CRASH DATA RESEARCH CENTER

Calspan Corporation Buffalo, NY 14225

CALSPAN REMOTE SIDE IMPACT OCCUPANT PROTECTION SYSTEM CRASH INVESTIGATION

NASS/SCI CASE NO: 2007-41-174J VEHICLE: 2005 HYUNDAI ACCENT LOCATION: FLORIDA CRASH DATE: OCTOBER, 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 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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BACKGROUND

This investigation focused on the crash dynamics and injury sources for a 79 year old male driver of a 2005 Hyundai Accent that was involved in an intersection crash with 2006 Chrysler PT Cruiser. The Hyundai Accent was equipped with frontal air bags for the driver and front right passenger and front seat back mounted side impact air bags. The Hyundai's driver sustained right scalp lacerations and abrasions, a severe brain injury, and multiple right rib fractures as a result of the lateral impact. The crash occurred when the eastbound Hyundai turned left directly across the path of the westbound Chrysler. The front plane of the Chrysler struck the right side plane of the Hyundai in an 11/2 impact configuration. The momentum of the Chrysler displaced the vehicles into the northwest quadrant of the intersection where they came to rest.

The impact crushed the right side of the Hyundai and caused the right B-pillar to intrude into the

outboard aspect of the front right seat. The force of the impact caused the front right seat back mounted side air bag The side air bag deployed after the B-pillar to deploy. intrusion as evidenced by the captured air bag. The intruded B-pillar altered the deployment path of the air bag. The deflated air bag was found captured behind the B-pillar and front right seat. The impeded air bag appeared to have deployed vertically and rearward (rather than forward). The driver responded to the 2 o'clock direction of the impact force with a rightward trajectory across the front right seat. The driver's torso slipped out from under the shoulder belt and he loaded the lap portion of the safety belt with his pelvis. The restrained driver impacted the right B-pillar area with his head resulting in severe brain trauma. Figure 1 is an interior view across Row 1 of the Hyundai. The normally inflated right side impact air bag provided coverage for the aft aspect of the door and the right B-pillar area. If the air bag had deployed earlier in the crash sequence and protected the right B-pillar area, the driver's injuries may have been mitigated.



Figure 1: Interior view across Row 1.

This crash was initially selected for research within the National Automotive Sampling System (NASS). During Zone Center review, the Special Crash Investigations team at Calspan was notified of the crash circumstances. In-turn, the Calspan SCI team notified the Crash Investigation Division of the National Highway Traffic Safety Administration. A combined NASS/SCI investigation was subsequently assigned on January 14, 2008. Calspan SCI reviewed

the NASS data collection and medical records and this Technical Summary Report was attached to the completed EDS file.

SUMMARY Vehicle Data

2005 Hyundai Accent

The 2005 Hyundai Accent, Figure 2, was identified by the Vehicle Identification Number (VIN): KMHCG45C85U (production sequence deleted). The vehicle was manufactured in September 2004 and had registered 49,021 km (30,461 miles) at the time of the NASS This four-door, front-wheel drive inspection. sedan was powered by a 1.6 liter/I4 engine linked to a four speed automatic transmission. The vehicle was equipped with manual three-point lap and shoulder belts in the four outboard positions and a rear center (only) lap belt. The Hyundai was equipped with driver and front right Figure 2: Front right oblique view of the passenger air bags and front seat back mounted Hyundai.



side impact air bags. The front right seat back mounted air bag deployed as a result of the crash.

2006 Chrysler PT Cruiser

The 2006 Chrysler PT Cruiser was identified by the Vehicle Identification Number (VIN): 3A4FY48B36T (production sequence deleted) and was manufactured in November 2005. Figure 3 is a frontal view of the Chrysler. The digital odometer could not be read at the time of the NASS inspection due to damage to the electrical system. The four-door wagon was equipped with a 2.4 liter/I4 engine linked to a automatic transmission. four-speed The Chrysler's manual restraint system consisted of three-point lap and shoulder belts in the five seat positions. The vehicle was equipped a Certified Advanced Compliant (CAC) air bags for the Figure 3: Front view of the Chrysler. driver and front right passenger. The frontal air bags did not deploy as a result of the crash.



