was equipped with front seat back mounted side impact air bags and inflatable curtain (IC) air bags for the four outboard seating positions.



Figure 1. 2006 Kia Spectra.

The vehicle was involved in a run-off road collision with a utility pole. As a result of the crash, the driver's pretensioner actuated and the driver's frontal air bag deployed. The driver and child passenger, which was positioned on the lap of the driver and unrestrained, initiated a forward trajectory in response to the frontal crash forces and contacted the deploying driver's air bag. In addition to the contact, the driver loaded against the child passenger, which in turn resulted in the loading translating through the air bag and into the steering wheel rim and column. This loading severely deformed the steering wheel rim and resulted in the fatal injuries to the child passenger. The driver complained of knee and hand pain and was transported to a local hospital; however, the hospital did not have a record of treatment for the driver. Upon her release from the hospital, the driver was charged with various traffic and criminal violations and was arrested and transported to the County jail.

This crash was identified by the Crash Investigation Division (CID) of the National Highway Traffic Safety Administration (NHTSA) through an internet news search of potential cases of interest to the Special Crash Investigations (SCI) program. The article was forwarded to the Calspan SCI team for follow-up. Cooperation was established with the investigating police agency and permission to inspect the impounded Kia was obtained. An on-site investigation was assigned to the Calspan SCI team on February 1, 2008. The on-site aspects of this case were conducted on February 6 that included the inspection of the vehicle and the crash site.

SUMMARY

Crash Site

This off-road crash occurred on the northeast quadrant of a T-intersection during the early morning hours of January 2008. At the time of the crash, the weather conditions were cloudy and the road surface was dry. The light conditions were dark and the roadway was lighted by overhead luminaries. The east/west roadway was configured with four-lanes that were surfaced with asphalt and separated by double yellow center lines. The travel lanes were delineated by broken white lane lines. The roadway was bordered by a 1 m (3.3') asphalt shoulder on the north roadside and a 0.6 m (1.9') shoulder on the south roadside. A left curve with an uphill grade of 1.5 percent was present for the eastbound travel direction. Concrete curbs and sidewalks extended beyond the shoulders. A large 51 cm (20") diameter steel pole that supported high tension power lines was located 0.7 m (2.2') inboard of the north curb line. The posted speed limit for the east/west roadway was 56 km/h (35 mph). The north/south roadway consisted of two asphalt surfaced lanes that were bordered by concrete curbs. A schematic of the crash site is included in this report as **Figure 12**.

Vehicle Data - 2006 Kia Spectra

The vehicle in this crash was a 2006 Kia Spectra. A CARFAX vehicle history report was conducted on the Kia. This report revealed that the Kia was involved in a crash with another vehicle that resulted in serious frontal damage with frontal air bag deployment. The Kia was manufactured in 12/05 and was identified by Vehicle Identification Number (VIN): KNAFE121165 (production number deleted). The vehicle battery was expended at the time of the SCI inspection; therefore, the mileage of the Kia is unknown. The vehicle was a four-door sedan that was equipped with a 2.0-liter, I4 engine linked to a four-speed automatic transmission, front-wheel drive, and a center console mounted transmission shifter. The service brakes were hydraulic front and rear disc with an Antilock Braking System (ABS). The Kia was equipped with OEM steel wheels with plastic hub caps and P195/60R15 tires. The vehicle manufacturer recommended front and rear tire pressure was 207 kPa (30 PSI). The specific tire data at the time of the SCI inspection was as follows:

Position	Measured Tire Pressure	Measured Tread Depth	Damage
Left Front	338 kPa (49 PSI)	3 mm (4/32")	None
Left Rear	338 kPa (49 PSI)	7 mm (9/32")	None
Right Front	317 kPa (46 PSI)	0 mm (0/32")	None
Right Rear	Tire Flat	6 mm (8/32")	None

The interior of the Kia was equipped with cloth surfaced front bucket seats and a second row right-side-wide 60/40 split bench. The outboard seating positions were designed with height adjustable head restraints that were in the full-down positions at the time of the SCI inspection. The driver's seat was equipped with a synthetic two-piece aftermarket seat cover that covered the adjustable head restraint and the side air bag module. An aftermarket cover was positioned over the steering wheel rim.

Crash Sequence

Pre-Crash

The driver of the Kia was operating the vehicle eastbound on the east/west roadway in an unknown travel lane (**Figure 2**). The driver was operating the Kia with the 2-month-old female child passenger on her lap. A witness in a non-contact vehicle was traveling behind the Kia. As the driver of the Kia continued eastbound, she allowed the vehicle to drift to the left toward the southwest quadrant of the T-intersection. The witness stated that as the Kia approached the impending impact, the brake lights did not illuminate and the Kia was not traveling at a high rate of speed.



