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REMOTE AIR BAG RELATED CHILD FATALITY INVESTIGATION

VERIDIAN CASE NO. CA00-029

VEHICLE - 1995 HYUNDAI ACCENT

LOCATION - LOUISIANA

CRASH DATE - JUNE 1998

Contract No. DTNH22-94-07058

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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 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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17. *Abstract*

This remote investigation focused on the fatal injury mechanisms of a 3 year old female child passenger seated in the front right position of a 1995 Hyundai Accent. The Hyundai was equipped with a front Supplemental Restraint System (SRS) that consisted of driver and front right passenger air bags. The vehicle's air bags deployed as a result of an intersection crash with a 1988 Ford Ranger pick-up truck. The 3 year old passenger was improperly restrained by only the lap belt portion of the available 3-point restraint. She was probably seated forward on the seat cushion. The shoulder belt was positioned behind her back. The child responded to the vehicle's pre-crash braking by initiating a forward trajectory and jackknifing over the lap belt. At impact she was in-close proximity to the deploying front right passenger air bag and sustained a high cervical injury resulting in immediate death due to her interaction with the expanding air bag. The driver and two rear seated passengers sustained only police reported minor injuries.

The crash was identified through a search of the Fatal Analysis Reporting System (FARS) by the Crash Investigation Division of the National Highway Traffic Safety Administration (NHTSA) in August 2000. NHTSA in-turn assigned a remote level investigation of the crash to the Special Crash Investigations team at Veridian Engineering due to the delayed crash notification. The available data from the police investigation and medical examiner were analyzed and was the basis for this report.

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REMOTE AIR BAG RELATED CHILD FATALITY INVESTIGATION
VERIDIAN CASE NO. CA00-029

VEHICLE: 1995 HYUNDAI ACCENT
LOCATION: LOUISIANA
CRASH DATE: JUNE, 1998

BACKGROUND

This remote investigation focused on the fatal injury mechanisms of a 3 year old female child passenger seated in the front right position of a 1995 Hyundai Accent. The Hyundai was equipped with a front Supplemental Restraint System (SRS) that consisted of driver and front right passenger air bags. The vehicle's air bags deployed as a result of an intersection crash with a 1988 Ford Ranger pick-up truck. The 3 year old passenger was improperly restrained by only the lap belt portion of the available 3-point restraint. She was probably seated forward on the seat cushion. The shoulder belt was positioned behind her back. The child responded to the vehicle's pre-crash braking by initiating a forward trajectory and jackknifing over the lap belt. At impact she was in-close proximity to the deploying front right passenger air bag and sustained a high cervical injury resulting in immediate death due to her interaction with the expanding air bag. The driver and two rear seated passengers sustained only police reported minor injuries.

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SUMMARY

Crash Site

This two-vehicle crash occurred during the afternoon hours of June 1998. At the time of the crash, it was daylight and the weather was not a factor. The road surfaces were dry. The crash occurred at the four-leg intersection of a two-lane north/south concrete roadway and a two-lane east/west concrete roadway. The intersection was controlled by stop signs for traffic in the east/west direction of travel. The police reported speed limit was 72 km/h (45 mph). **Figure 1** is a southward view looking into the intersection.

Figure 1: Southward view into the intersection.

Pre-Crash

The Hyundai Accent was northbound on the approach to the intersection. The vehicle was driven by a 23 year old female. The front right sat was occupied by a 3 year old female. The left rear position was occupied by a restrained 5 year male. A 7 month old male was seated and restrained in a child safety seat located right rear position. The 1988 Ford Ranger was southbound, driven by a restrained 17 year old male. The driver of the Ford slowed the vehicle as it entered the mouth of the intersection and then initiated a left turn across the path of the Hyundai. It was the driver's intention to travel east on the intersecting roadway. The driver of the Hyundai began braking in an effort to avoid the crash.

