TRANSPORTATION SCIENCES
CRASH DATA RESEARCH CENTER

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VERIDIAN REMOTE KNEE BOLSTER AIR BAG DEPLOYMENT INVESTIGATION SCI TECHNICAL SUMMARY REPORT

NASS/SCI COMBO CASE NO. 00-41-152C

VEHICLE - 2000 KIA SPORTAGE

LOCATION - STATE OF FLORIDA

CRASH DATE - SEPTEMBER 2000

Contract No. DTNH22-94-D-07058

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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. *Abstract* This remote investigation focused on a two-vehicle intersection crash that involved a 2000 Kia Sportage that was equipped with redesigned frontal air bags for the driver and front right positions, and a knee bolster air bag for the driver position. The Sportage was involved in an intersection crash with a 1998 Ford E-Series van that initiated a left turn across the Sportage's path. The Sportage was occupied by a 32-year-old male driver and a 23-year-old female front right passenger. Both occupants were restrained by the 3-point manual lap and shoulder belt system. At impact, the redesigned frontal air bag system deployed and the knee bolster air bag deployed. The occupants initiated forward trajectories and loaded the manual restraints and the deployed air bags. The driver sustained seat belt-related chest abrasions and contusions. He also sustained facial abrasions from the driver's air bag. The driver's knees struck the knee bolster which was positioned in front of the knee bolster air bag which resulted in bilateral knee abrasions. He sustained left arm lacerations and abrasions from the interior hardware. The front right passenger sustained seat belt-related chest and abdomen contusions. She also sustained bilateral upper and lower extremity lacerations from flying glass. Both occupants were transported by ambulance to a regional trauma center where they were treated and released.			
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CRASH DATE - SEPTEMBER 2000

BACKGROUND

Figure 1. 2000 Kia Sportage

This remote investigation focused on a two-vehicle intersection crash that involved a 2000 Kia Sportage **(Figure 1)** that was equipped with redesigned frontal air bags for the driver and front right positions, and a knee bolster air bag for the driver position. The Sportage was involved in an intersection crash with a 1998 Ford E-Series van that initiated a left turn across the Sportage's path. The Sportage was occupied by a 32-year-old male driver and a 23-year-old female front right passenger. Both occupants were restrained by the 3-point manual lap and shoulder belt system. At impact, the redesigned frontal air bag system deployed and the knee bolster air bag deployed. The occupants initiated forward trajectories and loaded the manual restraints and the deployed air bags. The driver sustained seat belt-related chest abrasions and contusions. He also sustained facial abrasions from the driver's air bag. The driver's knees struck the knee bolster which was positioned in front of the knee bolster air bag which resulted in bilateral knee abrasions. He sustained left arm lacerations and abrasions from the interior hardware. The front right passenger sustained seat belt-related chest and abdomen contusions. She also sustained bilateral upper and lower extremity lacerations from flying glass. Both occupants were transported by ambulance to a regional trauma center where they were treated and released.

This crash was selected for investigation by the National Automotive Sampling System (NASS) as CDS case number 00–41-152C. The crash occurred in September 2000. Initial notification of this crash was made to the Veridian Special Crash Investigations team following a NASS CDS case review. The NASS PSU performed the vehicle inspection and scene inspection. The National Highway Transportation Safety Administration (NHTSA) assigned a case review and report preparation to the Veridian Special Crash Investigation (SCI) team on December 6, 2000.

SUMMARY

Crash Site

This two vehicle crash occurred at the intersection of a 4-lane north/south arterial roadway and a two-lane east/west residential roadway during the nighttime hours of September 2000. At the time of the crash, it was dark and the roadway was illuminated by overhead lighting. There were no adverse weather conditions as the asphalt road surface was dry. The north/south roadway was straight and level and consisted of two travel lanes in each direction and a center left-turn lane. The east/west roadway was straight and level and consisted of one travel lane in each direction separated by a double-yellow centerline. The north/south roadway was bordered by white fog lines on the outboard sides and by asphalt parking areas and concrete sidewalks on the west side. Traffic control at the intersection consisted of stop signs for east/west traffic. The posted speed limit for the north/south roadway was 56 km/h (35 mph). The roadside environment consisted of commercial buildings. The scene schematic is attached as **Figure 10** at the end of this report.