Figure 2. Pre-crash eastbound travel path of the Kia.

Crash

The Kia departed the northeast quadrant of the intersection. The left front tire mounted the barrier curb as the left front area engaged the 51 cm (20") diameter steel utility pole (**Figure 3**). The resultant direction of force was 12 o'clock. The impact speed was computed by the damage and trajectory algorithm of the WINSMASH program at 37.0 km/h (22.9 mph). The vehicle crushed to a depth of 55 cm (21.5") that resulted in a damage algorithm calculated total delta-V of 37.0 km/h (22.9 mph). The longitudinal and lateral components were -37.0 km/h (-22.9 mph) and 0 km/h respectively. Due to the offset left impact, the Kia rotated approximately five degrees counterclockwise and came to rest partially engaged against the struck pole.



Figure 3. Northeast view of impact with the utility pole and final rest location of the Kia.

This impact resulted in the actuation of the driver's safety belt pretensioner and the deployment of the driver's frontal air bag.

Post-Crash

Police and emergency medical personnel responded to the crash site. The 2-month-old female passenger was reportedly not breathing when the first responders arrived on-scene. She was transported to a local hospital where she was pronounced deceased approximately 40 minutes post-crash. The driver sustained injuries to her hand and knee and was transported to a hospital where she was treated and released. The SCI team contacted the hospital; however, the hospital did not have a record of treatment for the driver. The Kia sustained disabling damage and was towed from the crash site to the police impound yard where it was inspected for this SCI investigation.

Vehicle Damage

Exterior

The 2006 Kia Spectra sustained moderate severity frontal damage as result of the crash with the pole. The direct contact damage on the bumper fascia began 18 cm (7") right of the vehicle's center line and extended 48 cm (19") to the left. The maximum crush was located on the bumper beam 13 cm (5") left of the vehicle's centerline and was 55 cm (21.5") in depth. The impact deformed the front bumper system to a U-shape resulting in a combined induced and direct contact damage length (Field L) of 83 cm (32.5"). Six equidistant crush measurements were documented along the bumper beam of the vehicle and were as follows: C1 = 24 cm (9.3"), C2 = 49 cm (19.3"), C3 = 55 cm (21.5"), C4 = 38 cm (14.8"), C5 = 22 cm (8.8"), C6 = 0 cm. **Figures 4 and 5** are frontal and lateral views of the residual crush profile. The Collision Deformation Classification (CDC) for the pole impact was 12-FYEW-3. The crush was offset to the left which resulted in 5 cm (2") of compression of the left wheelbase and an elongation of the right wheelbase of 5 cm (2").



Figure 4. Overall view of the frontal crush of the Kia Spectra.



Figure 5. Lateral view of the crush to the frontal plane of the Kia Spectra.

All four doors remained closed during the crash and were operational post-crash. The laminated windshield was cracked vertically at the right aspect from the frontal deformation. An interior object impacted the windshield during the crash and produced two star-like fracture patterns. The door glazing was closed and intact and the backlight was not damaged.

Interior

The Kia sustained moderate interior damage from occupant contact and passenger compartment intrusion. The occupant contact points consisted of bending of the steering wheel rim from a combination of contact from the child reinforced by loading from the driver. The left aspect of the steering wheel rim was deformed forward 4 cm (1.6") with 8 cm (3.1") of bending at the bottom aspect (**Figure 6**). During this loading, the steering column was compressed 5 cm (2") and the steering wheel flange was deformed downward. The driver's left knee contacted the left aspect of the lower left instrument panel/knee bolster at the fuse box cover. This contact was evidenced by a 15 cm (6") denim fabric transfer, a fracture of the plastic panel, and separation the fuse box cover (**Figure 7**). The contact was located from 56 cm to 71 cm (22" to 28") left of the vehicle's centerline. A second area of contact was present on the right aspect of the knee

bolster from 11 cm to 23 cm (4" to 9") left of center. This contact fractured the adjacent mid instrument panel and contained a blue fabric transfer.



Figure 6. Lateral view of the bending to the lower steering wheel rim.



Figure 7. Knee contacts to the knee bolster/lower instrument panel.

Two star-like fractures were present on the right side of the windshield. These fractures were located 29 cm (11.4") and 30 cm (11.8") below the windshield header and 17 cm (6.7") and 14 cm (5.5") inboard of the right A-pillar. These fractures appeared to have occurred from an interior loose object. Also noted during the interior inspection, the gas pedal was missing from the pedal arm. This was probably dislodged from contact with the driver's right foot.