Crash Site

This two-vehicle crash occurred during the afternoon hours of October 2007 in a suburban commercial setting. At the time of the crash, it was daylight and it was raining. The asphalt road surface was wet. The crash occurred at the four-leg intersection of a four-lane east/west road and a three-lane north/south road. The eastbound and westbound lanes of the primary road were separated by a 1.3 m (4.3 ft) wide, 15 cm (6 in) raised concrete median. The respective east/west travel directions of the road consisted of three-through lanes and a left turn only lane. The intersection was controlled by overhead traffic signals (red/amber/green). The traffic light was green for the east/west traffic. A utility pole was located in the northwest quadrant of the intersection. The Hyundai contacted the pole with its left rear quarterpanel as it slid to final rest. The speed limit within the area of the crash was 56 km/h (35 mph). **Figure 3** is an eastbound approach view of the Hyundai. **Figure 4** is a view of the northwest intersection quadrant and the area of the vehicles' final rest location.



Figure 4: Eastbound trajectory view of the Hyundai.



Figure 5: Northwest quadrant of the intersection.

Crash Sequence

Pre-Crash

The 2006 Chrysler PT Cruiser was westbound in the outboard lane of the road. The PT Cruiser was occupied by a 75 year old male driver and a 72 year old female front right passenger. Coincident to this, the 2005 Hyundai Accent was eastbound in the left turn lane approaching the intersection. The 79 year old male driver of the Hyundai was the sole occupant of the vehicle. The Hyundai entered the intersection and for unknown reasons turned left directly across the path of the Chrysler.

Crash

The crash occurred with the front plane of the Chrysler impacting the right plane of the Hyundai in an 11/2 o'clock impact configuration. The direct contact to the Hyundai began at the right front corner and extended rearward to the C-pillar area. The impact force crushed the right side plane of the vehicle. The impact resulted in right B-pillar intrusion to the outboard aspect of the front right seat. The deployment of the air bag was impeded by the intruded B-pillar. The air bag expanded with a vertical and rearward pattern. The severity of the intersection impact was calculated by the Damage Algorithm of the WINSMASH Collision Model. The delta V of the Hyundai and Chrysler was 27 km/h (17 mph) and 19 km/h (12 mph), respectively.

The westbound momentum of the Chrysler redirected the Hyundai to the northwest and caused the vehicle to initiate a counterclockwise rotation. The Chrysler was deflected to its right and continued in a northwest trajectory. The Hyundai slid laterally onto the concrete sidewalk of the northwest intersection quadrant evidenced by two scuff marks attributed to the left side tires. The left rear aspect of the Hyundai then contacted a concrete utility pole located adjacent to the sidewalk in a minor secondary contact and came to rest. The Chrysler came to rest adjacent to the Hyundai facing northwest. A schematic of the crash is included at the end of this report as **Figure 11**.

Post-Crash

The police and ambulance personnel responded to the crash. The driver of the Hyundai sustained a brain injury, multiple rib fractures and soft tissues injuries. He was hospitalized at a regional trauma center for nine days and released. The driver and front right passenger of the Chrysler were transported by ground ambulance to a hospital where they were treated and released. The Hyundai Accent and Chrysler PT Cruiser both sustained disabling damage and were towed from the scene.

2005 Hyundai Accent

Exterior Damage

The right side plane of the Hyundai sustained moderate severity damage as a result of the intersection crash. Figure 6 is a right oblique view of the vehicle. The initial impact extended across the occupant compartment. The direct contact damage began at the right corner and

extended rearward 264 cm (104 in) to the mid aspect of the right rear door. The combined direct and induced damage length measured 312 cm (123 in). The residual crush documented at the mid-door elevation was as follows: C1 = 2 cm (0.8 in), C2 = 5 cm (2.0 in), C3 = 19 cm (7.5 in), C4 = 29 cm (11.4 in), C5 = 10 cm (3.9 in), C6 = 7 cm (2.8 in). The maximum crush measured 29 cm (11.4 in) and was located at C4, the mid aspect of the right front door. The force of the impact deformed the right side structure inboard resulting in 16 cm (6.3 in) of front right intrusion. Both doors were jammed shut. The right front window glazing disintegrated. The



right wheelbase was reduced 2 cm (0.8 in). The Figure 6: Oblique view of the impact damage. Collision Deformation Classification (CDC) of

the impact damage was 02-RYEW3. The delta V of the impact was 27 km/h (16.8 mph). The longitudinal and lateral components were -17 km/h (-10.6 mph) and -21 km/h (-13 mph), respectively.