Crash

The crash occurred with the right and center aspects of the Hyundai's front plane impacting the right side passenger compartment of the Ford. The right frontal aspect of the Hyundai underrode Ford's right side. As the Ford continued its southeastward trajectory, its right rear tire rolled up and over the Hyundai's right front corner. The Ford then rolled 1/4 turn onto its left side and slid to rest in the southeast intersection quadrant. The Ford came to rest on its left side approximately 8 m (25 ft) from the point of impact. The pick-up truck's cargo bed separated as a result of the rollover.

The lateral momentum of the Ford caused the Hyundai to rotate approximately 20 degrees clockwise. The Hyundai came to rest facing northeastward approximately 2.1 m (7 ft) from the point of impact. The force of the 11/2 o'clock impact caused the deployment of frontal air bags in the Hyundai. The Hyundai's delta V was an estimated 19 to 23 km/h (12 to 14 mph). **Figure 2** is a police sketch of the crash. **Figure 3** is a northward view of the vehicles at final rest.

Post-Crash

The driver of the Hyundai exited the vehicle following the crash. A witness reported, the driver removed the front right seated 3 year old child and the right rear seated 7 month old child from the vehicle. She was seen holding both children. It appeared to the witness that the 3 year old child was lifeless at this time. Police and ambulance personnel responded to the scene. A paramedic attempted to render aid to the 3 year old, however, efforts to resuscitate her were unsuccessful. The remaining occupants of the Hyundai were transported to a local hospital for minor injuries. The driver of the Ford was not injured and refused transport.