The passenger compartment space was reduced in volume by intrusion during the crash. These intrusions consisted of a 20 cm (7.9") reduction of the left toe pan and a 27 cm (10.6") of reduction of the right toe pan. These intrusions were in a rearward direction. The center floor area was displaced longitudinally rearward. This intrusion could not be measured due to the center stack placement aft of this location. The center floor intrusion resulted in the partial separation of the plastic trim panel surrounding the center instrument panel.

Certified Advanced 208-Compliant Frontal Air Bag System

The Kia Spectra was equipped with a Certified Advanced 208-Compliant (CAC) frontal air bag system that consisted of dual stage driver and front right passenger air bags, seat track positioning sensors, front seat retractor pretensioners, safety belt buckle switches and a front occupant presence detection (weight) sensor. The manufacturer of the Lexus has certified that this vehicle is compliant with the advanced air bag portion of the Federal Motor Vehicle Safety Standard (FMVSS) Number 208.



Figure 8. Deployed driver's CAC air bag.

As a result of the collision with the large diameter pole, the driver's frontal air bag system deployed. The air bag was conventionally mounted within the steering wheel hub and concealed by I-configuration cover flaps. The cover flaps measured 13 cm (5.1") in height. The left and right cover flaps measured 11 cm (4.3") and 6 cm (2.4") in width, respectively. The disparity in width measurements occurred due to the tear pattern of the cover flaps. At the center of the tear flaps was a circular shaped Kia logo. During the deployment, the logo remained attached to the left cover flap. The air bag membrane measured 56 cm (22") in diameter in its deflated state (**Figure 8**) and was vented by two ports located at the 11 and 1 o'clock positions on the rear panel of the air bag. Two wide-band tethers controlled the deployment excursion of the air bag. These tethers were vertically opposed at the 12 and 6 o'clock positions. The tethers were sewn to the face of the air bag membrane using a circular stitch pattern centered on the face of the membrane. The maximum rearward excursion documented at the center of the air bag membrane measured 32 cm (12.6").

The air bag membrane contained numerous areas of body fluid splatter and a black vinyl transfer. The body fluid transfers were located throughout the four quadrants and on the front and rear panels of the membrane. The heaviest concentration of body fluid was located on the left aspect of the membrane from the 11 o'clock sector to the 7 o'clock sector. These transfers varied in size from 2-12 cm (0.8-4.7"). Two spots of body fluid were noted on the face of the air bag membrane located near the center line above the tether stitching and at the 6 o'clock sector. The black transfer that also contained body fluid was present on the right aspect of the air bag membrane. This transfer measured approximately 17 cm (7") in height and 5 cm (2") in width. No apparent damage or malfunctions were present to the air bag components.

The front right seating position was not occupied during the crash; therefore the front right air bag was suppressed by the CAC system.

Side Impact Air Bag System

The Kia was equipped with seat back mounted side impact air bags for the front seating positions and IC air bags for the front and rear outboard seating positions. The side impact air bag system did not deploy in this crash.

Manual Safety Belt Systems

The Kia was equipped with manual three-point lap and shoulder belt systems for the five seat positions. All belt systems utilized continuous loop webbings with sliding latch plates. The driver's system retracted onto an Emergency Locking Retractor (ELR) and contained a retractor mounted pretensioner. The front right safety belt retracted onto a switchable ELR/Automatic Locking Retractor (ALR) and was equipped with a retractor mounted pretensioner. The rear safety belts were equipped with the switchable ELR/ALR.

As a result of the crash, the driver's retractor mounted safety belt pretensioner actuated locking the safety belt in the used position. The SCI inspection revealed 198 cm (77.9") of spooled out webbing on the driver's seat. During the crash, the driver loaded the safety belt system. Due to the driver loading, frictional abrasions occurred to the webbing as it spooled through the sliding latch plate. A distinct abrasion/loading pattern was present on the webbing from the contact with the latch plate which was located 102-117 cm (40-46.0") above the floor anchor. The movement

of the webbing resulted in full width frictional abrasions on the latch plate. The shoulder belt webbing was gathered at the D-ring from a combination of the actuation of the pretensioner and loading by the driver. Also present on the webbing was body fluid and dirt that was located on the lap belt portion of the safety system. **Figures 9 and 10** depict the driver's safety belt and loading evidence.

