

**TRANSPORTATION SCIENCES
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ON-SITE AIR BAG NON-DEPLOYMENT/DRIVER FATALITY INVESTIGATION

CASE NO.: CA01-051

VEHICLE: 1999 KIA SEPHIA

LOCATION: GEORGIA

CRASH DATE: JUNE 2001

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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 be 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 of the involved vehicle(s) or their safety systems.

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<p>17. <i>Abstract</i></p> <p>This investigation focused on the non-deployment crash of a 1999 Kia Sephia that resulted in the death of the 48 year old female driver. The Kia was involved in an off-set frontal collision with a 1983 Cadillac Coupe DeVille. The vehicle's Supplemental Restraint System (SRS) consisted of redesigned driver and front passenger air bags that did not deploy as a result of the severe frontal impact. The driver of the Kia was restrained at the time of the crash by the manual belt system, however, she sustained severe blunt chest and abdominal injuries as a result of contact to the steering wheel rim and steering column loading. These injuries included: flail chest, pulmonary contusions, ruptured left diaphragm, ruptured jejunum and multiple orthopedic injuries. She expired 14 days post-crash due to a septic process (infection) that developed as a result of her injuries. Three restrained children (ages 5, 11, and 12) were also seated in the Kia. They were transported to a local hospital and reportedly treated for minor injuries. The driver of the Cadillac was transported to a local hospital with a police reported visible injury.</p>			
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**ON-SITE AIR BAG NON-DEPLOYMENT/DRIVER FATALITY INVESTIGATION
SCI1 CASE NO: CA01-051**

**VEHICLE: 1999 KIA SEPHIA
LOCATION: GEORGIA
CRASH DATE: JUNE 2001**

BACKGROUND

This investigation focused on the non-deployment crash of a 1999 Kia Sephia that resulted in the death of the 48 year old female driver. The Kia was involved in an off-set frontal collision with a 1983 Cadillac Coupe DeVille. The vehicle's Supplemental Restraint System (SRS) consisted of redesigned driver and front passenger air bags that did not deploy as a result of the severe frontal impact. The driver of the Kia was restrained at the time of the crash by the manual belt system, however, she sustained severe blunt chest and abdominal injuries as a result of contact to the steering wheel rim and steering column loading. These injuries included: flail chest, pulmonary contusions, ruptured left diaphragm, ruptured jejunum and multiple orthopedic injuries. She expired 14 days post-crash due to a septic process (infection) that developed as a result of her injuries. Three restrained children (ages 5, 11, and 12) were also seated in the Kia. They were transported to a local hospital and reportedly treated for minor injuries. The driver of the Cadillac was transported to a local hospital with a police reported visible injury.

The Crash Investigation Division of the National Highway Traffic Safety Administration (NHTSA) was informed of the June 2001 crash on December 3, 2001 via a FAX from the Georgia State Patrol. NHTSA subsequently assigned an investigation of the crash to the General Dynamics SCI team. Cooperation with an attorney representing the family of the deceased driver was established. The Kia was located in an insurance salvage yard and was available for inspection. The Cadillac was crushed prior to SCI involvement and was not inspected. The on-site portion of the investigation occurred during the week of March 4, 2002.

SUMMARY

Crash Site

This two-vehicle crash occurred during the afternoon hours of June 2001. At the time of the crash, it was daylight and the weather was not a factor. The road surface was dry. The crash occurred in the northbound lane of a two-lane north/south asphalt state route in a rural setting. The travel lanes were separated by a double yellow centerline and white fog lines bordered the outboard edges of the lanes. The northbound approach to the point of impact had a positive five percent grade and transitioned to a level grade approximately 23 m (75 ft) north of the impact point. The roadsides were bordered by 2.4 m (8.0 ft) wide unimproved earthen shoulders. The terrain on the east roadside, beyond the shoulder, sloped away from the road into a ditch and run-off area which paralleled the road. The 1 m (3 ft) deep ditch was centered 4.3 m (14.0 ft) from the road edge. The point of impact was evidenced by a series of gouge marks centered approximately 0.6 m (2.0 ft) inboard of the northbound fog line. The speed limit in the area of the crash was 89 km/h (55 mph). **Figures 1 and 2** are northbound and southbound trajectory views approaching the point of impact, respectively.



