TRANSPORTATION RESEARCH GROUP
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REMOTE FATAL AIR BAG DEPLOYMENT INVESTIGATION

CASE NO. CA99-44

1997 HYUNDAI ACCENT GS
1996 HONDA CIVIC LX

LOCATION - STATE OF PENNSYLVANIA

CRASH DATE - DECEMBER, 1997

Contract No. DTNH22-94-D-07058

Prepared for:

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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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15. *Supplementary Notes*
Remote investigation of a front to side crash which deployed the air bag system resulting in fatal injuries to a 2 year old male.

16. *Abstract*

This two vehicle crash involved a 1997 Hyundai Accent GS and a 1996 Honda Civic LX which collided in a front to side impact configuration. The Honda was traveling eastbound on a two lane local roadway when it attempted to make an illegal right turn at a four leg intersection across the path of the Hyundai which was also traveling eastbound on an adjacent parallel exit ramp. The intersection was controlled by traffic control lights which were green prior to the crash. Signs posted at the intersection restricted travel to straight through travel with turns prohibited.

The 31 year old male driver of the Hyundai observed the presence of the Honda just prior to the crash and applied full brakes. The front of the Hyundai struck the right side plane of Honda resulting in light to moderate damage to both vehicles. The dual front air bags in the Hyundai deployed during the crash sequence.

An unrestrained 2 year old male front right occupant in the Hyundai moved forward during pre-impact braking and appeared to be in close proximity to the air bag at the time of the supplemental restraint system actuation. The boy's head experienced a tension/hyperextension motion from the expanding air bag which resulted in separation/transection of the spinal column and spinal cord (AIS-6), cerebellar brain swelling, and swelling of the brain stem (AIS-5), and left parietal hemorrhage (AIS-4). The air bag contacted the child's chest and abdominal area which resulted in contusions and hemothorax of both lungs (AIS-4) and lacerations of the spleen (AIS-2). He was subsequently propelled in an angular rearward direction where his right shoulder contacted the front right window glazing resulting in a fracture of the right humerus (AIS-2) and separation of the acromion-clavicular joint (AIS-2). He continued rearward where he contacted the front right seat back support resulting in multiple fractures of the right posterior ribs (AIS-3).

The crash occurred in the vicinity of a trauma hospital where the child was taken and pronounced deceased 24 minutes after the police reported time of the crash.

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Front Right Air Bag Related Child Fatality
State of Pennsylvania
December, 1997

BACKGROUND

Veridian Engineering (formerly Calspan Operations of Veridian) was notified of a two vehicle crash involving a 1997 Hyundai Accent GS and a 1996 Honda Civic LX by the Crash Investigation Division (CID) of the National Highway Traffic Safety Administration (NHTSA) in the month of September, 1999. The crash notification originated with the NHTSA's Office of Defects Investigations (ODI) as the result of ODI's request for crash information from Hyundai. The Veridian Engineering investigation team was requested to conduct a remote investigation to determine the relationship between the Hyundai's air bag deployment sequence and the fatal injuries sustained by the two year old male seated in the front right seat. Based on this investigation and our experience, the low severity of this crash in relation to the high injury outcome to the front right occupant indicated the air bag deployment energy was transmitted to the occupant.

SUMMARY

This two vehicle crash involved a 1997 Hyundai Accent GS and a 1996 Honda Civic LX which occurred in the State of Pennsylvania during the mid afternoon hours in the month of December, 1997. The Honda was traveling eastbound on a two lane local roadway when it attempted to make an illegal right turn at a four leg intersection across the path of the Hyundai which was also traveling eastbound on an adjacent parallel exit ramp **(Figure 3)**. The intersection was controlled by traffic control lights which were green prior to the crash. Signs posted at the intersection restricted travel to straight through travel with turns prohibited **(Figure 1)**.

