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ON-SITE CHILD SAFETY SEAT INVESTIGATION

CASE NUMBER - IN07032
LOCATION - ILLINOIS
VEHICLE - 2006 HYUNDAI SONATA GL
CRASH DATE - August 2007

Submitted:

September 30, 2008

Contract Number: DTNH22-07-C-00044

Prepared for:

U.S. Department of Transportation
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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.

Technical Report Documentation Page

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16. *Abstract*

The focus of this case was on a child passenger who was seated within a booster child safety seat that was in the second row right position of a 2006 Hyundai Sonata. This report covers an on-site investigation of a head-on crash that involved a 2006 Hyundai Sonata GL and 2001 Dodge Intrepid SE. The second row right passenger (4-year-old, male) was seated in his Cosco/Dorel, Alpha Omega, three-way, booster/convertible child safety seat. He was restrained in his booster safety seat by his lap-and-shoulder, safety belt system. The Hyundai's driver (23-year-old, female) was seated but leaning forward (i.e., having just picked up an object on the floor). She was restrained by her lap-and-shoulder, safety belt system and sustained, according to her interview and her medical records, moderate injuries that included a fractured right ankle and soft tissue injuries. The child occupant sustained, according to his medical records, a critical nonanatomic brain injury, a fractured right humerus, and soft tissue injuries. This occupant's primary head and brain lesions resulted from contacting the back surface of the front right seat.

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TABLE OF CONTENTS IN07032

This crash was brought to this contractor's attention on August 4, 2007. This contractor was informed of this crash while on site researching a different investigation in an adjacent county. This crash involved a 2006 Hyundai Sonata GL and a 2001 Dodge Intrepid SE. The crash occurred in August 2007, at 11:01 a.m., in Illinois and was investigated by the applicable county sheriff's department. This crash is of special interest because the Hyundai's second row right passenger was restrained in a child safety seat. This contractor contacted the investigating law enforcement agency on August 7, 2007. The sheriff's department did not respond to calls until September 13, 2007, and the department advised that they were holding the child seat. Final cooperation was established about September 27, 2007. This contractor inspected both vehicles on October 1, 2007. The scene and child seat were inspected on October 2, 2007. This contractor also interviewed the driver of the Hyundai on October 2, 2007. This report is based on the Police Crash Report; scene and vehicle inspections; interviews with the Hyundai's driver, the driver's father, and the investigating sheriff's deputy; occupant kinematic principles; occupant medical records; and this contractor's evaluation of the evidence.

CRASH CIRCUMSTANCES

Crash Environment: The trafficway on which both vehicles were traveling was a 2-lane, undivided, county roadway, traversing in a generally east-west direction. The east-west roadway had one through lane in each direction. The specific county road segment was curved slightly to the right for westbound traffic and had a grade near the area of impact (an upgrade in the Hyundai's direction of travel). The pavement was bituminous, but traveled, and the width of the travel lanes for both vehicles was 6.3 meters (20.7 feet). The shoulders were not improved (i.e., a thin strip of gravel followed by grass). In addition, there was a ditch on each side of the roadway. No pavement markings were present. There were no visible traffic controls in the immediate area of the crash. The speed limit was 89 km/h (55 mph), but no actual signs were posted near the crash site. At the time of the crash, the light condition was daylight, the atmospheric condition was cloudy, and the roadway pavement was dry, bituminous. There was no other traffic present, and the site of the crash was a rural farming area. See **CRASH DIAGRAM** at end of report.

Figure 1: Hyundai's uphill approach (grade: 4.2% positive to east) heading into right-hand curve

Figure 2: Dodge's eastward, uphill, travel path in eastbound lane approaching hill crest; Note: point of impact lies over crest of hill

Pre-Crash: The Hyundai was traveling west, up the grade (4.2% grade positive to the west), in the westbound lane, and the driver intended to continue ahead while negotiating the curve (**Figure**

1). The Dodge had been traveling east, up the grade, in the eastbound lane and intended to continue straight ahead (**Figure 2**). The Dodge had just crested a hill and began traveling down a grade just prior to the crash (3.1% negative to the east–**Figure 3**). According to the Police Crash Report, the Hyundai's driver leaned over to pick up an item dropped on the floor. Apparently, when the driver was retrieving this item, the Hyundai traveled across the centerline into the eastbound lane (**Figure 4**). According to the Police Crash Report, the Hyundai's driver made no mention of any avoidance maneuvers. The driver of the Dodge probably braked just prior to impact. The crash occurred in the eastbound lane of the roadway, just east of the hill crest (**Figures 5** and **6**).