Pre-Crash

The driver of the Kia Sportage was operating the vehicle southbound on the outboard travel lane on approach to the four-leg intersection **(Figure 2)**. The front right passenger stated in an interview that the approximate pre-impact travel speed was 56 km/h (35 mph). The 1998 Ford Van was traveling northbound in the inboard lane on approach to the four-leg intersection. The van traveled into the center left-turn lane with the intent to turn left onto the east/west roadway **(Figure 3)**. The driver of the Ford van initiated a left turn across the path of the Kia Sportage. The driver of the van stated that he estimated his pre-impact travel speed to have been 56 km/h (35 mph). There were no skid marks in either vehicle's trajectory indicative of pre-crash braking. The front right passenger of the Kia Sportage stated that the driver of the Sportage did not attempt any avoidance maneuver prior to the crash.

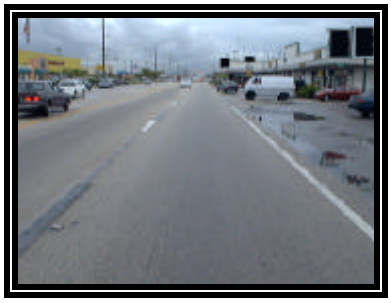

Figure 2. Southbound approach for the Kia Sportage

Figure 3. Northbound approach for the Ford van

Crash

As the Kia Sportage entered the intersection, the front area impacted the right front area of the Ford van. Impact resulted in moderate damage to the Sportage. The resultant direction of force was in the 11 o'clock sector for the Sportage. The damage algorithm of the WinSMASH program was used to calculate the Delta-V of the Sportage based on the crush profile that was documented by the NASS researcher. Since a vehicle inspection of the Ford van could not be obtained, the Missing Vehicle routine was used to compute a total velocity change of 29 km/h (18 mph) for the Sportage. The longitudinal and latitudinal aspects were -27 km/h (-17 mph) and 10 km/h (6 mph), respectively. The impact induced deceleration was sufficient to deploy the redesigned frontal air bag systems in both vehicles, and the knee bolster air bag in the Sportage. The Sportage was redirected to the right in a near tracking mode, and came to rest in the southwest corner of the intersection facing southwest.

The force of the impact and southward momentum of the Sportage caused the Ford van to be redirected in a southwest direction across the southwest quadrant of the intersection. It rotated a total of 180 degrees in a counterclockwise (CCW) direction to final rest in the outboard southbound lane facing southeast approximately 15 m (50') south of the point of impact. A post-impact tire mark from the Ford van was noted in the photographs by the NASS researcher.

Post-Crash

The occupants of the Kia Sportage were removed from the vehicle by rescue personnel. Both occupants of the Ford van exited the vehicle under their own power. The driver was transported to a regional trauma center by private vehicle and the front right passenger of the Sportage was transported by ambulance to a regional trauma center. They were both treated and released. The driver and passenger of the Ford van were transported to a regional trauma center and admitted overnight. Both vehicles were towed from the scene.

VEHICLE DATA - 2000 Kia Sportage

The 2000 Kia Sportage was identified by the Vehicle Identification Number (VIN): KNDJB7235Y5 (production sequence omitted). The vehicle was a 4-door compact sport utility vehicle equipped with a 2.2 liter, 4-cylinder engine, and rear wheel drive. At the time of the NASS vehicle inspection, the odometer read 214 km (133 miles). The seating was configured with front bucket seats with adjustable head restraints. The driver's seat was found to be upright and at the rear-most track position. The front right seat was found to be slightly reclined and between the mid and full-rear seat track positions. The second row consisted of a split bench seat with folding backs with integral head restraints for the outboard positions. Both front seat positions were equipped with 3-point manual lap and shoulder belts. The driver's adjustable D-ring was in the full-up position and the front right adjustable D-ring was in the mid-position. The outboard positions in the second row were equipped with 3-point manual lap and shoulder belts. The second row middle position was equipped with a lap belt. The Sportage was also equipped with a tilt steering column that was in the full-up position at the time of the NASS vehicle inspection.