A second region of damage was noted to the rear aspect of the Hyundai's left side as a result of its minor contact to the utility pole. This damage region measured 82 cm (32.2 in) in length and consisted of abrasions to the quarterpanel. There was no residual crush identified. The CDC was 11-LBEU01

2006 Chrysler PT Cruiser Exterior Damage

The front plane of the Chrysler sustained moderate damage as a result of the overlapping impacts, Figure 7. The extent of the damage was primarily related to the initial intersection impact. The direct contact damage extended across the full 150 cm (59 in) front end width of the vehicle. The lateral momentum of the Hyundai caused a right shift of the front bumper structure and forward sub-frame of the Chrysler. The residual documented crush along the bumper reinforcement bar was as follows: C1 = 5 cm (2.0 in), C2 = 9 cm (3.5 in), C3 = 12 cm (4.7 in),C4 = 14 cm (5.5 in), C5 = 13 cm (5.1 in), C6 =

resulted in induced damage to the right front



15 cm (5.9 in). The angular impact configuration Figure 7: Chrysler frontal profile.

fender. The doors remained closed during the impact and were operational post-crash. There was no change in the wheelbase dimensions. The CDC of the impact damage was 71-FDEW1. (Note: the 11 o'clock principle direction of force was incremented by 60 to denote the right shift of the forward sub-frame.) The delta V of the impact was 19 km/h (12 mph). The longitudinal and lateral components were -15 km/h (-9.3 mph) and 12 km/h (7.5 mph), respectively.

2005 Hyundai Accent

Interior Damage

The interior damage to the Hyundai consisted of moderate intrusion of the right side structures, the deployment of the front right side impact air bag, and the occupant interior contact points. The intrusion of the front right door measured 16 cm (6.3 in). The right aspect of the instrument panel was fractured and laterally compressed. The right B-pillar intrusion measured 9 cm (3.5 in). The right B-pillar intruded to the outboard aspect of the front right seat back and impeded the deployment of the seat back-mounted side air bag. The rear right door intrusion measured 12 cm (4.7 in). Refer to the *Air Bag System* section of the report for greater detail regarding the impeded deployment.

The driver seat was adjusted to a full rear track position at the time of the NASS inspection. It could not be verified if the seat was in this position at the time of the crash. The driver interview was not obtained. At inspection, the driver seat back was slightly reclined and retained this position. The seat was not damaged. The driver's head restraint was found lying on the rear bench seat. It was completely separated from the seat back for reasons that could not be determined.

The NASS researcher documented contact evidence to the left side of the driver's knee bolster that was attributed to interaction with his left lower extremity. A large body fluid transfer was noted to the right B-pillar and the stowed front right safety belt, **Figure 8**. This region was attributed to contact from the driver's head.



Figure 8: Driver head contact to the right B-pillar.

Manual Restraint System

The manual restraint system in the Hyundai consisted of three-point lap and shoulder belts in the four outboard seat positions and a center rear lap The front restraints were equipped with belt. retractor pretensioners. The driver's restraint consisted of continuous loop webbing that spooled onto an Emergency Locking Retractor (ELR), an adjustable D-ring and a sliding latch plate. The webbing was stowed within the retractor upon initial observation and the retractor was operational. Inspection of the safety belt system revealed the webbing was gathered in the latch plate. With the latch plate captured at this location, there was excessive slack in the lap portion of the restraint in the buckled condition. Refer to Figure 9.

The SCI reconstruction of the crash indicated the driver was only restrained by the lap portion of the webbing. As the driver responded to the 2 o'clock direction of the impact force, he loaded the lap portion of the locked webbing with his pelvis. The driver's upper torso slipped laterally out from under Figure 9: Driver's safety belt. the shoulder webbing. The continued belt loading of



the driver caused the excess webbing to slide through the latch plate until it gathered and jammed. In this manner, webbing slack developed in the lap section and allowed the driver to be displaced across the front row of seats.