Figure 3 Dodge's downhill approach (grade: 3.1% negative to west) heading toward left-hand curve

Figure 4: Hyundai drifts leftward toward centerline along uphill approach in right-hand curve

Figure 5: Hyundai's uphill westward travel path in eastbound lane just prior to impact; Note: arrow indicates final rest position of right rear tire

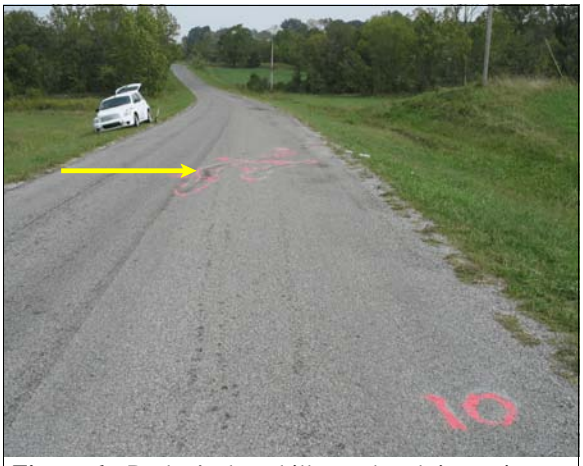


Figure 6: Dodge's downhill travel path just prior to impact with Hyundai; Note: arrow indicates impact scuff from Dodge's left front tire

Crash: The front of the Hyundai (**Figure 7**) impacted the front of the Dodge (**Figure 8**), slightly offset toward each vehicle's right side, causing the Hyundai's driver air bag to deploy. It is unknown whether more than one stage of the Hyundai's multi-stage air bag was activated. The front right passenger air bag did not deploy during the crash sequence. However, the right side curtain air bag also deployed (**Figure 9**). As a result of the impact, the Hyundai rotated

approximately 45 degrees counterclockwise, while being pushed rearward from the force of the impact, and came to rest with its right rear tire on the southern edge of the roadway, straddling the eastbound lane and the south shoulder, heading in a west-northwesterly direction (**Figure 5**). The Dodge continued forward a short distance while deflecting clockwise approximately 30 degrees (**Figure 10**). The Dodge came to rest in the eastbound lane, heading in an east-southeasterly direction.

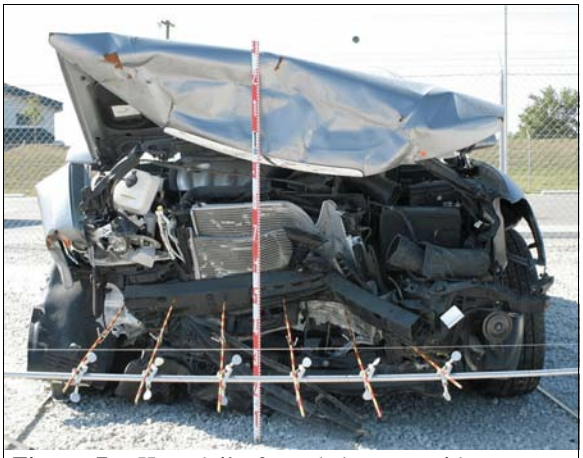


Figure 7: Hyundai's frontal damage with contour gauge set at bumper level

Figure 8: Dodge's frontal damage with contour gauge set at bumper level

Figure 9: Hyundai's frontal damage and induced right side damage showing deployed right side curtain air bag

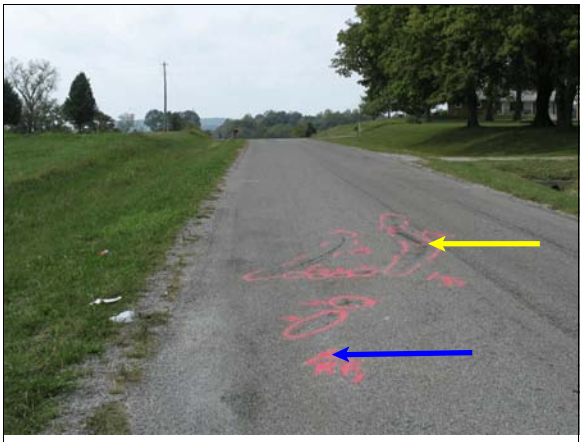


Figure 10: Westerly view showing Dodge's path to impact; Note: back arrow indicates impact scuff and point of deflection for left front tire, and front arrow indicates final rest position of Hyundai's right front tire

Post-Crash: The driver of the Hyundai remained inside the vehicle at final rest. She was conscious and was able to exit her vehicle without any assistance. The second row right passenger also remained inside the vehicle at final rest. He was unconscious but breathing upon arrival of the investigating police officer. He was unable to exit the Hyundai because of his injuries. The investigating police agency was notified of the crash within 7 minutes post-crash and arrived on-scene a short time later. Traffic control procedures were established and emergency medical and towing services were called to assist. The driver was transported by ambulance to the hospital where she was hospitalized over night. The second row right passenger was removed from his vehicle by emergency medical technicians and was transported by ambulance to a medical facility where he was pronounced dead 62 minutes post-crash. Following the police investigation, the Hyundai and the Dodge were towed from the scene due to damage.

The 2006 Hyundai Sonata GL was a front wheel drive, 5-passenger, 4-door sedan (VIN: 5NPET46C06H------) equipped with a 2.4L, I-4 engine and a 4-speed automatic transmission. Braking was achieved by a power-assisted, front and rear disc, 4-wheel, anti-lock system with electronic brake force distribution. Inspection of the vehicle's interior revealed adjustable front bucket seats with adjustable head restraints, a non-adjustable second row bench seat with adjustable head restraints for the second row outboard seating positions, and an integral head restraint for the second row center seating position. The Hyundai's wheelbase was 273 centimeters (107.4 inches), and the odometer reading at inspection was unknown because the Hyundai was equipped with an electronic odometer. The Hyundai was manufacturer Certified Advanced 208-Compliant and was equipped with multi-stage driver and front right passenger air bag inflators, driver and front right passenger seat whiplash protection systems, and traction and stability control. Furthermore, there was an occupant weight sensor for the front right passenger seating position. The occupant sensing system automatically switches the front right passenger front air bag on or off based on the passenger's weight and the type of pressure on the seat. In addition, the Hyundai was equipped with front seat back-mounted side impact air bags, and right and left side inflatable curtain air bags protecting all outboard seating positions. The Hyundai was equipped with height adjustable head restraints for all positions, Lower Anchors and Tethers for Children (LATCH) system features, and a tire pressure monitor.