VEHICLE DAMAGE

Exterior Damage - 2000 Kia Sportage

The 2000 Kia Sportage sustained moderate damage as a result of the impact with the van **(Figure 4)**. The direct damage began at the front left bumper corner and extended 98 cm (39") across the frontal plane. Direct damage was also noted on the leading edge of the hood at the left corner. The combined direct and induced damage measured 131 cm (52") across the entire frontal plane. The maximum crush was located at C1 and measured 27 cm (11"). The bumper beam was crushed rearward on the left side, and fractured at the front left corner. The bumper fascia and grille were separated from the vehicle. The radiator core and upper radiator support were crushed rearward. The front left fender was crushed rearward and displaced to the right. The

Figure 4. Frontal damage to the Kia Sportage

hood was significantly buckled on the left side, and displaced vertically on the right side. The left front wheel was deflated and restricted and the right rear wheel was deflated. Based on the post-crash measurements from the NASS researcher, the left wheelbase was shortened 13 cm (5") and the right wheelbase was shortened 7 cm (3"). The Collision Deformation Classification (CDC) for this event was 11-FDEW-2. Six crush measurements were taken by the NASS researcher at the level of the bumper beam and above the bumper and the average profile was as follows: C1= 27 cm (11"), C2 = 14 cm (6"), C3 = 16 cm (6"), C4 = 11 cm (4"), C5 = 0, C6 = 0.

Interior Damage - 2000 Kia Sportage

Interior damage to the 2000 Kia Sportage was moderate and attributed to occupant contact. The NASS researcher documented 17 cm (7") of integrity loss at the top aspect of the left front door. The windshield was fractured from impact forces and occupant contact and the left front door glazing was disintegrated from impact forces. The remaining glazing did not sustain damage. The rearview mirror was separated from the windshield glazing. The plastic cover around the steering column was fractured. The padded knee bolster was deformed from occupant contact, and lower left instrument panel was scuffed and cracked. The foot controls were bent. The center instrument panel and below was cracked and abraded from occupant contact. The glove box door opened as a result of the crash and was abraded from occupant contact. The left door interior surface was deformed and abraded from occupant contact. The NASS researcher did not document any intrusions.

Figure 5. View of interior damage to the Kia Sportage

REDESIGNED FRONTAL AIR BAG SYSTEM - *2000 Kia Sportage*

The 2000 Kia Sportage was equipped with redesigned air bags for the driver and front right passenger positions that deployed as a result of the impact with the Ford van. The driver's air bag was housed in the center of the steering wheel with asymmetrical module cover flaps **(Figure 6)**. Both the top and bottom flaps measured 16 cm (6") in width. The height of the top and bottom flaps were 7 cm (3") and 6cm (2"), respectively. The driver's air bag measured 54 cm (21") in diameter in its deflated state. The air bag was not tethered and was vented by two ports located at the 10 and 2 o'clock positions. Blood was noted on the front aspect of the air bag and on the top rear aspect of the air bag. A black transfer, most likely a vinyl transfer from the module cover flap, was identified by the NASS researcher on the right side aspect of the air bag.

Figure 6. Driver's redesigned air bag

The redesigned front right passenger's air bag deployed from the mid-instrument panel area with a single cover flap design hinged at the top aspect **(Figure 7)**. The module cover flap was rectangular in shape and measured 12 cm (5") in height and 24 cm (9") in width. The redesigned front right passenger's air bag measured 70 cm (28") in height and 58 cm (23") in width in its deflated state. The air bag was not tethered. The NASS researcher identified blood and a single unknown circular black transfer on the frontal surface of the front right passenger's air bag. Probable vinyl transfers were noted on the top rear aspect of the air bag.

Figure 7. Front right passenger's redesigned air bag

KNEE BOLSTER AIR BAG SYSTEM - ***2000 Kia Sportage***

The Sportage was also equipped with a knee bolster air bag for the driver's position **(Figure 8)**. The knee bolster air bag deployed from behind the bolster panel as a result of the frontal collision. The plastic knee bolster was rectangular in shape. The top edge of the bolster was contoured to fit around the bottom aspect of the steering column. The height of the bolster measured 28 cm (11") and the overall width measured 30 cm (12"). Two holes on each side which measured 2 cm (1") in diameter were located 7 cm (3") vertically from the top aspect of the bolster and spaced vertically 10 cm (4") apart. The knee bolster air bag measured 30 cm (12") in height and 48 cm (19") in width. The NASS researcher documented a puncture in the rear right quadrant of the air bag membrane **(Figure 9)**. This puncture was a result of the compression of the air bag between the driver's knees and the bolt on the mounting bracket for the air bag module.