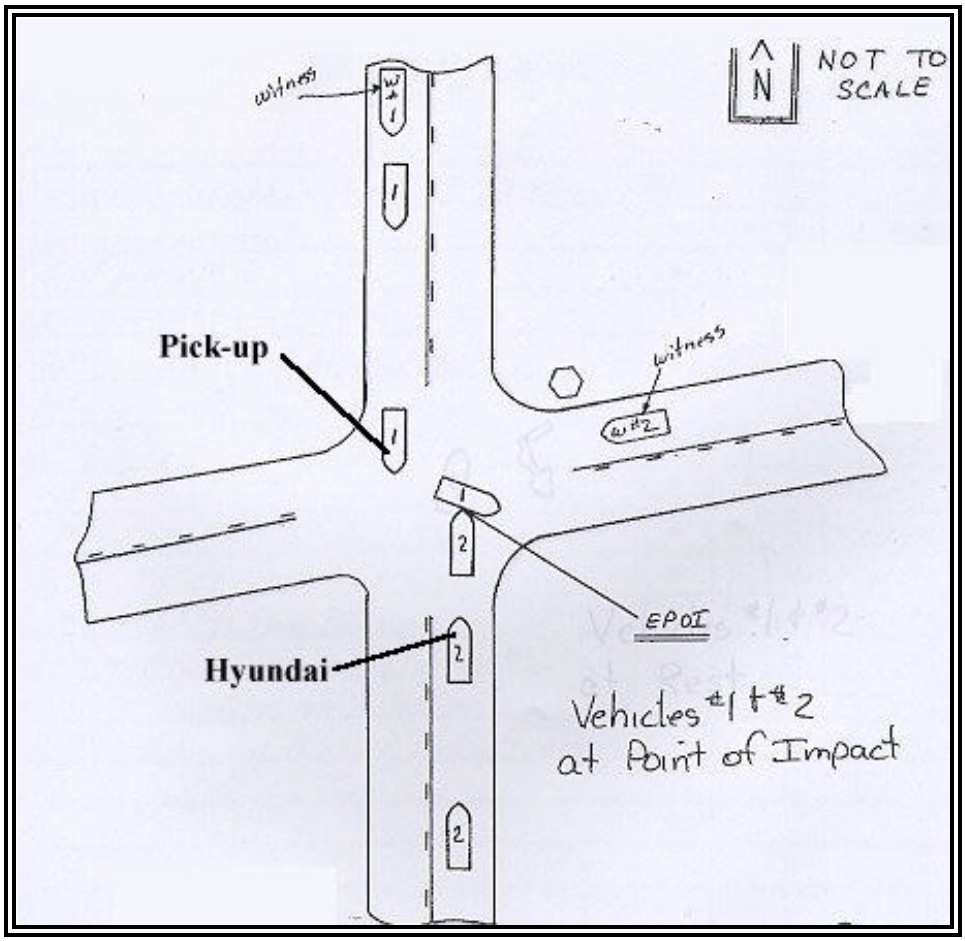

Figure 2: Police sketch of the crash**.**

Figure 3: View of the vehicle's final rest positions.

1995 HYUNDAI ACCENT

The 1995 Hyundai Accent was identified by the Vehicle Identification Number (VIN): KMHVF14NXSU (production sequence deleted). The vehicle's power train consisted of a 1.5 liter/I-4 engine linked to a 4-speed automatic transmission. The brakes were power-assisted front disc/rear drum with an anti-system lock system as standard equipment. The Supplemental Restraint System consisted of driver and front right passenger air bags that deployed as a result of the above threshold crash.

Exterior Damage

Figures 4 and 5 are the front and right side views of the damaged vehicle. The Hyundai sustained an estimated 76 cm (30 in) of direct contact damage to the center and right aspects of its frontal plane. The direct contact began approximately at the vehicle's centerline and extended to the right corner of the front bumper. The damaged components included the front bumper and fascia, right head lamp assembly, hood, upper radiator support and right front fender. The longitudinal damage on the hood extended rearward an estimated 81 cm (32 in) as a result of the Ford's rear tire rolling up and over the right front corner of the vehicle. The crash dynamics were beyond the scope of the WINSMASH model. Analysis of the damage indicated the Hyundai's delta V in this impact was approximately 19 to 23 km/h (12 to 14 mph) based on SCI experience. The Collision Deformation Classification (CDC) was 11-FZEW-1.

Figure 4: Front view of the damaged Hyundai.

Figure 5: Right side view of the Hyundai.

Interior Damage

The interior damage of the Hyundai was limited to the deployment of the Supplemental Restraint System. Examination of the available photographs revealed there was no intrusion or interior deformation associated to the exterior crash forces. The only noteworthy damage to the interior was a fracture of the right aspect of the windshield. The windshield fracture was caused by contact from the right corner of the mid-mount passenger air bag module cover flap. The forward position of the right passenger altered the normal deployment path of the air bag. The altered bag deployment loaded the interior surface of the cover flap, causing the flap to contact and fracture the windshield. The only other noted damage was the shattered right front window glazing. The glazing shattered upon impact.

Manual Restraint System

The Hyundai was equipped with manual 3-point lap and shoulder belts in the four outboard positions. The restraint webbing was a continuous loop system with a sliding latch plate. The restraint systems retractors were dual-mode emergency locking retractors and locked due to the inertial deceleration of the vehicle. The inboard buckle anchors of the front restraints were attached to the inboard aspect of the front seats. The adjustment of the upper anchorages (D-rings) were not known.

The police report indicated the driver and left rear passenger were restrained by the vehicle's 3-point lap and shoulder belt. The right rear passenger was in a child safety seat. The reported restraint use of these occupant was consistent with their police reported minor injuries.