CASE VEHICLE DAMAGE

Damage Classification: The CDC for the Hyundai was determined to be: **12-FDEW-3** (**0** degrees). The WinSMASH reconstruction program, Damage Only algorithm, was used on the Hyundai's highest severity impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 55.0 km/h (34.2 mph), -55.0 km/h (-34.2 mph), and 0.0 km/h (0.0 mph).

Figure 11: Hyundai's frontal damage viewed from left of front; Note: measurement location of C_6 and rightward movement of crush profile

Figure 12: Hyundai's frontal damage viewed from right along stringline; Note: restriction of right front tire from crush

Exterior Damage: The Hyundai's contact with the Dodge involved the entire front with the damage distributed across the entire frontal plane (**Figures 7**, **11**, and **12**). The direct damage began at the front right bumper corner and extended 107 centimeters (42.1 inches), along the front

bumper's metal reinforcement bar. The residual maximum crush was measured as 65 centimeters (25.6 inches) at C_4. The table below shows the Hyundai's crush profile.

Units	Event	Direct Damage		Field L	C_1	C_2	C_3	C_4	C_5	C_6	Direct	Field L
		Width CDC	Max Crush								±D	±D
cm	1	107	65	94	7	40	61	65	63	62	0	0
in		42.1	25.6	37.0	2.8	15.7	24.0	25.6	24.8	24.4	0.0	0.0

The wheelbase on the Hyundai's left side was shortened 3 centimeters (1.2 inches) while the right side was shortened 29 centimeters (11.4 inches). The Hyundai's front bumper, bumper fascia, grille, radiator, hood, right and left headlight and turn signal assemblies, and right fender were directly damaged and crushed rearward. There was induced damage to both right and left fenders as well as the hood, the windshield's glazing, and both right side doors which were jammed rearward and could not be opened. Remote buckling was also found on the right central portion of the Hyundai's roof near the right B-pillar. No obvious induced damage or remote buckling was noted to the remainder of the Hyundai's exterior.

The vehicle manufacturer's recommended tire size was P215/60R16, and the Hyundai tires were the recommended size. The Hyundai's tire data are shown in the table below. In addition, the Hyundai's right front wheel was rotated outward from the crash (**Figure 9**).

Tire	*Measured Pressure*		*Vehicle Manufacturer's Recommended Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kPa	psi	kPa	psi	milli-meters	32nd of an inch			
LF	172	25	207	30	5	6	None	No	No
LR	172	25	207	30	6	8	None	No	No
RR	179	26	207	30	6	8	None	No	No
RF	0	0	207	30	6	8	None observed	Yes	Yes

Interior Damage: Inspection of the Hyundai's interior revealed no evidence of occupant contact on the front interior surfaces (**Figures 13** and **14**). However, there was deformation to the back surface of the front right seat back from loading by the second row right passenger and/or child safety seat in the second row right position (**Figures 15** and **16**). In addition, the Hyundai sustained several minor intrusions in this crash. There was a 2 centimeter (0.8 inch) vertical intrusion to the floor pan on the driver's side, a 3 centimeter (1.2 inch) longitudinal intrusion to the toe pan on the front right passenger side, and the center console intruded 3 centimeters (1.2

inches) laterally toward the steering column (**Figure 13**). In addition, all three second row seating positions were intruded forward, longitudinally, probably from unknown cargo in the vehicle's trunk. The largest intrusion was 4 centimeters (1.6 inches) to the second row center position. Finally, there was no evidence of compression of the energy absorbing steering column and no deformation to the steering wheel rim.

Figure 13: Hyundai's driver seating area showing no obvious occupant contacts to front interior surfaces

Figure 14: Hyundai's front right seating area showing non-deployed air bag and no evidence of occupant contact; Note: dislodged glove box door

Figure 15: Hyundai's back surface of front right seat back showing contact evidence (arrow) from back right passenger and/or child safety seat

Figure 16: Close-up of deformation to left side back surface of Hyundai's front right seat back from back right passenger and/or child safety seat

The Hyundai's manual restraint systems are shown in the table below.

