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ON-SITE CHILD SAFETY SEAT INVESTIGATION

CASE NUMBER - IN-06-034

LOCATION - IOWA

VEHICLE - 2003 HYUNDAI ELANTRA XD

CRASH DATE - November 2006

Submitted:

May 1, 2007

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The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points be coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety systems.

Technical Report Documentation Page

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15. <i>Supplementary Notes</i> On-site child safety seat investigation involving a 2003 Hyundai Elantra XD equipped with manual safety belts, dual front air bag system and a child safety seat installed in the back right seat position.					
16. <i>Abstract</i> This report covers an on-site child safety seat investigation that involved a 2003 Hyundai Elantra (case vehicle) and a 1997 Chrysler Sebring JXi (other vehicle), which were involved in an intersection crash on a county roadway. This crash is of special interest because the case vehicle's back right passenger [22-month-old, female], was seated in a child safety seat, ejected from the case vehicle and sustained an incapacitating injury as a result of the crash. The case vehicle was traveling east approaching a stop sign at a four-leg intersection. The Chrysler was traveling north in the northbound lane also approaching the intersection. As the case vehicle entered the intersection, the front of the Chrysler impacted the case vehicle's right rear side. The case vehicle rotated clockwise and traveled off the northeast corner of the intersection and the left quarter panel impacted a metal street sign, knocking it over. The case vehicle continued into a grassy field and came to final rest facing southwest. The Chrysler rolled backward to final rest on the west roadside heading southeast. The case vehicle's back right passenger was seated in her forward facing child safety seat, which was improperly secured in the case vehicle resulting in the ejection of the back right passenger out of the right rear window during the crash. The back right passenger was transported to a hospital and admitted.					
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This on-site investigation was brought to NHTSA's attention on or before November 8, 2006 from an Iowa newspaper article. This crash involved a 2003 Hyundai Elantra XD (case vehicle) and a 1997 Chrysler Sebring JXi (other vehicle). The crash occurred in November, 2006, at 6:54 a.m., in Iowa and was investigated by the applicable county sheriff's department. This crash is of special interest because the case vehicle's back right passenger [22-month-old, White (non-Hispanic) female], was seated in a child safety seat and was ejected from the case vehicle and sustained an incapacitating injury. This contractor inspected the case vehicle and interviewed the case vehicle's driver on November 20, 2006. Inspections of the Chrysler and crash scene were completed on November 21, 2006. This report is based on the sheriff's department crash report, on-scene photographs, interviews with the case vehicle's driver and the investigating sheriff's deputies, scene and vehicle inspections, back right passenger's medical records, occupant kinematic principles, and this contractor's evaluation of the evidence.

SUMMARY

The case vehicle was traveling east on a two lane county roadway approaching a stop sign at a four-leg intersection. The Chrysler was traveling north in the northbound lane also approaching the intersection. The Chrysler's approach was uncontrolled. The case vehicle entered the intersection. The front of the Chrysler impacted the case vehicle's right rear side causing the case vehicle's driver air bag to deploy. The Chrysler's driver and front right passenger air bags also deployed. The case vehicle rotated clockwise and traveled off the northeast corner of the intersection and the left quarter panel impacted a metal street sign, knocking it over. Following the impact with the street sign, the case vehicle continued into a grassy field and came to final rest facing southwest. Following impact with the case vehicle, the Chrysler rotated clockwise and traveled to the northeast corner of the intersection. The Chrysler then rolled backward northwest across the southbound travel lane and came to final rest facing southeast with its rear wheels on the west roadside and the front wheels in the southbound lane. The case vehicle's back right passenger was ejected from her child safety seat and out the right rear window during the crash.

The CDCs for the case vehicle were determined to be: **02-RZEW-3 (70 degrees)** for the initial impact with the Chrysler and **09-LBEN-2 (270 degrees)** for the street sign impact. The case vehicle sustained maximum residual crush from the impact with the Chrysler of 32 centimeters (12.6 inches) occurring at C₂. The WinSMASH reconstruction program, damage only algorithm, calculated the case vehicle's Total, Longitudinal, and Lateral Delta Vs for the impact with the Chrysler (i.e., highest severity impact) respectively as: 26 km.p.h. (16.2 m.p.h.), -8.9 km.p.h. (-5.5 m.p.h.), and -24.4 km.p.h. (-15.2 m.p.h.). The crash fit the reconstruction model and the results appeared reasonable. The case vehicle was towed due to damage.

The CDC for the Chrysler was determined to be: **11-FDEW-3 (340 degrees)**. The Chrysler sustained residual maximum crush of 44 centimeters (17.3 inches) occurring at C₆. The WinSMASH reconstruction program, damage only algorithm, calculated the Chrysler's Total, Longitudinal, and Lateral delta Vs respectively as: 22.0 km.p.h (13.7 m.p.h.), -20.7 km.p.h.

