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ON-SITE SIDE IMPACT INFLATABLE OCCUPANT PROTECTION INVESTIGATION

CASE NUMBER - IN07020 LOCATION - TEXAS VEHICLE - 2006 HYUNDAI ACCENT CRASH DATE - May 2007

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

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16.	Abstract This report covers an on- involved a 2006 Hyundai intersection crash. This cra back-mounted side impact a male) sustained a police re Hyundai was stopped for a turn lane. The Jeep was tra The Hyundai's driver pro- intersection. The left side Hyundai's left side curtain a Both vehicles came to fina by his manual lap-and-show laceration due to contact w hospital where he was treat	site side impact inflatable occ Accent and a 1998 Jeep Che ash is of special interest because in bags, side curtain air bags, an ported B (non-incapacitating) is traffic signal at a four-leg, urbu- veling south in the center throug ceeded into the intersection to of the Hyundai was impacted be air bag and driver's seat back-me l rest within the intersection. The der safety belt. He sustained a with his side curtain air bag and ted and released.	cupant protection investigation that prokee, which were involved in an the Hyundai was equipped with seat ad the Hyundai's driver (53-year-old, injury as a result of the crash. The an intersection facing east in the left gh lane approaching the intersection. to turn left as the Jeep entered the by the front of the Jeep, causing the ounted side impact air bag to deploy. The Hyundai's driver was restrained in upper left arm abrasion and mouth was transported by ambulance to a				
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BACKGROUND

This crash was brought to the National Highway Traffic Safety Administration's attention on or before June 26, 2007 by the sampling activities of the National Automotive Sampling System. This crash involved a 2006 Hyundai Accent and a 1998 Jeep Cherokee Sport. The crash occurred in May, 2007, at 11:17 a.m., in Texas and was investigated by the applicable city police department. This crash is of special interest because the Hyundai was equipped with seat backmounted side impact air bags, side curtain air bags, and the Hyundai's driver (53-year-old male) sustained a police reported B (non-incapacitating) injury as a result of the crash. This contractor inspected the scene and vehicles on July 16-17, 2007 and interviewed the Hyundai's driver on July 20, 2007. This report is based on the police crash report, scene and vehicle inspections, an interview with the Hyundai's driver, the Hyundai driver's medical records, occupant kinematic principles, and this contractor's evaluation of the evidence.

SUMMARY

The Hyundai was stopped for a traffic signal at a four-leg, urban intersection facing east in the left turn lane. The Jeep was traveling south in the center through lane approaching the intersection. The Hyundai's driver proceeded into the intersection to turn left as the Jeep entered the intersection. The Hyundai's driver made no avoidance actions. The Jeep's driver locked her brakes in an attempt to avoid the crash. The left side of the Hyundai was impacted by the front of the Jeep, causing the Hyundai's left side curtain and driver's seat back-mounted side impact air bag to deploy. The Hyundai rotated counterclockwise, traveled southeast, and came to final rest in the intersection facing northeast. The Jeep rotated counterclockwise, traveled southeast and came to rest in the intersection facing southeast. At the time of the crash the light condition was daylight, the atmospheric condition was clear, and the roadway pavement was dry, level concrete.

The Collision Deformation Classification (CDC) for the Hyundai was determined to be: **09-LPEW-2** (**280** degrees). The WinSMASH reconstruction program, missing vehicle algorithm calculated the Hyundai's Total, Longitudinal, and Lateral Delta V as: 22 km/h (13.7 mph), -3.8 km/h (-2.4 mph), and 21.7 km/h (13.5 mph), respectively. The collision fit the reconstruction model and the results were borderline. The Hyundai was towed due to damage.

The WinSMASH reconstruction program, missing vehicle algorithm calculated the Jeep's Total, Longitudinal, and Lateral Delta V as: 17 km/h (10.6 mph), -16.7 km/h (-10.4 mph), and 3.0 km/h (1.9 mph), respectively. The collision fit the reconstruction model and the results were borderline. The Jeep was driven from the crash scene.

The Hyundai's driver was restrained by the manual lap-and-shoulder safety belt. He sustained a left upper arm abrasion and mouth laceration due to contact with the side curtain air bag and was transported by ambulance to a hospital where he was treated and released. He received no follow-up treatment and lost one work day as a result of the crash.