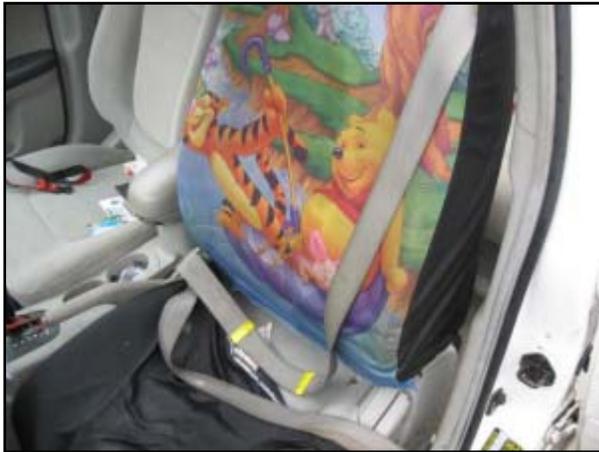


Figure 9. Driver's safety belt system.



Figure 10. Loading abrasions from the latch plate.

Occupant Demographics/Data

Driver

Age/Sex: 20-year-old/Female
 Height: 160 cm (63")
 Weight: 84 kg (185 lb)
 Seat Track Position: Mid-track position
 Eyewear: Unknown
 Manual Safety Belt Usage: 3-point lap and shoulder belt
 Usage Source: Vehicle inspection
 Egress from Vehicle: Unassisted through left door
 Mode of Transport from Scene: Transported by ambulance to a local hospital
 Type of Medical Treatment: Treated and released

Driver Injuries

Injury	Injury Severity AIS90/Update 98	Injury Source
Complaint of injury to the knee	Unknown	Knee bolster
Complaint of injury to a hand	Unknown	Unknown

Source – Police report

Driver Kinematics

The driver was seated in a mid track position with the seat back reclined to a measured angle of 15 degrees aft of vertical. She was restrained by the manual lap and should belt system. Belt

usage was supported by significant loading evidence on the webbing and hardware components. The driver was operating the vehicle with the 2-month old child positioned on her lap.

As a result of the frontal impact, the driver's frontal air bag deployed and the retractor pretensioner actuated. The driver initiated a forward trajectory in response to the frontal impact. She loaded the manual safety belt system. Her loading of the belt system produced frictional abrasions on the latch plate with abrasions and stretching of the belt webbing. Additionally, the shoulder belt webbing was gathered in the D-ring.

The driver's knees contacted the lower instrument panel/knee bolster. The knees fractured the lower panel with denim fabric transfers surrounding the contact areas. The extent of her injury is unknown.

During the driver's forward trajectory, she loaded the child passenger and compressed the child against the lower steering wheel rim. The steering wheel rim was deformed forward at the lower aspect. Additionally, the steering column was compressed and steering wheel flange was deformed. **Figure 11** is a lateral view of the driver position and loading of the steering wheel rim.



Figure 11. Lateral view of the driver's position and loading deformation of the steering wheel rim.

The driver complained of hand and knee pain and was transported to a local hospital where she was treated and released. Medical records for the driver were not available as the hospital did not have a record of treatment for her.

Child Passenger

Age/Sex:	2-month-old/Female
Height:	58 cm (22.8")
Weight:	5 kg (11 lbs)
Seat Track Position:	Mid track, positioned on lap of driver
Manual Safety Belt Usage:	None used
Usage Source:	Vehicle inspection
Egress from Vehicle:	Removed from vehicle by emergency responders
Mode of Transport from Scene:	Ground ambulance
Type of Medical Treatment:	Transported to a local hospital where she expired

Child Passenger Injuries

Injury	Injury Severity (AIS 90, Update 98)	Injury Source
Ruptured cauda equina with spinal column disruption at L4 and L5. Superior portion of the spinal column displaced anteriorly and inferior portion displaced posteriorly.	Severe (630636.4,8)	Steering wheel rim
Bilateral lung contusions in the areas of the spinal column fracture and the inferior tips with bilateral hemothorax that completely fill both chest cavities	Severe (441410.4,3)	Steering wheel rim
Non-displaced right mid-shaft femur fracture	Serious (851814.3,1)	Steering wheel rim
Extremely superficial small oval contusion on unknown parietal scalp 1-2 cm (0.4-0.8") area	Minor (190402.1,9)	Steering wheel rim (aftermarket cover)
Right lower back (near the level of the hips) a horizontal band of abrasions up to 1 cm (0.4") in width and extend for 10 cm (3.9") from left flank around to just past the mid-line	Minor (690202.1,8)	Air bag membrane

Source – Autopsy

Child Passenger Kinematics

The 2-month old child passenger was positioned on the lap of the belted driver with the seat adjusted to a mid track position. Based on the resultant injuries, it appears that the child was held in a cradle position with her head facing the left door panel. The driver may have been feeding the child prior to the crash. It was noted in the autopsy that the stomach contained 30 cc of curdled milk. In this position, her back was facing the steering wheel.