Air Bag System

The vehicle was equipped with frontal air bags for the driver and front right passenger that did not deploy in the lateral impact. In addition to the frontal air bags, the Hyundai was equipped

with front seat back mounted side impact air bags. The right side impact air bag deployed in the crash.

The deployment of the side air bag was impeded by the intruded right B-pillar. The air bag deployed vertically and rearward. The deflated air bag was captured behind the seat back. **Figure 10** is a left interior view across the second row.



Figure 10: Left interior view across Row 2.

2005 Hyunuui Mcccm		
	Driver	
Age/Sex:	79 year old/Male	
Height:	157 cm (62 in)	
Weight:	Unknown	
Seat Position:	Unknown	
Manual Restraint Use:	3-point lap and shoulder belt	
Usage Source:	SCI reconstruction, NASS inspection	
Medical Treatment:	Transported and hospitalized 9 days	

DRIVER DEMOGRAPHICS 2005 Hyundai Accent

DRIVER INJURY

Injury	Injury Severity (AIS 98 Update)	Injury Source	
Small right cerebral subdural	Severe	Dight D millor	
hemorrhage (4 mm thickness)	(140652.4,1)	Kigin D-pinar	
Right cerebral subarachnoid	Serious	Right B-pillar	
hemorrhage	(140684.3,1)		
Non-displaced cervical spine odontoid	Serious	Right B-pillar	
fracture (C2)	(650228.3,6)		
Posterior right rib fractures 3 rd , 4 th , 5 th	Severe	Right front door	
and 6 th with hemothorax	(450232.4,1)		
Right lung contusion with small, right	Serious	Bight front door	
posterior hemothorax	(441406.3,1)	Right front door	
Dight frontal to pariatal scalp abrasian	Minor	Right B-pillar	
Right fromai to parletar scarp abrasion	(190202.1,1)		
Dight upper forshead lageration NES	Minor	Dight D. millon	
Right upper forenead faceration, NFS	(290600.1.7)	Right D-pillar	

Injury	Injury Severity (AIS 98 Update)	Injury Source
Right hand abrasion, NFS	Minor (790202.1,1)	Right front seat
Right knee abrasion, NFS	Minor (890202.1,1)	Lower center instrument panel

Note: the above injuries were identified from the driver's medical records.

DRIVER KINEMATICS

The 79 year old driver of the Hyundai was seated in a presumed upright posture. He was restrained by manual safety belt. The driver initiated a left steering maneuver as the Hyundai entered the intersection and crossed the path of the Chrysler precipitating the crash. The crash occurred with the front of the Chrysler impacting the right side of the Hyundai. The force of the impact caused the ELR retractor to lock. The right side structure of the Hyundai deformed and the right B-pillar intruded into contact with the outboard aspect of the front right seat. The expansion of the air bag was impeded by the intruded right B-pillar. The intruded pillar caused the air bag to expand vertically and rearward.

The driver responded to the 2 o'clock direction of the impact force by initiating a right trajectory. The displaced driver slipped out from under the shoulder webbing and loaded the lap portion of the safety belt with his pelvis and lower extremities. His loading of the locked restraint resulted in a portion of the excess webbing sliding through the latch plate. The webbing roped and gathered, and became restricted in the latch plate.

The belt slack that developed in the lap portion of the loaded restraint allowed the driver to translate across the front right seat. The angular impact force coupled with the vehicle's counterclockwise rotation resulted in the driver's head impacting the right B-pillar evidenced by the identified contact. This contact resulted in the soft tissue head injuries, brain hemorrhages and the cervical fracture. The driver's right shoulder and right chest impacted the door panel resulting in the rib fractures, a right lung contusion and the small right hemothorax. The driver was removed from the vehicle by the first responders and transported by ground ambulance to a local hospital. The driver was hospitalized for nine days and then released.

The side impact air bags in the Hyundai Accent were designed to provide thorax protection. An unimpeded deployment of the air bag would have provided some occupant protection from the aft aspect of the front door panel and the right B-pillar area. In this crash had the side impact air bag deployed in an unimpeded manner, the driver's head and right chest may have been protected by the inflated air bag; thereby reducing the driver's injury potential.



Figure 11: Crash Schematic