CRASH CIRCUMSTANCES

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Crash Environment: The trafficway on which the Hyundai was traveling was a seven-lane, divided, city street, traversing in an east-west direction. The Hyundai's driver was stopped on the western leg of a four-leg intersection. On the western leg of the intersection, the eastbound roadway had two through lanes, a left turn lane and a right turn lane. The westbound roadway had three through lanes. The trafficway was divided by a raised concrete median. Each lane was approximately 3.6 meters (12 feet) in width. Roadway markings consisted of "bots dots" designating each lane, and there was a designated pedestrian crossing at the intersection. The trafficway on which the Jeep was traveling was an eight-lane, divided, city street, traversing in a north-south direction, and the Jeep was traveling south approaching the same four-leg intersection. On the northern leg of the intersection, the southbound roadway had three through lanes, a left turn lane, and a right turn lane. The northbound roadway had three through lanes. The trafficway was divided by a raised concrete median. Each lane was approximately 3.6 meters $(\sim 12 \text{ feet})$ in width. Roadway markings consisted of "bots dots" designating each lane, and there was a designated pedestrian crossing at the intersection. The intersection was controlled by threephase traffic signals. At the time of the crash the light condition was daylight, the atmospheric condition was clear, and the roadway pavement was dry, level concrete. Traffic density was

moderate, and the site of the crash was a combination of commercial and industrial. See the Crash Diagram at end of this report.

Pre-Crash: The Hyundai was stopped for the traffic signal facing east in the left turn lane (Figure 1). The driver intended to accelerate into the intersection and turn left. The Jeep was traveling south in the center through lane (Figure 2), and the driver intended to continue south through the intersection. The police report indicated that the Hyundai's driver proceeded into the intersection to execute the left turn when the traffic signal turned green. The police crash report indicated that the Jeep entered the intersection as his traffic signal turned red. The Hyundai's driver indicated that he saw the Jeep just prior to the crash and did not have time to take any avoidance actions. The Jeep's driver locked her brakes in an attempt to avoid the crash. The crash occurred in the four-leg intersection of the two trafficways (Figure 1).

Crash: The left side of the Hyundai (**Figure 3**) was impacted by the front of the Jeep, causing the Hyundai's left side curtain air bag and driver's seat back-mounted side impact air bag to deploy. The Hyundai rotated counterclockwise, traveled



Figure 1: Overview of Hyundai's approach into the intersection from the left turn lane; the Hyundai was stopped in the left turn lane; arrow shows area of impact in the intersection



Figure 2: Overview of approach of Jeep southbound in the left through lane (arrow)

Crash Circumstances (Continued)

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southeast, and came to final rest in the intersection facing northeast. The Jeep rotated counterclockwise, traveled southeast and came to rest in the intersection facing southeast.

Post-Crash: The Hyundai's driver exited the vehicle through the right front door with some assistance from passers-by. Police and emergency medical personnel responded to the scene and the driver was transported to a hospital by ambulance. The Hyundai was towed from the scene due to damage. The Jeep was driven from the scene.



Figure 3: Left side damage to Hyundai from impact with front of the Jeep

CASE VEHICLE

The 2006 Hyundai Accent GLS was a front wheel drive, four-door sedan (VIN: KMHCN46C36U-----) equipped with four wheel, anti-lock brakes with electronic brake force distribution. The Hyundai was also equipped with driver and front right passenger seat back-mounted side impact air bags, right and left side curtain air bags protecting all outboard seating positions, advanced dual stage driver and front right passenger frontal air bags, driver and front right passenger adjustable head restraints, and manual lap-and-shoulder safety belts with adjustable upper anchors, buckle-mounted pretensioners and load limiters. Furthermore, there was an occupant weight sensor for the front right passenger seating position. The back seating row was equipped with lap-and-shoulder safety belts and Lower Anchors and Tethers for Children (LATCH) for securing child safety seats. The supplemental restraint (air bag) system in the Hyundai is certified by the manufacturer to be compliant to the Advanced Air Bag portion of the Federal Motor Vehicle Safety Standard (FMVSS) No. 208.