At impact, the driver's frontal air bag deployed. The expanding air bag contacted the back of the child passenger producing the abrasions on the lower back. The driver initiated a forward trajectory and loaded the child against the lower steering wheel rim. Deformation of the rim was noted to the lower aspect with compression of the column and bending of the steering wheel

flange. As a result the driver loading the child against the steering wheel rim, the 2-month-old female sustained the spinal column disruption at L4/L5, bilateral lung contusions, and the right mid-shaft femur fracture.

The child was transported to a local hospital where she expired approximately 40 minutes following the crash.

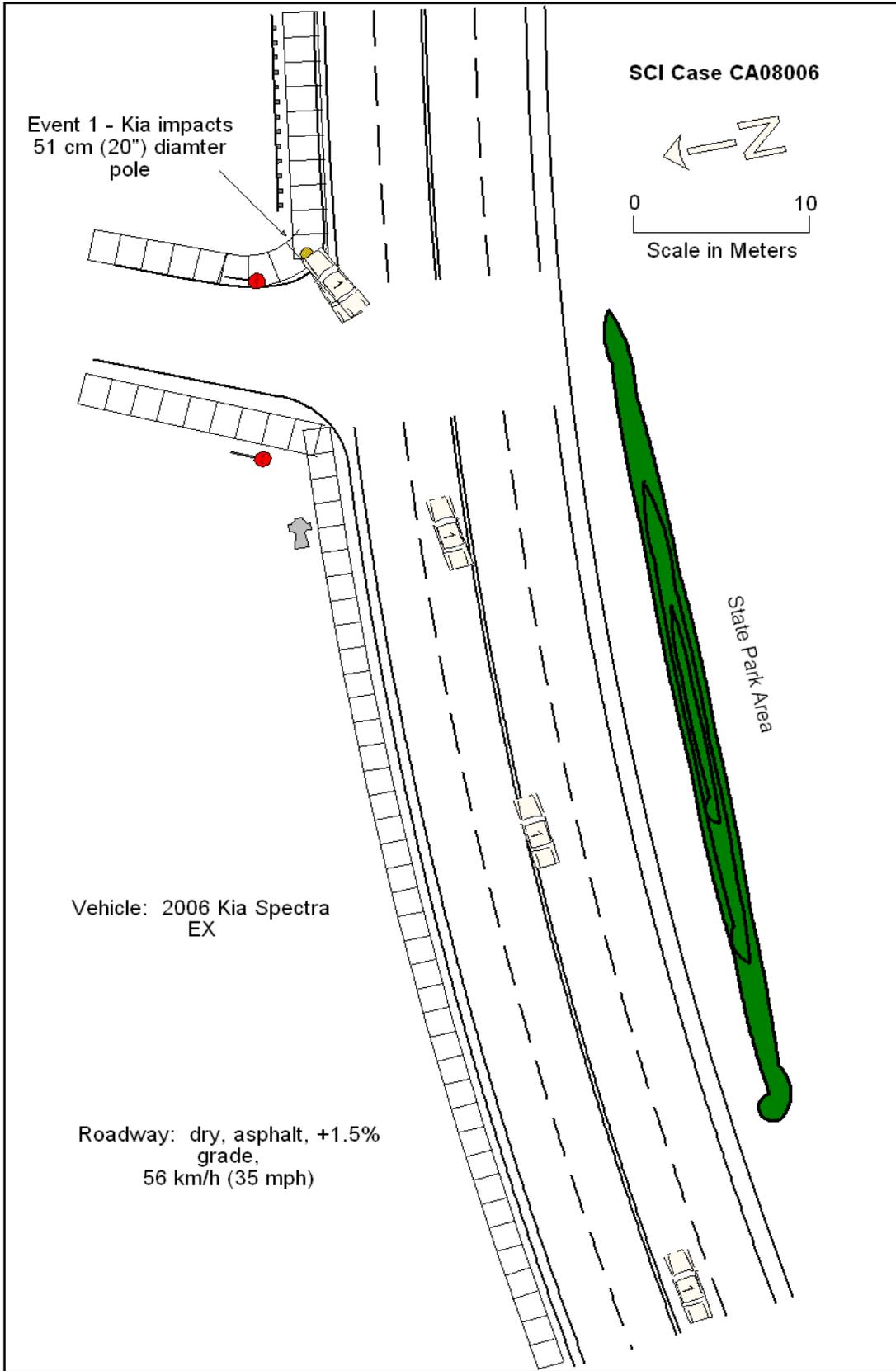


Figure 12: Scene Schematic