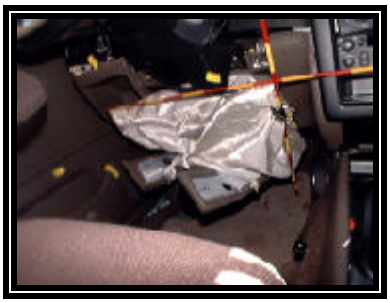

Figure 8. Kia Sportage knee bolster air bag

Figure 9. Puncture damage to the right rear aspect of the knee bolster air bag

OCCUPANT DEMOGRAPHICS - 2000 Kia Sportage

Driver

Age/Sex:	32-year-old male
Height:	183 cm (72")
Weight:	86 kg (190 lb)
Seat Track Position:	Full rear
Manual Restraint Use:	3-point lap and shoulder belt
Usage Source:	Vehicle inspection, injury data
Eyewear:	None
Type of Medical Treatment:	Transported by private vehicle to a regional trauma center and treated and released

Driver Injuries

Injury	Injury Severity (AIS 90)	Injury Mechanisms
Multiple superficial lacerations on left elbow	Minor (790602.1,2)	Left side interior door surface
Contusion to the left aspect of the chest	Minor (490402.1,2)	Shoulder belt webbing
Bilateral knee abrasions	Minor (890202.1,3)	Knee bolster
Multiple abrasions on left elbow	Minor (790202.1,2)	Left side interior door surface
Abrasion to the left aspect of the chest	Minor (490202.1,2)	Shoulder belt webbing
Left eyelid abrasion	Minor (297202.1,2)	Driver's air bag membrane
Left facial abrasion	Minor (290202.1,2)	Driver's air bag membrane

*Injury source: Emergency Room records, NASS interview with front right passenger

Driver Kinematics

The 32-year-old male driver of the 2000 Kia Sportage was presumed to be seated in an upright posture with the seat track adjusted to the full-rear position. The seat back was positioned in an upright orientation prior to the crash and retained its pre-impact position. The driver was restrained by the manual 3-point lap and shoulder belt system. The NASS interview data indicates that he had both hands on the steering wheel prior to the crash. At impact, the redesigned frontal air bag system and the driver's knee bolster air bag deployed. A fracture on the lower left aspect of the windshield suggested a possible fling-type hand strike attributed to the driver's air bag expansion against the left arm. Although this contact was documented, there were no soft tissue injuries to support this contact. The driver initiated a forward trajectory and loaded the manual restraint and the knee bolster. He sustained a contusion to the left aspect of the chest and an abrasion to the left aspect of the chest from loading the shoulder belt webbing. He also sustained bilateral knee abrasions from loading the knee bolster and the knee bolster air bag. The driver loaded the deployed driver's air bag. The contact with the driver's air bag membrane resulted in a left eyelid abrasion and a left facial abrasion. The driver also contacted the left interior door surface with his left arm/elbow which resulted in multiple superficial lacerations and abrasions to the left elbow. The NASS researcher also documented a head contact on the driver's sun visor evidenced by hair. Considering the height of the driver, it was uncertain if he struck the visor with his head. The driver was removed from the vehicle by rescue personnel, and transported by private vehicle to a regional trauma center. He was treated and released.

Front Right Passenger

Age/Sex:	23-year-old female
Height:	173 cm (68")
Weight:	66 kg (146 lb)
Seat Track Position:	Between mid track and full rear positions
Manual Restraint Use:	3-point lap and shoulder belt
Usage Source:	Vehicle inspection, injury data
Eyewear:	None
Type of Medical Treatment:	Transported by ambulance to a regional trauma center and treated and released

Front Right Passenger Injuries

Injury	Injury Severity (AIS 90)	Injury Mechanisms
Left chest contusion	Minor (490402.1,2)	Shoulder belt webbing
Left abdomen contusion	Minor (590402.1,2)	Lap belt webbing
Multiple superficial lacerations bilateral arms	Minor (790602.1,3)	Flying glass from left front door
Multiple superficial lacerations bilateral legs	Minor (890602.1,3)	Flying glass from left front door

*Injury source: Emergency Room records, interviewee

Front Right Passenger Kinematics

The 23-year-old female front right passenger of the 2000 Kia Sportage was presumed to have been seated in an upright posture with the seat track adjusted between the mid-track and full rear positions. The seat back was slightly reclined and retained its pre-impact position. The front right passenger was restrained by the manual 3-point lap and shoulder belt system. At impact, the redesigned frontal air bag system deployed and the front right passenger initiated a forward trajectory. She loaded the manual restraint and sustained a left chest contusion and a left abdomen contusion from the shoulder and lap portions of the webbing. The specific location of the left chest contusion was not identified in the NASS interview, however, the interviewee noted that the contusions were seat belt related. She contacted the deployed redesigned front right passenger's air bag which mitigated contact with the instrument panel. Based on the interview with the front right passenger, flying glass from the left front door glazing resulted in multiple superficial lacerations on both arms and both legs. She was removed from the vehicle by rescue personnel and transported by ambulance to a regional trauma center. She was treated and released.