Figure 1: Northbound approach view.



Figure 2: Southbound approach view.

Crash Sequence

Pre-Crash

The 1999 Kia Sephia was northbound driven by a 48 year old restrained female. The Kia was also occupied by three restrained children whose reported ages were 5, 11, and 12. The children were seated in the front right, rear left and rear right, respectively. The 1983 Cadillac Deville was southbound driven by a 22 year old male. This driver was police reported as being restrained. The police investigation determined the Cadillac driver was alcohol impaired and driving with a suspended license at the time of the crash.

Immediately prior to the crash, the driver of the Cadillac relinquished directional control of the vehicle and allowed the Cadillac to cross the double yellow centerline into the northbound lane. The driver of the Kia responded to the Cadillac encroaching into her lane by steering clockwise (right) in an attempt to avoid the crash. No pre-crash tire/skid marks were identified during the police investigation

Crash

The crash occurred with the left frontal area of the Cadillac impacting the left frontal area of the Kia in an off-set head-on configuration. The south-eastbound momentum of the Cadillac reversed the Kia's northbound momentum and forced the vehicle onto the east shoulder. The delta V's calculated by the Missing Vehicle Algorithm of the WINSMASH model were 53.3 km/h (33.1 mph) and 38.6 km/h (24.0 mph) for the Kia and Cadillac, respectively.

The Kia rotated approximately 170 degrees counterclockwise and came to rest facing southwestward in the ditch and run-off area bordering



Figure 3: Look back view from the Kia's final rest to the POI.

the road. **Figure 3** is a look back view from the estimated final rest position of the Kia toward the point of impact. Its final rest location was an estimated 9.4 m (31.0 ft) southeast of the point of impact. The final rest location was estimated by a possible tire furrow in the ditch.

The Cadillac disengaged from the Kia with a counterclockwise rotation and came to rest in the northbound lane facing northeastward 51 m (167 ft) south of the impact. The post-crash tire marks and the final rest location of the vehicle were documented by the Georgia State Patrol. Portions of those marks remained visible and were documented during the SCI inspection. A schematic of the crash is attached at the end of this report, **Figure 16**.

Post-Crash

The police and ambulance personnel responded to the scene. The driver of the Kia had to be extricated from the vehicle. This process was reportedly extensive and involved removing the vehicle's roof. The EMS record indicated the driver was removed from the vehicle approximately 67 minutes post-crash. Reportedly she remained alert and conscious throughout the extrication with chief complains of shortness of breath and pain to her lower extremities. The Kia driver was transported to a regional trauma center via life-flight arriving 103 minutes post-crash. She was admitted and with severe blunt chest and abdominal trauma. These injuries included: flail chest, pulmonary contusions, ruptured left diaphragm, ruptured jejunum and multiple orthopedic injuries. The medical records indicated the driver underwent numerous successful medical procedures to repair those injuries and her condition initially stabilized. However, seven to ten days post-crash the driver developed a septic process and began to deteriorate. Medical intervention to control the sepsis was unsuccessful and the driver expired 14 days following the crash. The three restrained child passengers in the Kia and the driver of the Cadillac were transported to a local county hospital and treated for minor injuries.

1999 KIA SEPHIA

Figure 4 is a view of the vehicle upon initial inspection. It exhibited evidence of extensive extrication and had been exposed to the elements since the date of the crash. The 1999 Kia Sephia was identified by a Vehicle Identification Number (VIN): KNAFB1217X5 (production sequence deleted). The subject Kia was the base model. The four-door, front wheel drive sedan was equipped with a 1.8 liter, I4 engine linked to a 4-speed automatic transmission. The brakes were front disc/rear drum without ABS. The vehicle was reportedly purchased used by the driver from a local dealership. At the time of this purchase, the odometer had recorded approximately 63,915 km (39,716 miles). The odometer reading at the time of the inspection was 66,577 km (41,370 miles). The history of this vehicle prior to the subject driver's purchase was unknown.



Figure 4: Left front view of the Kia Sephia.