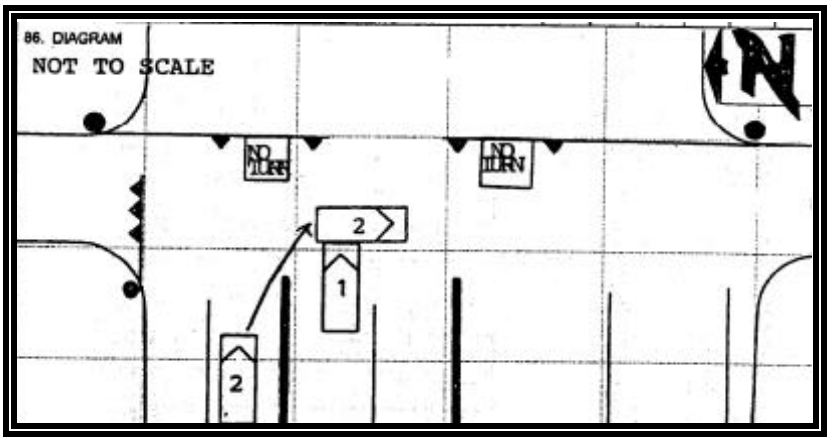

Figure 1: Police diagram of the crash

The 31 year old male driver of the Hyundai observed the presence of the Honda just prior to the crash and applied full brakes. The driver indicated that the Honda was moving very slowly as it made a right turn **(Figure 2)**. The front of the Hyundai struck the right side plane of Honda resulting in light to moderate damage to both vehicles. The dual front air bags in the Hyundai deployed during the crash sequence.

Figure 2: Hyundai trajectory view just prior to impact.

Figure 3: Look back view of the Hyundai trajectory.

An unrestrained 2 year old male front right occupant in the Hyundai was taken to a trauma unit which was located in the vicinity of the crash where he was pronounced deceased 24 minutes after the police reported time of the crash. The autopsy listed the cause of death as multiple blunt force trauma. The child suffered complete separation of the spinal column and complete transection of the spinal cord at the first cervical vertebra (AIS-6) which appeared to be consistent with an air bag deployment related injury mechanism. The driver was not injured.

The 51 year old driver of the Honda and his two passengers were en route to the hospital

(coincidentally the same hospital that the 2 year old child was later taken) from another city in Pennsylvania. The driver indicated that he was familiar with the area and was unaware of the "No Turn" regulatory overhead signs. He indicated to police that he was traveling at an estimated speed of 8 km/h (5 mph) at the time of the crash. There were no police reported injuries in this vehicle.

VEHICLE DATA

1997 Hyundai Accent GS

The 1997 Hyundai Accent GS was equipped with a dual front Supplemental Restraint System (SRS) which deployed as the result of the impact with the 1996 Honda Civic LX. Exterior damage to the vehicle involved the front bumper, grille, hood, left headlight assembly, and left front fender **(Figure 4)**. The police listed rear displacement of the hood as 10.2 cm (4.0") and 7.6 cm (3.0") at the left front fender **(Figure 5)**. An imprint of the Honda's right rear wheel cover was noted on the bumper cover located below the left headlight assembly. The front right door glazing was shattered with glazing fragments noted along the right instrument panel.

Figure 4: Front view of the Hyundai.

Figure 5: Left lateral view of the Hyundai's damaged front plane.

1996 Honda Civic LX

The 1996 Honda Civic LX was equipped with a dual front SRS which did not deploy as the result of the impact with the 1997 Hyundai Accent GS. Exterior damage to the Honda involved the right rear door surface, right rear wheel and axle, the right rear fender, the right C-pillar, the right rear bumper corner, and the trunk **(Figure 6)**. The crush to the right rear door was listed by police as 10.2 cm (4.0") and 15.2 cm (6.0") for the right rear fender **(Figure 7)**. The side glazing remained intact.

Figure 6: Right side view of the damaged Honda Civic.

Figure 7: Rear view along the right side of the Honda.