	Left	Center	Right
First Row	Continuous loop, lap-and-shoulder, safety belt system with upper anchorage adjustor for the D-ring located in its upmost position; retractor-mounted pretensioner without force limiter; sliding type latch plate with ELR		Continuous loop, lap-and-shoulder, safety belt system with upper anchorage adjustor for the D-ring located in its upmost position; retractor-mounted pretensioner without force limiter; sliding type latch plate with ELR
Second Row	Continuous loop, lap-and-shoulder, safety belt system without upper anchorage adjustor for the shoulder belt guide; sliding type latch plate with switchable retractor type; lower anchor present; top tether anchor located behind the seat back	Continuous loop, lap-and-shoulder, safety belt system; sliding type latch plate with switchable retractor type; no lower anchor present; top tether anchor located behind the seat back	Continuous loop, lap-and-shoulder, safety belt system without upper anchorage adjustor for the shoulder belt guide; sliding type latch plate with switchable retractor type; lower anchor present; top tether anchor located behind the seat back
ELR = Emergency Locking Retractor		Switchable = either	ALR = Automatic Locking Retractor

Figure 17: Loading evidence on torso portion of safety belt for Hyundai's driver; Note: tag identifying location of driver's non-deployed, seat back-mounted, side impact air bag

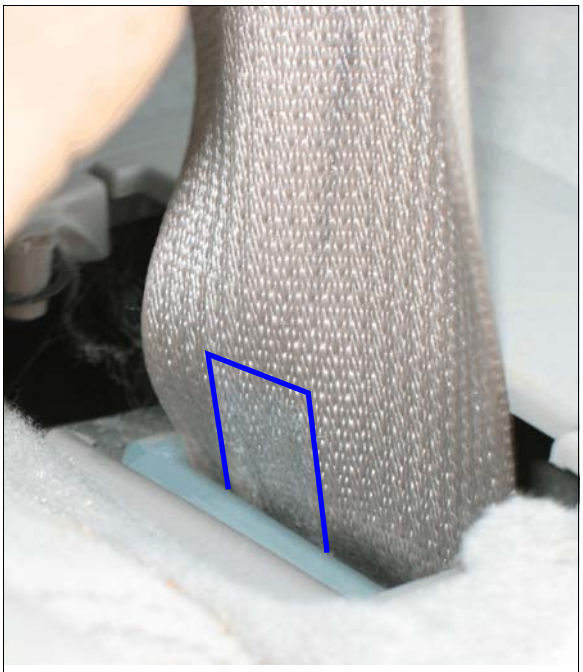


Figure 18: Loading evidence (outlined) on lap belt portion of Hyundai's second row right safety belt from lap belt guide in bight of seat

Both front and second row seat belts exhibited indications of historical usage. The inspection of the driver's safety belt webbing, D-ring, and latch plate revealed that the pretensioner had actuated and showed evidence of loading (**Figure 17**). The inspection of the second row right passenger's safety belt webbing, shoulder belt guide, and latch plate revealed evidence of loading on the lap belt portion from the guide in the bight of the second row right seat (**Figure**

18). According to the driver, the child's lap belt was across his hips/upper thighs and the shoulder belt was positioned through the child seat's middle guide path.

AUTOMATIC RESTRAINT SYSTEM

The Hyundai was equipped with a Supplemental Restraint System (**SRS**) that consisted of multi-stage frontal air bags at the driver and front right passenger positions. In addition, the Hyundai was equipped with front seat back-mounted side impact air bags and right and left side-inflatable curtain air bags that were designed to deploy from the A-pillars and roof side rails. The driver's air bag deployed as a result of the frontal impact with the Dodge (**Figure 19**); however, it is unknown whether more than one stage of the multi-stage air bag was activated. The Hyundai's right side inflatable curtain also deployed as a result of the Hyundai's frontal impact (**Figures 20** and **21**). It is not known why the right side inflatable curtain deployed while the left side inflatable curtain did not deploy; however, several factors could have influenced this occurrence. First, the severe crash [i.e., -55.0 km/h (-34.2 mph) Longitudinal Delta V] was offset toward the vehicle's right side making the actual deceleration along the right side of the vehicle higher than the reported WinSMASH results. In this contractor's experience, instances of side curtain air bags deploying in primarily frontal collisions are rare but not unheard of. Second, the Hyundai rotated clockwise post-crash while also being redirected backwards. While the vehicle was yawing with its right side leading, loading occurred to the right side surface which could possibly have triggered the deployment of the side inflatable curtains. Finally, during the clockwise rotation the vehicle may have experienced some degree of rightward roll, and this roll may have triggered the side curtain deployment.

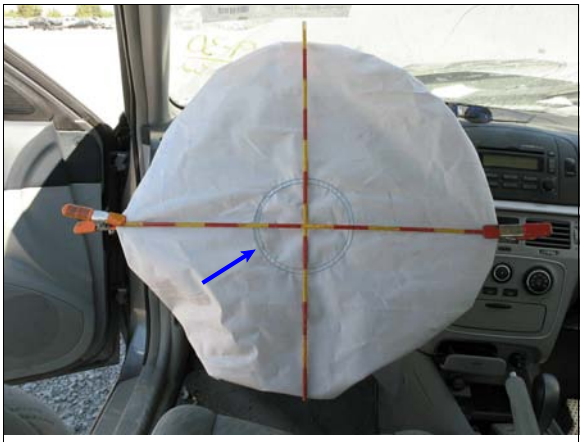


Figure 19: Hyundai's deployed driver air bag showing only minimal evidence of occupant interaction (e.g., arrow indicates a discoloration near the 8 o'clock position of the tether's stitching)

The Hyundai's driver air bag was located in the steering wheel hub. An inspection of the air bag module's cover flaps and the air bag's fabric revealed that the cover flaps opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover flaps. The driver's air bag was designed with two tethers, each approximately 7.5 centimeters (3.0 inches) in width. The driver's air bag had two vent ports, approximately 4 centimeters (1.6 inches) in diameter, located at the 11 and 1 o'clock positions. The deployed driver's air bag was circular with a diameter of 62 centimeters (24.4 inches). An inspection of the