(-12.9 m.p.h.), and 7.5 km.p.h. (4.7 m.p.h.). The crash fit the reconstruction model and the results appeared reasonable. The Chrysler was towed due to damage.

The case vehicle's back right passenger was seated in a forward-facing, convertible child safety seat with a tray shield. The child safety seat was manufactured by Evenflo, October 13, 2000. Its model number was 2591134P1. The model name was "Secure Advantage 1". The child safety seat was designed with a tray shield harness with a harness retainer clip. The tray shield straps and latch plate buckled between the child's legs into a recessed buckle. The on-site investigation determined that the back right passenger's harness straps were most likely not secured and the child safety seat was improperly secured in the case vehicle. Both factors contributed to the ejection of the back right passenger through the right rear window during crash. The back right passenger sustained a fractured right femur due to contact with the right side of the child safety seat during the initial right side impact. The child also sustained numerous brain injuries and facial fractures, which were most likely due to contact with the ground following the ejection. The back right passenger was transported by ground ambulance to a local hospital and then airlifted to a children's hospital where she was hospitalized for 12 days.

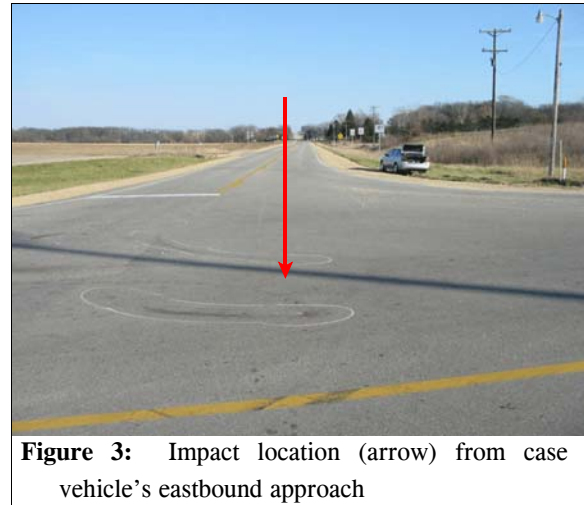
CRASH CIRCUMSTANCES

Crash Environment: The trafficway on which the case vehicle was traveling was a two-lane, undivided, county roadway, traversing in an east-west direction. The case vehicle was approaching a four-leg intersection. The case vehicle's approach to the intersection was straight and level and controlled by a stop sign. The eastbound lane was 3.6 meters (11.8 feet) in width while the westbound lane was 3.7 meters (12.1 feet) in width. The roadway was bordered by gravel shoulders. The westbound approach to the intersection was also controlled by a stop sign. The trafficway on which the Chrysler was traveling was a two-lane, undivided, county roadway traversing in a north-south direction. The Chrysler was approaching the same four-leg intersection. The Chrysler's approach was straight, had a negative 3.9% grade and was uncontrolled. The northbound lane was 3.9 meters (12.8 feet) in width on the approach to the intersection, while the southbound lane was 3.4 meters (11.2 feet) in width. The roadway was bordered by gravel shoulders. Roadway pavement markings for the case vehicle consisted of solid white edge lines, a double yellow center line and solid white stop bar at the intersection. Roadway pavement markings for the Chrysler consisted of solid white edge line and broken yellow center line. The speed limit was 89 km.p.h (55 m.p.h). There was no regulatory speed limit sign posted near the crash site. At the time of the crash, the light condition was daylight, the atmospheric condition was partly cloudy, and the roadway pavement was dry, traveled bituminous. Traffic density was light and the site of the crash was a rural farming area. See the Crash Diagram at the end of this report.



Figure 1: Case vehicle eastbound approach to impact area (denoted by arrow)

Pre-Crash: The case vehicle was traveling east in the eastbound lane (**Figure 1** above) approaching the stop sign at the intersection. The case vehicle's driver was intending to proceed straight ahead through the intersection. The sheriff's department crash report indicated that the case vehicle's driver failed to yield the right-of-way and entered the intersection. The Chrysler was traveling north in the northbound lane (**Figure 2**) also approaching the intersection. The Chrysler's driver was intending to continue northbound through the intersection. The case vehicle's driver made no avoidance maneuvers prior to the crash. The crash occurred in the four-leg intersection of the two trafficways (**Figure 3**).



Crash: The front of the Chrysler (**Figure 4**) impacted the right rear side of the case vehicle (**Figure 5**) causing the case vehicle's driver air bag to deploy. In addition, the Chrysler's driver and front right passenger air bags also deployed. As a result of the impact, the case vehicle rotated clockwise approximately 410 degrees and traveled off the northeast corner of the intersection (**Figure 6** below). As it rotated off the shoulder, the left quarter panel (**Figure 7** below) impacted a metal street sign, knocking it over (**Figure 6** below). The case vehicle's back right passenger was ejected from her child safety seat and out the right rear window during the crash.