Exterior Damage

Figures 5 and 6 are front and left lateral views of the impact damage. The front plane of the Kia sustained 66 cm (26 in) of direct contact damage. The direct contact damage began 7.6 cm (3.0 in) left of center and extended to the left front bumper corner. The combined width of the direct and induced damage extended across the entire 137 cm (54 in) end width of the vehicle. The off-set frontal impact resulted in a left lateral end-shift that measured approximately 25 cm (10 in). The damage profile of the Kia was indicative of an underride. Therefore, the crush profile was documented at the bumper elevation and along the upper radiator support. The residual crush along the reinforcement bar was as follows: C1 = 72.0 cm (28.3 in), C2 = 39.0 cm (15.4 in), C3 = 24.0 cm (9.0 in), C4 = 3.0 cm (1.2 in). The crush profile measured along the upper radiator support was: C1 = 87.0 cm (34.3 in), C2 = 56.0 cm (22.0 in), C3 = 24.0 cm (9.4 in), C4 = 12.0 cm (4.7 in). An average of these documented profiles was used to assess the severity of the crash. The averaged profile used as the input to the WINSMASH model was as follows: C1 = 80.0 cm (31.5 in), C2 = 48.0 cm (18.9 in), C3 = 24.0 cm (9.4 in), C4 = 3.0 cm (1.2 in). The force of the impact separated the left front wheel and suspension from the vehicle. There was evidence of direct contact to the left front wheel rim. The hood buckled rearward and contacted the lower aspect of the windshield. The rake angle of the left A-pillar was nearly vertical and measured approximately 80 degrees. The roof, **Figure 7**, had buckled up and rearward over the driver's position. The left side direct contact damage extended rearward onto the mid aspect of the left door. The roof was removed by cutting all six pillars and the left door was forced opened during the driver's extrication. Sections of the windshield laminate were found lying about the vehicle's interior. The windshield was fractured in multiple locations from the exterior crash forces. The Collision Deformation Classification of the Kia was 12-FYEW-4.



Figure 5: Front view of the Kia.



Figure 6: Left lateral view.



Figure 7: View of roof and left A-pillar damage.

Interior Damage

Figure 8 is an overall interior view of the Kia. The driver's occupant space sustained moderate intrusion as a result of the exterior crash force. The intrusion of the left A-pillar and left corner of the instrument panel measured 32.0 cm (12.6 in) and 23.0 cm (9.0 in), respectively. The toe pan intrusion measured on the steering column center line was approximately 26 cm (10 in).

The left bolster exhibited evidence of contact and penetration from the driver's lower extremities, **Figure 9**. These contacts were located 10.9 cm (4.3 in) right and 12.7 cm (5.0 in) left of the steering column center line. The driver's foot wear was noted to be lying in the foot well.



Figure 8: Overall view interior view.



Figure 9: Knee bolster deformation.

The driver's seat was adjusted to a forward track position and could not be moved due to floorpan deformation. Its track position was an estimated 15 cm (6 in) forward of full rear. The driver's seat back adjustment was in the fully reclined position. It was reclined by the EMS during the driver's extrication. The right front seat was in a full rear track adjustment and was used to estimate the driver's seat track position.

The driver's chest and abdomen contacted and deformed the lower aspect of the steering wheel rim, **Figure 10**. The lower rim deformation measured 3.8 cm (1.5 in). There was complete separation of the column from the shear capsules. The deformed steering wheel rim and non-deployed driver air bag assembly was found on the driver seat. The steering shaft had fractured below the upper bearing, **Figure 11**, and separated from the column. **Figure 12** is a view of the end of the steering column and the upper bearing. The cause of this separation could not be determined. The separation may have occurred during extrication procedures or due to the exterior crash force coupled with the dynamic steering wheel rim loading by the driver.



Figure 10: View of the steering wheel rim deformation and non-deployed driver air bag.



Figure 11: Fractured steering shaft.

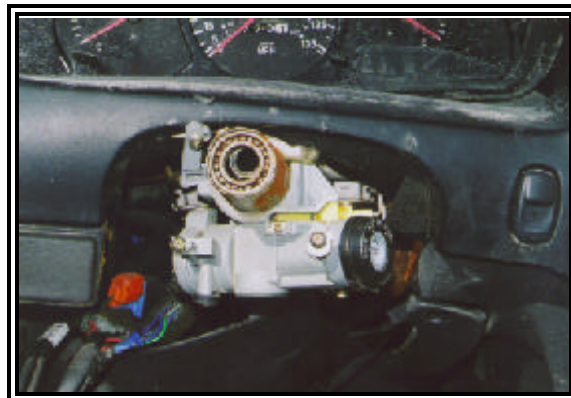


Figure 12: View of the end of the steering column and upper bearing.