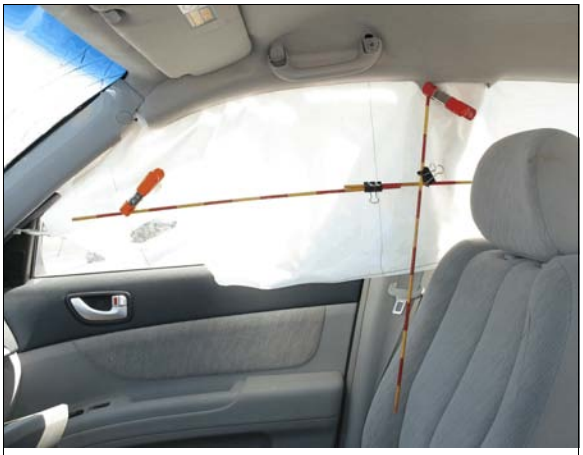


Figure 20: Front portion of Hyundai's deployed right side curtain air bag showing no contact evidence on air bag's interior surface

driver's air bag fabric revealed very light deployment scuffs in the left upper quadrant and right half and a faint orangish/yellowish discoloration at the circular tether stitching near the 8 o'clock position (**Figure 19**).

Figure 21: Back portion of Hyundai's deployed right side curtain air bag showing no contact evidence on air bag's interior surface

The Hyundai's right and left side curtain air bags were housed within the A-pillar and the roof side rails under the headliner (**Figures 20** and **21**). The right side curtain air bag extended from the A-pillar to near the C-pillar. It was designed to provide protection to an occupant's head during a side impact. The air bag was attached to the right A-pillar (**Figure 20**) and the right C-pillar (**Figure 21**). There was no tether at either the front or back of the air bag. The right side curtain air bag was rectangular with a length of 170 centimeters (66.9 inches) and a height of 36 centimeters (14.2 inches); however, for the first 30 centimeters (11.8 inches) rearward of the right A-pillar, the height of the air bag was a little shorter in height than the height of the remainder of the air bag (**Figure 20**), and there were two cutouts (see through elliptical areas) in the material (**Figures 9** and **20**). The air bag was designed with 4 U-shaped inflatable chambers adjacent to each seat position. For the front right seating position, the four chambers were all adjacent to one another. For the second row right seating position, three chambers were adjacent to each other while the forward-most chamber was separated from the three rearmost chambers by a non-inflatable area. The air bag chambers were designed without any tethers or vent ports. Inspection of the air bag revealed no deployment damage on either the outboard or inboard surfaces. An inspection of the air bag's fabric revealed no contact evidence on the interior surface of the air bag's fabric.

Figure 22: Cosco Alpha Omega, convertible child safety seat used in forward-facing position by Hyundai's second row right passenger as a high-back, belt-positioning booster seat

CHILD SAFETY SEAT

The second row right passenger was seated in a child safety seat that was designed by the manufacturer as a 3-in-1, booster/convertible seat (BSS/CSS). In this crash the child seat was used in its forward-facing configuration as a high-back belt-positioning booster seat (**Figure 22**). The BSS/CSS was manufactured by Cosco/Dorel on May 24, 1999. The child seat was identified by model name Alpha Omega and model number **02**

331 ZAC. Based on this contractor's inspection of the vehicle and a search for information on the world wide web, the booster/convertible seat was designed with a five-point harness connected to a pullover tray-shield which attached between the child's legs into a recessed buckle. There was only one slot to thread the harness through. However, the seat as used in this crash did not have its base, tray-shield (**Figure 23**), or harness straps attached. The BSS was in the upright position.

Figure 23: Left (inboard) side of child safety seat used by Hyundai's second row right passenger; arrow denotes location where tray-shield attaches

The BSS/CSS consisted of a plastic one-piece shell. The driver indicated that she had placed the child in the seat prior to the crash. Although she had spooled the vehicle's safety belt out, she did not know whether she engaged the automatic locking feature while securing the child restraint. No locking clip was used on this passenger's safety belt.

Figure 24: Stress marks on inboard side of Cosco child safety seat's left lap belt guide

Figure 25: Stress marks on outboard side of Cosco child safety seat's left lap belt guide

An inspection of the CSS revealed no apparent fractures to the seat's shell, but there was damage (stress marks indicating buckling of the plastic) on the seat's left lap belt guide (**Figures 23** through **Figure 26**). Furthermore, there was loading evidence (belt scrapes) on the right lap belt guide (**Figures 27** and **28**). In addition, there was damage to the right shoulder belt guide (stress marks indicating buckling of the plastic–**Figure 29**), and one of the guide's fastening screws had been pulled out of its attachment point on the shell (**Figure 30**).