The 3-year old front right passenger was reported as unrestrained. A review of the autopsy record indicated the child sustained a wide area of abrasion over her lower abdomen. This injury was consistent with the occupant being lap belted during the crash sequence. A 3-point lap and shoulder restraint is not suited to proper fit the anthropometry of a 3 year old because this type of belt system is designed for the adult population. The shoulder belt webbing (if worn over the shoulder) would have cut across the child's face and/or neck due to her short seated height. The child probably positioned the shoulder portion of the restraint behind her back. The position of the restraint in this manner was further supported by the child's kinematic and cervical injury pattern, indicative of her involvement with the expanding passenger air bag. The right front seat was adjusted to a rear track position, as depicted in **Figure 6**. For the child to interact with the passenger air bag, she would have had to have been seated on the forward aspect of the seat cushion, with her back away from the seat back. This forward seated position would have introduced excessive belt webbing into the restraint system, exacerbating the child's improper restraint use. It should be noted that a child of this age should have been restrained in a forward facing child safety seat positioned in a rear seat. The use of the child seat would have mitigated the child's devastating injuries and offered far more overall crash protection.

Supplemental Restraint System

The front Supplemental Restraint System (SRS) in the 1995 Hyundai Accent consisted of driver and right passenger air bags that deployed as a result of the intersection crash. **Figure 6** is a view of the front interior and deployed air bags taken during the police investigation. The driver air bag was designed in the typical manner and located in the center of the steering wheel rim. The passenger air bag was a mid-mount design located in the right aspect of the instrument panel. A single point sensing control module located under the center aspect of the instrument panel monitored and commanded the deployment of the system. Upon impact, the control module sensed the above-threshold deceleration of the crash and deployed the vehicle's Supplemental Restraint System.

Figure 6: View of the deployed air bags.

OCCUPANT DEMOGRAPHICS

	Driver	**Front Right Passenger**
Age/Sex:	23 year old/Female	3 year old/ Female
Height/Weight:	Unknown	Unknown
Restraint Use:	Manual 3-pt lap and shoulder belt	Lap belt only
Usage Source:	Occupant kinematics/Police Report	Occupant kinematics/SCI evaluation
Injury Outcome:	Police reported minor injuries	Fatally injured at the scene
Medical Treatment:	Examined and released	None

	Left Rear Passenger	**Right Rear Passenger**
Age/Sex:	5 year old/Male	7 month old/ Male
Height/Weight:	Unknown	Unknown
Restraint Use:	Manual 3-pt lap and shoulder belt	Forward facing child safety seat
Usage Source:	Occupant kinematics/Police Report	Occupant kinematics/Police report
Injury Outcome:	Police reported minor injuries	Police reported minor injuries
Medical Treatment:	Examined and released	Examined and released

DRIVER KINEMATICS AND INJURY

Immediately prior to the crash, the driver was seated in a presumed normal posture with her seat adjusted in a rear track position. The driver applied the brakes in an attempt to avoid the pick-up truck turning across her path. The vehicle sensitive retractors locked the seat belt system. It was likely she braced against the steering wheel with her arms. Upon impact, the vehicle's Supplemental Restraint System detected the crash and deployed the air bags.

The driver exhibited a forward trajectory in response to the 12 o'clock direction of the impact force. She contacted and loaded the 3-point restraint and the deployed driver air bag. The proper use of the 3-point lap and shoulder belt supplemented by the driver air bag effectively restrained the driver and mitigated potential contact with the steering wheel and other interior components. She sustained police reported minor injuries. She was ambulatory post-crash as reported by witnesses to the crash.

FRONT RIGHT PASSENGER INJURIES

Injury	Severity (AIS 98 Update)	Injury Mechanism
Cervical dislocation (subluxation) without fracture, NFS	Moderate (650204.2,6)	Deploying passenger air bag
Wide abrasion over the lower abdomen	Minor (590202.1,8)	Inertial contact with the lap belt

Note: The above injuries were identified by an external (only) autopsy conducted by the coroner's office.

The cause of death was listed as a severe cervical spine injury. The description of the injury taken from the Coroner's report was as follows:

"...The most remarkable portion of the examination is a palpable subluxation right below the base of the skull that will allow approximately two finger breadths to be placed between the vertebra with extreme mobility of the neck."