Collision Deformation Classification (CDC)

The Collision Deformation Classification (CDC) for the Hyundai was 11-FDEW-1 while the CDC for the Honda was 02-RZEW-2. The damage patterns on both vehicles indicated that the Honda was traveling at a slow rate of speed at the time of the crash.

SPEED RECONSTRUCTION

The damage routine of the WinSMASH speed reconstruction was used to compute delta V values. Using estimated crush values that were derived from police reported deformation values and visual estimates from police photographs, the total delta V for the Hyundai was 14.4 km/h (8.9 mph) and 11.7 km/h (7.3 mph) for the Honda. The following tables list estimated crush data and WinSMASH computed results:

Crush Data				
1997 Hyundai Accent	C_1 = 7.6 cm (3.0")	C_2 = 2.5 cm (1.0")		
1996 Honda Civic	C_1 = 0	C_2 = 10.2 cm (4.0")	C_3 = 15.2 cm (6.0")	C_4 = 0

WinSMASH Speed Reconstruction Algorithm	**1997 Hyundai Accent**	**1996 Honda Civic**
Total delta V	14.4 km/h (8.9 mph)	11.7 km/h (7.3 mph)
Longitudinal delta V	-13.5 km/h (–8.4 mph)	-4.0 km/h (-2.5 mph)
Lateral delta V	4.9 km/h (3.1 mph)	-11.0 km/h (6.8 mph)

WinSMASH Speed Reconstruction Algorithm	1997 Hyundai Accent	1996 Honda Civic
Energy dissipated	10,914 joules (8,054 ft-lb)	15,476 joules (11,421 ft-lb)
Barrier equivalent speed	14.4 km/h (8.9 mph)	11.7 km/h (7.3 mph)

The delta V results appeared to be slightly lower for the Honda than a visually estimated value of 16-19 km/h (10-12 mph).

SUPPLEMENTAL RESTRAINT SYSTEM (SRS)

The Hyundai's dual front supplemental restraint system deployed during the crash **(Figure 8)**. The front left air bag module cover opened in the typical "H" configuration. The air bag appeared to be untethered with vent ports in the 11/1 o'clock positions. It was not possible to determine if the driver came in contact with the air bag at the time of deployment as the photographic evidence was not conclusive. The driver, however, was not injured in the crash.

Figure 8: Right interior view of the Hyundai's deployed frontal air bags.

The front right air bag was a mid mount design where the hinge point of the air bag module cover was located along the top surface of the front right instrument panel. The air bag cover did not exhibit occupant contact evidence, although the quality of the police photographs was insufficient to categorically rule out occupant contact. It was not known whether the air bag was vented or tethered. There were no discernable occupant contact evidence artifacts noted on the air bag in the police photograph.

INJURY DATA

The two year old male front right occupant, who was 96.5 cm (38.0") tall and weighed 15.4 kg (34.0 lbs.), was not restrained at the time of the crash. The driver reacted to the presence of the Honda by applying full brakes. As a result, the child moved forward toward the instrument panel and was in close proximity to the front right air bag module cover at the time of the crash. During the SRS actuation sequence, the front right air bag contacted the child's neck, face, and thoracic area resulting in trauma of the brain, spinal column, lungs, and spleen. The available vehicle interior documentation data was insufficient to categorically attribute these injuries to the air bag actuation sequence, but given the injury pattern, it was probable that the air bag was the injury source. The child suffered trauma of the right shoulder and arm which was attributed to contact with the side glazing. He also suffered rib fractures from contact with the seat back support.

The crash occurred in the immediate vicinity of a trauma hospital. The boy was taken to the emergency room either by carry or by stretcher (police reported method of transport as "other"). The child was subsequently pronounced deceased 24 minutes after the police reported time of the crash. The driver of the Hyundai was not injured nor were the three occupants in the Honda. The following table lists the injuries as reported in the autopsy report with related AIS-90 injury codes and injury source.