Manual Restraint System

The four outboard seat belt systems in the Kia were 3-point lap and shoulder belts with continuous loop webbings and sliding latch plates. The rear center position was equipped with a lap belt. The front belt systems had adjustable D-rings and dual-mode emergency locking retractors located in the base of the B-pillars. The front right and both rear retractors were switchable retractors for use with a child safety seat.

The driver's seat belt webbing was cut during the extrication process. The webbing was cut, at an angle, 137.2 cm (54.3 in) above the outboard floor anchor. Refer to **Figure 13**. Using the stop button as a reference, this cut was located 79.3 cm (31.3 in) above button. The balance of the webbing had spooled back into the left retractor. Upon examination, the end of the spooled webbing was cut straight across. A section of the webbing (length unknown) apparently was cut out of the webbing for unknown reasons.

A crease in the driver's webbing was located 13 cm (5 in) above the stop button, **Figures 14 and 15**. The crease resulted from the driver loading to the webbing at the latch plate turning loop. The left D-ring was in the full up position. The friction surface exhibited a minor webbing transfer across its full width. The latch plate was located on the driver's seat cushion. Examination of the latch plate revealed evidence of historical use, however it should be noted, this evidence was more related to the historical use by the previous owner of the Kia. The deceased driver had only operated the vehicle approximately 2,662 km (1,654 miles). The plastic hardware of the turning loop revealed loading evidence related to the aforementioned webbing crease. The latch plate was inserted into the buckle and a positive latching occurred. The latch and buckle functioned as designed during the crash event. All evidence identified during the course of the inspection indicated the driver was restrained at the time of the crash.



Figure 13: View of the cut driver seat belt webbing.



Figure 14: View of the webbing crease.



Figure 15: Left overhead view of the driver's seat belt.

Examination of the front right, rear right, and rear left manual restraint systems identified evidence of the use during the crash. The use of the manual restraint systems probably benefitted those respective occupants and mitigated greater injury.

Supplemental Restraint System

The Supplemental Restraint System (SRS) in the Kia consisted of redesigned driver and front right passenger air bags. The air bags did not deploy as a result of the above-threshold crash. The driver air bag was located in the center hub of the four-spoke steering wheel rim. The front right passenger was a mid-mount design located in the right aspect of the instrument panel.

The examination of the non-deployed driver air bag module revealed all the wiring and electrical connectors were intact. There was no apparent damage to the module. The following manufacturer's labels identified the air bag module:

**K2A3 57 K00
S2ADAJZ8330310**

The following nomenclature identified the inflator:

**4IMN272L10245
?C06680101**

The design of the SRS consisted of the driver air bag module and clock spring, the front right passenger air bag module, an instrument cluster indicator lamp, associated wiring, and an Air Bag Diagnostic Unit (ADU). The ADU consisted of a processor, memory, auxiliary power supply, and the crash and safing

sensors. The ADU was located under the center electronic stack. The ADU performed a diagnostic test, assessing the integrity of the SRS system, upon each key-cycle, and also initiated the air bag deployment sequence upon crash recognition. The ADU was identified by the following manufacture's nomenclature:

0 K2AA 67 7F0A
Part # SAT-1200
Serial # S2EPAJYLAA0480

The ADU was attached to the vehicle by three 5 mm fasteners. The nuts were tight upon disassembly. A ground wire was attached to the forward left fastener and was corrosion free. The wiring harness appeared to be positively attached upon disassembly.

The root cause of the air bag non-deployment could not be determined based on the vehicle inspection. The subject ADU may have diagnostic trouble codes stored within its memory regarding the pre-crash state of the air bag system. It may be possible to read potential fault codes by installing this ADU into an undamaged exemplar vehicle and downloading the codes via a scan tool. The SCI team does not have the diagnostic software required to download or interpret these codes.