Figure 26: Close-up of stress damage behind left lap belt guide of CSS used by Hyundai's second row right passenger

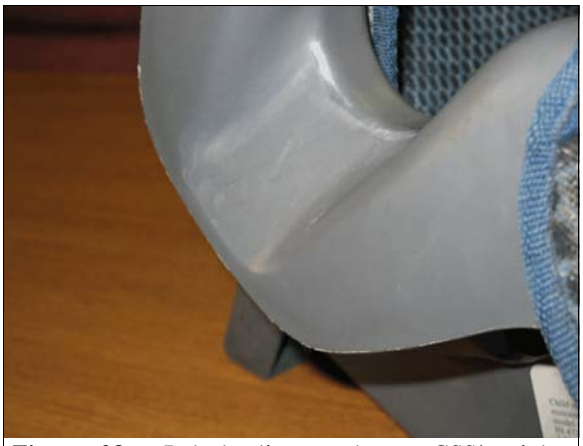


Figure 28: Belt loading marks on CSS's right (outboard) lap belt guide used by second row right passenger

Figure 27: Right (outboard) side of CSS used by second row right passenger

Figure 29: Right (outboard) shoulder belt guide on CSS used by second row right passenger showing white stress marks from loading on guide; Note: screw (arrow) pulled out of seat's plastic frame

The BSS/CSS, when used in the forward-facing configuration without the shield/harness, was designed for use by children with weight limitations between 13.6 - 31.8 kilograms (30-70 pounds).

CASE VEHICLE KINEMATICS–OVERVIEW

The Hyundai's distracted driver (see Driver Kinematics below) made no known pre-crash avoidance maneuvers. As a result and independent of the use of the occupants available safety belts, their pre-impact body positions did not change just prior to impact. The Hyundai's impact with the 2001 Dodge Intrepid enabled the Hyundai's occupants to continue forward and

slightly upward along a path opposite the **0** degree Direction of Principal Force as the Hyundai decelerated. At maximum engagement, the Hyundai rotated approximately 45 degrees clockwise and was pushed backward by the force of the impact with the Dodge.

Figure 30: Close-up of location on CSS's plastic frame where screw holding right (outboard) shoulder belt guide pulled out

DRIVER KINEMATICS

The Hyundai's driver [23-year-old, female; 165 centimeters and 50 kilograms (65 inches, 110 pounds)] was seated but was leaning forward (having just picked up an object on the floor), her left foot on the floor, her right foot either on the accelerator or in transition between her accelerator and brake and, according to her interview, she had both of her hands on the steering wheel–possibly in the 3 and 9 o'clock positions. Her seat track was located in its middle position, the seat back was slightly reclined, and the tilt steering column was located in its center position.

The Hyundai's driver was restrained by her safety belt system. There was evidence of belt pattern bruising and abrasions to the driver's torso.

As a result of the impact, the driver loaded both the lap and torso portions of her safety belt webbing and her head probably hyper-flexed (bent forward) because her trunk was restrained by her lap belt. Based on kinematic principles, the driver's face impacted her deploying air bag, possibly depositing the orange/yellow transfer. Because of the severity of the crash, the driver would have moved upward as well, but her safety belts inhibited this movement.

As a result of maximum engagement, the driver moved rearward and rightward toward the back of her seat. Her exact position at final rest is unknown.

DRIVER INJURIES

According to her interview and medical records, the injuries sustained by the Hyundai's driver included: a fractured right ankle, abdominal abrasions and contusions, contusions along her right forearm and wrist, contusions along the medial side of her left leg, a right ankle contusion, and a laceration on her left big toe.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source	Source Confidence	Source of Injury Data
1	Fracture, non-displaced or minimal displaced right medial malleolus with joint effusion	moderate 853412.2,1	Floor, foot controls {indirect injury}	Certain	Hospitalization records
2	Abrasions x2 lower right abdomen	minor 590202.1,1	Torso portion of safety belt system	Certain	Emergency room records
3	Abrasions {rash} across lower abdomen	minor 590202.1,8	Lap portion of safety belt system	Certain	Emergency room records
4	Contusion {bruising}, extensive, over lower abdomen	minor 590402.1,8	Lap portion of safety belt system	Certain	Hospitalization records
5	Contusions {bruising}, random, from right elbow to	minor 790402.1,1	Left instrument panel, right of steering column	Probable	Interviewee (same person)
	wrist with edema, not further specified				Emergency room records
6	Contusion {bruises} over left medial lower leg from knee to calf with swelling	minor 890402.1,2	Left lower instrument panel and/or knee bolster, left of steering column	Probable	Hospitalization records
7	Contusion {ecchymosis, bruising} right ankle with edema	minor 890402.1,1	Floor, foot controls	Probable	Hospitalization records
8	Laceration {cut} on left big toe, not further specified	minor 890600.1,2	Floor, foot controls	Probable	Interviewee (same person)

SECOND ROW RIGHT PASSENGER KINEMATICS

The Hyundai's second row right passenger [4-year-old, male; 122 centimeters and 34 kilograms (48 inches, 75 pounds)] was seated in his BSS/CSS in an upright posture with his back against the back of his child seat, and his feet dangling over the front edge of the child seat's cushion. According to the driver, before the crash he had a cup in one of his hands. It is unknown if the cup was still in his hands just prior to impact or the exact position of his hands. The second row had a non-adjustable bench seat, and the folding seat back was upright.