The seat back-mounted side impact air bags and side curtain air bags are designed to deploy in a side impact crash when an impact of sufficient severity is detected by a side impact sensor. The side impact sensor is located on each side of the vehicle on the floorboard below the B-pillar.

CASE VEHICLE DAMAGE

Exterior Damage: The Hyundai's contact with the Jeep involved the left side. The left front and left rear doors sustained direct damage and were crushed inward. The direct damage began 43 centimeters (16.9 inches) rear of the left front axle and extended 156 centimeters (61.4 inches) rearward along the left side. The residual maximum crush was measured as 18 centimeters (7.1 inches) occurring at C₄ (**Figure 4**). The table below shows the Hyundai's left side crush profile.



Figure 4: Top view of crush to left side of Hyundai from impact with front of the Jeep

		Direct Damage									Direct	Field L
Units	Event	Width CDC	Max Crush	Field L	C ₁	C ₂	C ₃	C_4	C ₅	C ₆	±D	±D
cm	- 1	156	18	193	0	8	6	18	12	0	4	-1
in		61.4	7.1	76.0	0.0	3.2	2.4	7.1	4.7	0.0	1.6	-0.4

The Hyundai's left side wheelbase was extended 1 centimeter (0.4 inch) while the right side wheelbase was extended 2 centimeters (0.8 inch). Induced damage involved the left fender and left quarter panel.

Damage Classification: Based on the vehicle inspection, the CDC for the Hyundai was determined to be: **09-LPEW-2** (**280** degrees). The WinSMASH reconstruction program, missing vehicle algorithm was used to reconstruct the Hyundai's Delta V. The Total, Longitudinal, and Lateral Delta V were: 22 km/h (13.7 mph), -3.8 km/h (-2.4 mph), and 21.7 km/h (13.5 mph), respectively. The collision fit the reconstruction model and the results were borderline.

The Hyundai manufacturer's recommended tire size was: P185/65R14, and the vehicle was equipped with tires of this size. The Hyundai's tire data are shown in the table below.

Tire	Meas Pres.	ured sure	Vehi Manufac Recomn Press	cle cturer's nended sure	Tread Depth		Damage	Restricted	Deflated
	kPa	psi	kPa	psi	milli- meters	32 nd of an inch			
LF	200	29	207	30	6	8	None	No	No
LR	193	28	207	30	8	10	None	No	No
RR	193	28	207	30	7	9	None	No	No
RF	193	28	207	30	7	9	None	No	No

Vehicle Interior: Inspection of the Hyundai's interior revealed several small blood spots on the inboard side of the driver's seat back-mounted side impact air bag. A scuff mark was also noted on the left front door arm rest (**Figure 5**). There was no evidence of contact to the steering wheel and no indication of compression of the energy absorbing steering column. The left front door and the left B-pillar intruded 7 centimeters (2.8 inches) and 2 centimeters (0.8 inch), respectively into the driver's occupant space.

AUTOMATIC RESTRAINT SYSTEM

The Hyundai's driver air bag was located within the steering wheel hub and the front right passenger's air bag was located in the top of the instrument panel. Neither of the air bags deployed as a result of the Hyundai's left side impact with the front of the Jeep, and the bucklemounted pretensioners did not actuate.

The left side curtain air bag was located along the left roof side rail, inside the head liner and extended along the roof side rail from the left A-pillar to the left C-pillar (Figures 6 and 7). The air bag inflation cylinder was located in the left C-pillar. The side curtain air bag was 130 centimeters (51.2 inches) in length and 40 centimeters (15.7 inches) in height at its maximum height adjacent to the left front seat position (Figure 6). The remainder of the side curtain air bag was 28 centimeters (11 inches) in height (Figure 7). The air bag was tethered to the A and C-pillars by a rope tether. The air bag was designed with a large inflation chamber adjacent to the left front seat position and a smaller inflation chamber adjacent to the back left seat position. Inspection of the air bag revealed three small cuts on the front portion of the air bag. These cuts were possibly caused by flying tempered glass fragments from the left front window, which disintegrated due to the left side impact. The remainder of the side curtain air bag was unremarkable and sustained no damage during the deployment.