DRIVER DEMOGRAPHICS

Age/Sex: 48 year old/Female
 Height: 160 cm (63 in) (estimated by daughter)
 Weight: 82 kg (180 lb) (estimated by daughter)
 Restraint Use: Restrained by manual 3-point lap and shoulder belt
 Usage Source: SCI inspection, belt webbing cut by first responders
 Medical Outcome: Expired 14 days post-crash due to a septic process that developed during the course of her hospitalization

DRIVER INJURIES

<i>Injury</i>	<i>Injury Severity (AIS update 98)</i>	<i>Injury Mechanism</i>
Bilateral flail chest, multiple bilateral rib fractures extending from T4 to T9 level and fractures of posterior 11 th and 12 th rib with bilateral pulmonary contusions	Critical (450266.5,3)	Steering wheel rim/column loading
Left diaphragmatic rupture w/ herniation of the stomach	Severe (440606.4,8)	Steering wheel rim/column loading

Jejunum rupture	Severe (541426.4,8)	Lower steering wheel rim loading
Comminuted mid shaft fracture left ulna	Serious (753204.3,2)	Left instrument panel, possible
Comminuted mid shaft fracture left radius	Serious (752804.3,2)	Left instrument panel, possible
Hepatic lacerations, NFS	Moderate (541820.2,1)	Seat belt loading
Comminuted mid-shaft fracture left fibula	Moderate (851606.2,2)	Intrusion of the lower instrument panel
Non-displaced fracture of the right superior pubic rami	Moderate (852600.2,5)	Driver knee bolster loading, indirect
Open right patella fracture with 4.5 cm laceration	Moderate (852400.2,1) Minor (890602.1,1)	Driver knee bolster loading
Complicated large laceration left distal thigh and proximal leg	Minor (890600.1,2)	Intrusion of the lower instrument panel
3 cm laceration of the lower lip	Minor (290602.1,8)	Upper steering wheel rim, possible
Two lacerations eyebrow, NFS	Minor (290600.1,7)	Flying glass, possible
Multiple lacerations 2 to 3 cm in size left forearm	Minor (790600.1,2)	Left instrument panel, possible

Note: The above injuries were identified in the driver's emergency room records, radiology reports and discharge summary.

The medical records documented a septic process that developed approximately seven to ten days post-crash. The driver's condition rapidly declined due to the sepsis and medical intervention was unsuccessful. She died 14 days post-crash. The death certificate obtained from the driver's attorney listed the immediate cause of death as the "delayed effects of blunt force chest and abdominal injury". An autopsy was not performed.

DRIVER KINEMATICS

The restrained driver was seated in a presumed normal posture with her seat adjusted to a forward track position. Upon impact, the driver responded to the 12 o'clock direction of force by exhibiting a forward trajectory and loading her locked safety belt system. Coincident with this kinematic pattern, the exterior force of the crash caused the left interior components to intrude into the driver's occupant space.

The forward position and forward trajectory of the driver coupled with the intrusion of the interior caused the driver to contact and load the steering wheel rim and steering column with her chest and abdomen. The driver loaded through and displaced the steering column from the shear capsules and deformed the lower sector of the steering wheel rim. The rim/column loading resulted in the driver's bilateral flail chest and diaphragm rupture. The lower rim contacted resulted in a ruptured jejunum. The driver's inertial loading of the seat belt resulted in the hepatic lacerations. The driver's lower extremities contacted and penetrated the knee bolster. The bolster loading resulted in right patella fracture. That loading was transmitted through the right femur and indirectly caused the right pubic rami fracture. The intruding left lower instrument panel resulted in the fracture of the left fibula. The driver also sustained a fracture of the left forearm (radius and ulna). The forearm fracture possibly occurred due to contact with the left instrument panel.

CHILD PASSENGER DATA

The Kia Sephia was occupied by three restrained children with reported ages of 5, 11, and 12. These children were seated in the front right, rear left, and rear right, respectively. The height and weight of the children was unknown. Upon impact, the children exhibited forward trajectories in response to the 12 o'clock direction of the impact. The children contacted and loaded their respective manual restraint systems. The exact nature of their injuries is not known, however, those injuries were reportedly minor.

CRASH SCHEMATIC