Figure 31: On-scene police photo of child safety seat used by Hyundai's back right passenger

Based on the vehicle inspection, the Hyundai's second row right passenger was restrained in his booster safety seat (**Figure 31**) by his vehicle's safety belts. There was no direct evidence of belt pattern bruising and/or abrasions

to the passenger's torso. However, it was reported by the second row right passenger's grandfather that this occupant sustained a crushed heart, implying significant loading occurred to the torso webbing of the safety belt.

As a result of the impact, the second row right passenger loaded the torso belt and his head probably hyper-flexed (bent forward) because his trunk was restrained by the lap belt. Because of the severe nature of the crash, this occupant would have moved upward as well, but his safety belts inhibited this movement. As indicated above, objects in the trunk of the Hyundai loaded the second row seat causing the seat to intrude forward 3 centimeters (1.2 inches). As a result of the intrusion and the dynamic forces of the collision, the occupant and BSS moved forward into the back surface of the front right seat back, deforming it (**Figures 15**, **16**, and **32**).

Figure 32: On-scene police photo of child safety seat used by Hyundai's second row right passenger; Note: seat and occupant intruded into back of front right seat back

As a result of the impact, the second row right passenger moved leftward and rearward toward the back of his booster CSS. According to the Police Crash Report, the investigating officer observed the child in his booster safety seat, slightly angled towards the right side of the vehicle, with his head slumped over.

SECOND ROW RIGHT PASSENGER INJURIES

According to the interview with this occupant's grandfather and his medical records, the Hyundai's second row right passenger sustained a nonanatomic brain injury, a fractured right humerus, a crushed heart, a broken neck, forehead and scalp contusions, and safety belt-related contusions. This occupant's primary head and brain lesions resulted from contacting the back surface of the front right seat.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Nonanatomic brain injury with loss of consciousness, pupils fixed and dilated, unresponsive, asystole, GCS = 3	critical 160824.5,0	Seat back, front right passenger's	Possible	Emergency room records
2	Fractured neck, not further specified[1]	unknown 615999.7,6	Seat back, front right passenger's	Possible	Interviewee (relative)

[1] This occupant's emergency room records do not rule out this lesion. Specifically, a questionable instability was noted; however, this occupant only spent twenty minutes in the ER before being pronounced dead, and the majority of the medical effort involved his resuscitation. No autopsy was performed.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
3	Fracture right humerus, not further specified	moderate 752600.2,1	Torso portion of safety belt system	Possible	Emergency room records
4 5	Contusion {ecchymosis} central forehead and anterior scalp, not further specified	minor 190402.1,5 290402.1,7	Seat back, front right passenger's	Certain	Emergency room records
6	Crushed heart, not further specified	unknown 415999.7,0	Torso portion of safety belt system	Probable	Interviewee (relative)
7	Contusion {ecchymosis} diagonally across chest and abdomen	minor 490402.1,4	Torso portion of safety belt system	Certain	Emergency room records
8	Contusion {ecchymosis} transversely across lower abdomen	minor 590402.1,8	Lap portion of safety belt system	Certain	Emergency room records
9	Contusion {ecchymosis} diagonally on right shoulder	minor 790402.1,1	Torso portion of safety belt system	Certain	Emergency room records
10	Contusion {bruising}, 5.1-7.6 cm (2-3 in) on right upper arm and just below elbow	minor 790402.1,1	Torso portion of safety belt system	Possible	Interviewee (driver)

OTHER VEHICLE

The 2001 Dodge Intrepid SE was a front wheel drive, 5-passenger, 4-door sedan (VIN: 2B3HD46R51H------) equipped with a 2.7L, V-6 engine, 4-speed automatic transmission, and redesigned driver and front right passenger air bags that deployed as a result this vehicle's impact. Braking was achieved by a power-assisted, front disc and rear drum system. The Dodge's wheelbase was 287 centimeters (113.0 inches), and the odometer reading is unknown because the Dodge's interior was not inspected. Based on the available information, the vehicle was equipped with manual, lap-and-shoulder, safety belt systems for the front and back outboard seating positions. The second row center seat had a manual lap belt. Standard interior equipment included bucket seats for the driver and front right passenger, and a non-adjustable 60/40 split back bench seat.

Figure 33: Dodge's frontal damage viewed from left of front; Note: measurement location of C_6 and rightward movement of crush profile

Damage Classification: The CDC for the Dodge was determined to be: **12-FDEW-3** (**0** degrees).

Exterior Damage: The Dodge's contact with the Hyundai involved the entire front with the damage distributed across the width of the bumper (**Figures 8** and **33**). The direct damage began on the front left bumper corner and extended 105 centimeters (41.3 inches), along the front bumper. The residual maximum crush was measured as 69 centimeters (27.2 inches) at C_4. The table below shows the Dodge's crush profile.