The cervical dislocation (NFS) code was used due to the inexact description of the injury. Specific references to the atlanto-axial or atlanto-occipital landmarks were not used. The use of the external autopsy protocol restricted an internal examination that could have determined an associated spinal cord injury. Considering the immediate death of the child there exists a strong probability of an unidentified cord injury and/or transection.

RIGHT FRONT PASSENGER KINEMATICS

Prior to the crash, the 3 year old child was seated in the front right passenger position in a presumed upright posture. The passenger seat was adjusted to a rear track position as identified by a photograph of the vehicle's interior (Figure 6) taken during the on-scene police investigation. The child was improperly restrained by only the lap portion of the manual 3-point restraint as evidenced by the post-crash abdominal abrasion. The shoulder portion of the belt was positioned behind her back. The kinematics of the child (described below) were indicative of the lack of any upper torso restraint. Additionally, given the short seated height of the child, if the shoulder belt had been positioned over the shoulder, it would have cut across the child's face and/or neck. The child would have repositioned the belt behind her back for her comfort.

The child probably was seated on the forward aspect of the seat cushion, allowing her legs to bend at the knees over the front of the cushion. Her back was not against the back rest. She was believed to have been seated in this manner because of the rear track adjustment of the seat. If she had been seated with her back against the back rest, the child's interaction with the deploying air bag would not have been as great due to her height. The forward pre-crash position coupled with her forward kinematic pattern

allowed the child to interact with the expanding air bag; altering its deployment path as evidenced by the windshield fracture. Additionally, the forward position on the seat introduced additional slack into the belt system.

The driver of the Hyundai attempted to avoid the impact by applying the vehicle's brakes. The retractors of the manual restraint system locked the seat belt webbing. The child responded to the pre-crash braking by exhibiting a forward trajectory and loading the lap belt. Her unrestrained torso began to jackknife forward about the waist.

At impact, the vehicle's frontal air bags deployed. The child responded to the 11 o'clock direction of the impact force by continuing her jackknifing kinematic pattern. The child's head was in-close proximity to the deploying air bag. The expanding passenger air bag struck the child in the head and upper chest. The child's forward position and contact with the air bag early in the deployment sequence altered the normal deployment path of the bag. The air bag loaded the interior contact of the module cover flap which in-turn contacted and fractured the windshield. The continued expansion of the air bag hyper-extended the child's head causing the identified cervical injury. It should be noted the facial and chin abrasion pattern typically associated with air bag interaction were not identified.

As the child rebounded rearward, she was probably lifted from the seat cushion by the air bag expansion. The abdominal abrasion occurred at this time as a result of contact with the lap belt. The child then rebound back into the passenger seat where she was found.

LEFT REAR PASSENGER KINEMATICS AND INJURY

Prior to the crash, the 5 year old male child passenger was seated with a normal posture and restrained by the available 3-point lap and shoulder belt. The passenger responded to the vehicle's pre-crash braking by exhibiting a forward trajectory. He contacted and loaded the locked seat belt system. At impact, he responded to the 11 o'clock direction of the impact forces by continuing to load the belt system. The proper use of the 3-point restraint effectively restrained this passenger and spread the force of the crash over his body mitigating any significant injury. The police report indicated the passenger sustained minor unspecified injuries.

RIGHT REAR PASSENGER KINEMATICS

Prior to the crash, the 7 month old male child passenger was seated with a normal posture in a forward facing child safety seat. The details regarding the make, model and installation of the safety seat were unknown. The seat was reportedly restrained to the vehicle with the manual 3-point lap ans shoulder belt system. It should be noted that this child should have been restrained in a rear facing mode considering his young age.

The passenger responded to the vehicle's pre-crash braking by exhibiting a forward trajectory. He

contacted and loaded the restraint system of the child seat. At impact, he responded to the 11 o'clock direction of the impact forces by continuing to load the belt system. The use of the child safety seat restrained this passenger and spread the force of the crash over his body mitigating significant injury. The police report indicated the passenger sustained minor unspecified injuries.