The driver's seat back-mounted side impact air bag was located in the left side of the driver's seat back. It deployed through a tear seam in the side of the seat back. The seat back-mounted side impact air bag was rectangular in shape, measuring 14 centimeters (5.5 inches) in width and 37 centimeters (14.6 inches) in height (**Figure 8**). Several small blood spots were observed on





Figure 5: Overview of Hyundai driver's seat position; arrow shows location of occupant contact scuff on left front door arm rest



Figure 6: Front portion of Hyundai's left side curtain air bag



Figure 7: Rear portion of Hyundai's left side curtain air bag

the inboard portion of this air bag. Otherwise, the air bag was unremarkable and sustained no damage due to the deployment.

CASE VEHICLE DRIVER KINEMATICS

The Hyundai's driver [53-year-old, male; [180 centimeters and 98 kilograms (71 inches, 215 pounds)] stated during the interview that prior to the crash he was seated in an upright posture with his back against the seat back. He had his left foot on the floor, right foot on the accelerator, and his hands on the steering wheel at the 3 and 9 clock positions. The seat track was located between the middle and rearmost positions, the seat back was slightly reclined, and the tilt steering column was located in its full up position. The driver was wearing glasses at the time of the crash.

The driver stated that he was restrained by the lap-and-shoulder safety belt. Inspection of the safety belt assembly revealed evidence of historical usage but no load mark evidence was observed.

The Hyundai's driver made no pre-crash avoidance maneuvers. As a result, his pre-impact body position did not change prior to the impact. The impact with the Jeep displaced the driver



impact air bag

primarily to the left opposite the Hyundai's 280 degree direction of principal force. The driver's left thigh impacted the left front door armrest causing a large contusion that extended from his hip to above his left knee. Even though there was no contact evidence, the side curtain air bag probably contacted his left upper arm and the left side of his face causing a severe abrasion to the arm and a laceration to the inside of his mouth. In addition, flying glass from the disintegrated left front window probably contacted and lacerated his left arm. The driver remained restrained in his seat as the Hyundai came to final rest.

CASE VEHICLE DRIVER INJURIES

The driver sustained several minor injuries and was treated and released from the emergency room. The table below lists the driver's injuries and injury sources. The driver reported that he received no follow-up treatment and lost one work day as a result of the crash.

Injury Number	Injury Description (including Aspect)	NASS In- jury Code & AIS 90	Injury Source	Source Confi- dence	Source of Injury Data
1	Laceration {cut} on inside of mouth, not further specified	minor 243099.1,8	Air bag, driver's side curtain	Probable	Interviewee (relative)

Case Vehicle Driver Injuries (Continued)

Injury Number	Injury Description (including Aspect)	NASS In- jury Code & AIS 90	Injury Source	Source Confi- dence	Source of Injury Data
2	Abrasion, severe, left upper arm, posterior surface, not further specified	minor 790202.1,2	Air bag, driver's side curtain	Probable	Emergency room records
3	Laceration left arm, not further specified	minor 790600.1,2	Noncontact injury: flying glass, left front glazing	Probable	Emergency room records
4	Contusion {bruising}, severe, left lateral thigh from hip to above left knee	minor 890402.1,2	Left side interior hardware and/or armrest	Certain	Interviewee (relative)

OTHER VEHICLE

The 1998 Jeep Cherokee Sport was a rear wheel drive, four-door sport utility vehicle (VIN: 1J4FT68S4WL-----) and was equipped with driver and front right passenger air bags, which the police crash report indicated did not deploy. Four-wheel, anti-lock brakes were optional for this vehicle, but it is not known if it was so equipped.

Exterior Damage: There were no available photographs of the Jeep. As a result, a CDC could not be estimated for damage to the Jeep. The WinSMASH reconstruction program, missing vehicle algorithm was used to reconstruct the Jeep's Delta V for its front impact with the left side of the Hyundai. The Total, Longitudinal, and Lateral Delta V were: 17 km/h (10.6 mph), -16.7 km/h (-10.4 mph), and 3.0 km/h (1.9 mph), respectively. The collision fit the reconstruction model and the results were borderline.

Jeep's Occupants: The police crash report indicated that the Jeep's driver (32-year-old, female) was restrained by her lap-and-shoulder safety belt. The driver was not transported by ambulance to a hospital, and did not sustain any police reported injuries as a result of this crash.

CRASH DIAGRAM