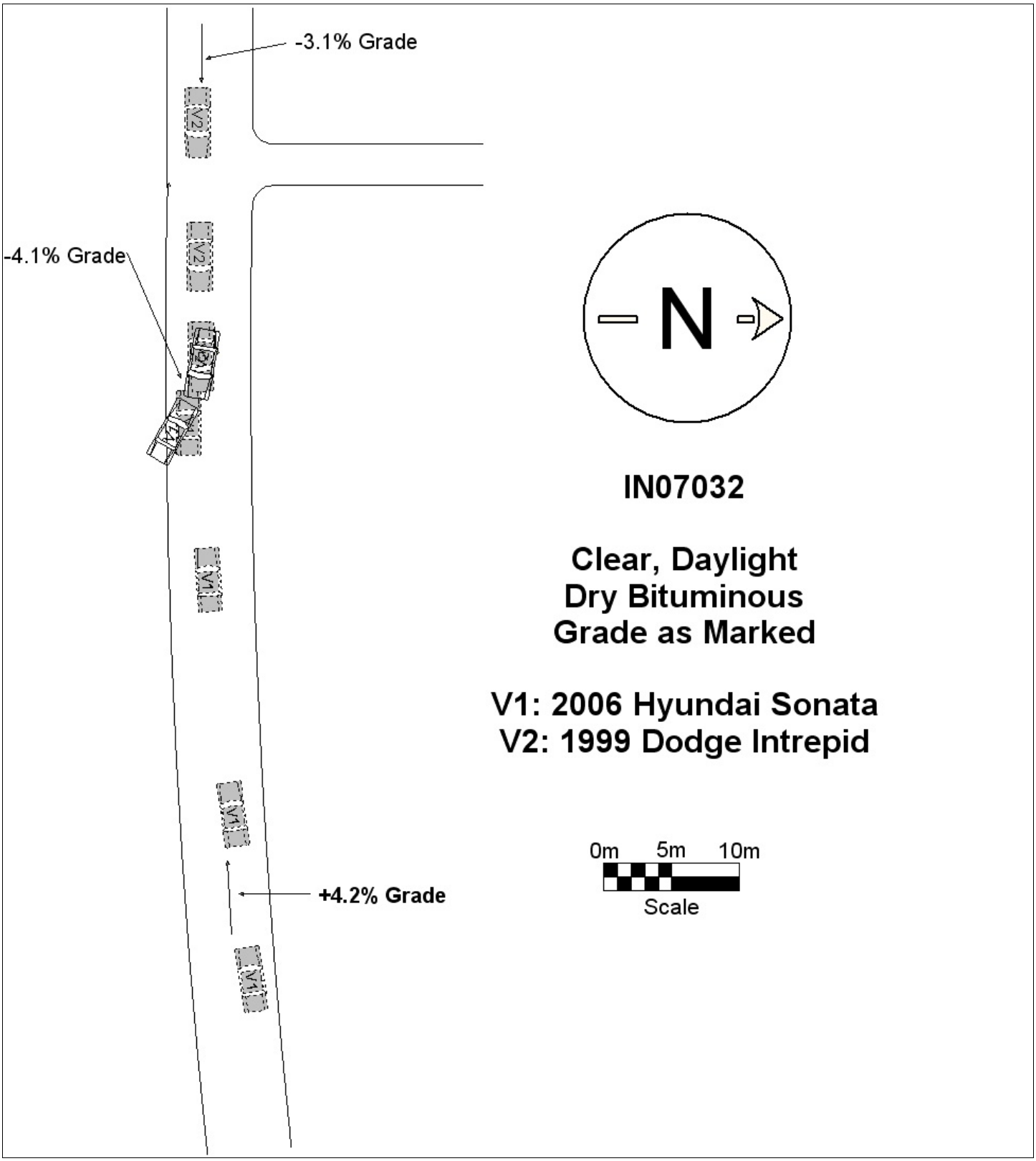
Units	Event	Direct Damage		Field L	C_1	C_2	C_3	C_4	C_5	C_6	Direct	Field L
		Width CDC	Max Crush								±D	±D
cm	1	130	69	105	29	42	66	69	62	61	0	0
in		51.2	27.2	41.3	11.4	16.5	26.0	27.2	24.4	24.0	0.0	0.0

The wheelbase on the Dodge's left side was shortened 8 centimeters (3.1 inches) while the right side was shortened 30 centimeters (11.8 inches). The Dodge's front bumper, bumper fascia, both the right and left headlight and turn signal assemblies, grille, radiator, and hood were directly damaged and crushed rearward. There was induced damage to as well to the hood, the windshield's glazing, roof, both the right and left fenders, and the left front and left rear doors. No obvious induced damage or remote buckling was noted to the remainder of the Dodge's exterior.

The vehicle manufacturer's recommended tire size was P225/60R16, and the Dodge's tires were the recommended size. The Dodge's tire data are shown in the table below.

Tire	*Measured Pressure*		*Vehicle Manufacturer's Recommended Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kPa	psi	kPa	psi	milli-meters	32nd of an inch			
LF	207	30	221	32	6	8	None	Yes	No
LR	159	23	221	32	4	5	None	No	No
RR	200	29	221	32	6	8	None	No	No
RF	Flat	Flat	221	32	5	6	Heavy impact and rim damage from Hyundai	Yes	Yes

Dodge's Occupant: According to the Police Crash Report, it is unknown whether the Dodge's driver [28-year-old, male] was restrained by his lap-and-shoulder, safety belt system. The driver was also transported by ambulance to the hospital, and he sustained police-reported "A" (incapacitating) injuries as a result of this crash. His treatment status as well as specific injuries are unknown.


-3.1% Grade
-4.1% Grade
+4.2% Grade
V1
V2
N
IN07032
Clear, Daylight
Dry Bituminous
Grade as Marked
V1: 2006 Hyundai Sonata
V2: 1999 Dodge Intrepid
0m 5m 10m
Scale