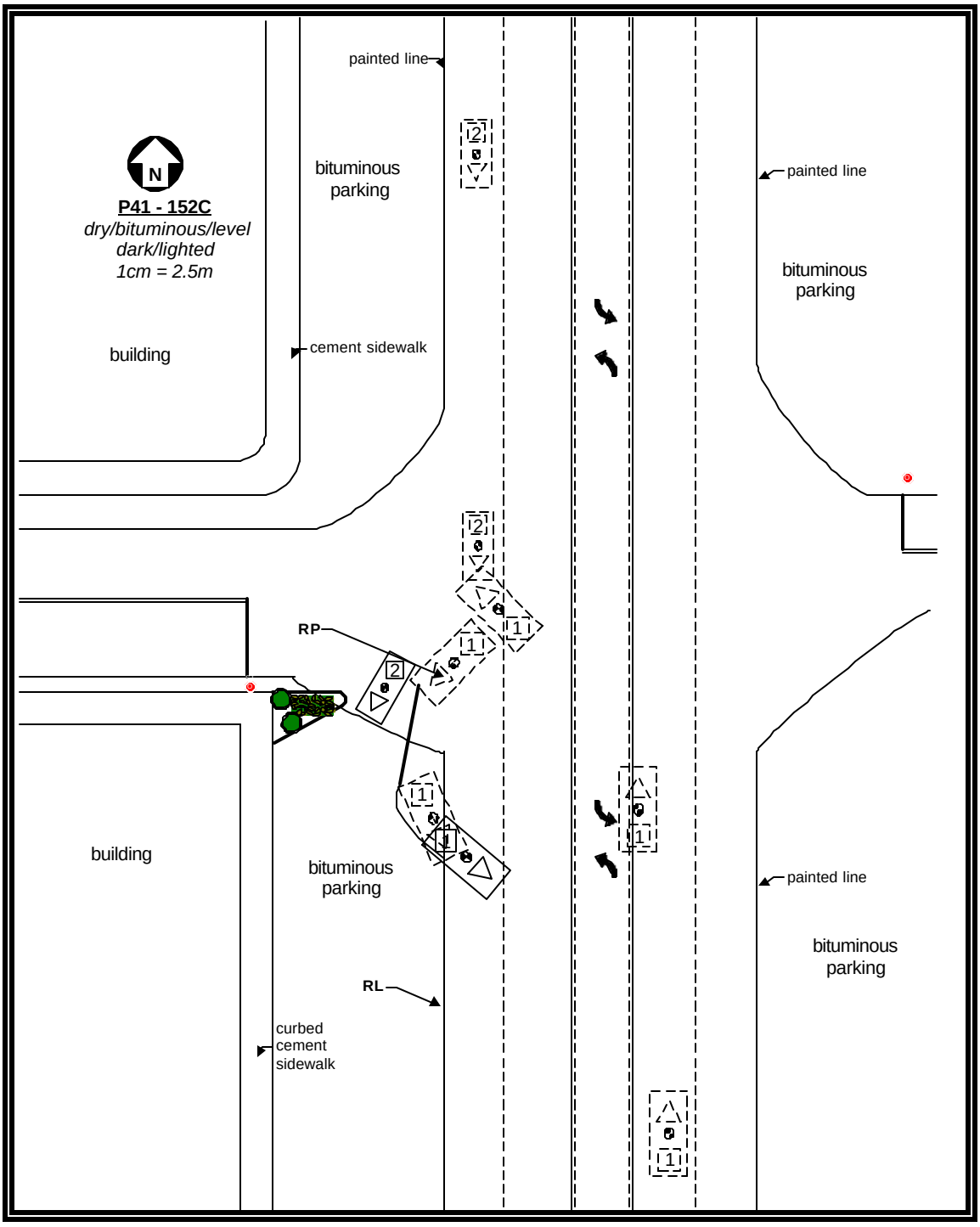

Figure 10. NASS scene schematic