INJURY - 2 YEAR OLD MALE	AIS-90	INJURY SOURCE
1. Left parietal hemorrhage, 3.5 cm x 2 cm	140608.4,2	Front right air bag (probable)
2. Cerebellar swelling with cisterns almost totally obliterated, brain stem swollen	140666.5,6	Front right air bag (probable)
3. Small focal subarachnoid hemorrhage over the cerebellum	140466.3,6	Front right air bag (probable)
4. Complete separation of the spinal column and complete separation of the spinal cord at the first cervical vertebra	640270.6,6	Front right air bag (probable)
***Supplemental discussion**: There was minimal amount of soft tissue hemorrhage surrounding the anterior and posterior aspects of the cervical vertebrae.*		
5. Multiple intersecting splenic lacerations measuring from 1.3 cm x 1.3 cm (0.5" x 0.5") to 3.8 cm x 1.3 cm (1.5" x0.5")	544222.2,2	Front right air bag (probable)
6. Posterior medial aspects of ribs 3 through 6 on the right were fractured with 250 ccs if liquid blood in the right pleural cavity and 75 ccs of liquid blood in the left pleural cavity	450230.3,1	Seat back support (probable)
7. Multiple pulmonary contusions, both lungs had scattered pulmonary contusions measuring from 0.6 cm x 0.6 cm (0.25" x 0.25") to 1.3 cm x1.3 cm (0.5 x 0.5"). Each contusion were characterized by dark purple softening and discoloration.	441410.4,3	Front right air bag (probable)
8. Separation of the right acromion-clavicular joint with minimal soft tissue hemorrhage	750230.2,1	Front right side glazing (possible)
9. Palpable fracture of the right humerus	752602.2,1	Front right side glazing (possible)

INJURY - 2 YEAR OLD MALE	AIS-90	INJURY SOURCE
10. Discontinuous abrasion of the left aspect of the lower lip extending from the lip to the right part of the chin measuring 3.8 cm x 0.6 cm (1.5" x 0.25"). Oval abrasion along the lateral aspect of the right lower lip which measured 1.9 cm x 0.9 cm (0.75" x 0.375")	290202.1,8	Front right air bag (possible)
11. 6.4 cm x 5.0 cm (2.5" x 2.0") oval yellow abrasion on the right side of the neck	390202.1,1	Front right air bag (possible)

Occupant Kinematics

The 31 year old male driver of the Hyundai and his 2 year old son were traveling along an exit ramp when they approached a multiple leg intersection which was controlled by traffic control lights and "No Turn" regulatory signs. The driver of the Hyundai observed the driver of the Honda make a right turn across his travel path from a parallel road and reacted by applying full brakes. The police measured 7.6 m (25.0') of skid marks which they attributed to the Hyundai.

The 2 year old was sitting in the right front seat and was not restrained by the restraint belt. During pre-impact braking, the child more than likely moved forward and was in close proximity to the front right air bag module cover at the time of impact. During the SRS actuation sequence, the air bag deployed as designed and contacted the child's head and neck. The expanding air bag applied a vertical force under the child's chin area which resulted in tension/hyperextension type injuries (i.e., complete separation/transection of the spinal column and spinal cord, swelling of the cerebellar with cisterns almost totally obliterated, and brain stem swelling).

As the air bag continued to expand, it applied a force against his chest and abdominal area resulting in multiple contusions of both lungs and lacerations of the spleen. The child was subsequently propelled in an outboard angular direction where his right shoulder and arm contacted the front right solid temper window glazing which subsequently disintegrated. As a result, the child suffered in a separation of the right acromion-clavicular joint and a fracture of the right humerus.

The child continued in a rearward direction and was more than likely redirected away from the front right door surface as the result of his interaction with the glazing and contacted the outboard aspect of the front right seat back support with the posterior aspect of his upper torso. He suffered fractures of the posterior medial aspects of ribs 3 through 6 on the right side as the result of this contact. It was not known where the child came to final rest.