Post-Crash: Following the impact with the street sign, the case vehicle continued into a grassy field and came to final rest facing southwest (**Figure 8**) rotating a total of approximately 500 degrees. Following impact with the case vehicle, the Chrysler rotated clockwise and traveled to the northeast corner of the intersection. The Chrysler then rolled backward northwest across the southbound travel lane and came to final rest facing southeast with its rear wheels on the west roadside and the front wheels in the southbound lane (**Figure 9**).



Figure 6: Case vehicle's roadway departure, arrow shows location of impacted street sign

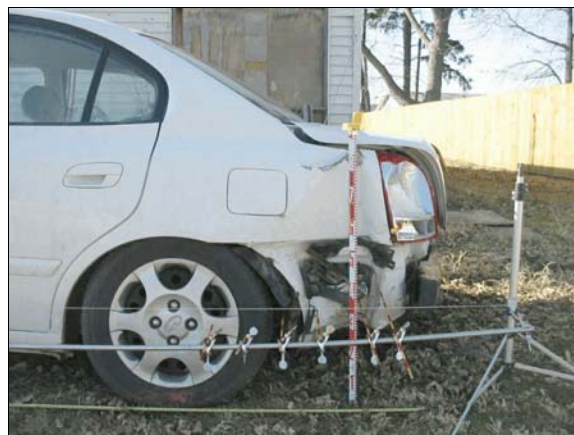


Figure 7: Overview of left quarter panel damage from impact with street sign

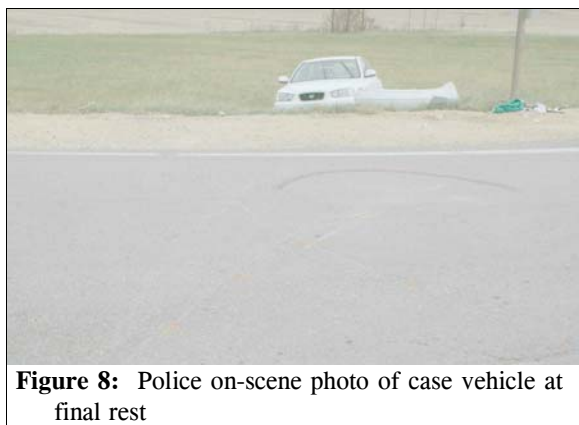


Figure 8: Police on-scene photo of case vehicle at final rest



Figure 9: Police on-scene photo showing view northwest to Chrysler's final rest position

CASE VEHICLE

The 2003 Hyundai Elantra XD was a front wheel drive, four-door sedan (VIN: KMHDN45D83U-----) equipped with a 2.0 L, I-4 engine, and a five-speed manual transmission. Four wheel, anti-lock brakes and traction control were an option on the case vehicle, but it is unknown if it was so equipped. In addition, the case vehicle was equipped with Advanced Occupant Protection System (AOPS) features, such as dual stage driver and front right passenger air bag inflators, safety belt pretensioners, seat position sensor and seat back-mounted side impact air bags. The front seating row was equipped with bucket seats, adjustable head restraints, and manual, three-point, lap-and-shoulder belts with adjustable upper anchors. The back seating row was equipped with a bench seat with folding backs, adjustable head restraints at the outboard seating positions and three-point, lap-and-shoulder safety belts at all three seating positions. The case vehicle was also equipped with upper tether anchors at all rear seating

positions and LATCH at the outboard seating positions for securing child safety seats. The case vehicle's specification wheelbase was 261 centimeters (102.8 inches). The case vehicle's odometer reading at the time of the inspection is unknown because the case vehicle was equipped with an electronic odometer.

CASE VEHICLE DAMAGE

Exterior Damage: The case vehicle's impact with the Chrysler involved the rear half of the right side. The right rear door, right rear wheel, right quarter panel, rear bumper, and rear bumper fascia were directly damaged and crushed inward. In addition, the rear bumper was slightly displaced rearward. Direct damage began 184 centimeters (72.4 inches) rear of the right front axle and extended 166 centimeters (65.3 inches) rearward to the right rear bumper corner. Crush measurements were taken along the lower door level and the residual maximum crush was measured as 32 centimeters (12.6 inches) occurring at C₂ (**Figure 10**). The table below shows the case vehicle's right side crush profile.



Figure 10 Damage to right rear wheel, right rear door and quarter panel

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	166	32	194	2	32	17	28	17	0	-137	-123
in		65.4	12.6	76.4	0.8	12.6	6.7	11.0	6.7	0.0	-53.9	-48.4

The case vehicle's impact with the street sign involved the left quarter panel. Direct damage was limited to the left quarter panel and the back bumper fascia that wrapped around the back left corner. Direct damage began 338 centimeters (133 inches) rear of the left front axle and extended 13 centimeters (5.1 inches) rearward along the left quarter panel. Crush measurements were taken at the middle door level of the left quarter panel. The residual maximum crush was measured as 13 centimeters (5.1 inches) at C₂ (**Figure 11**). The table below shows the case vehicle's left side crush profile.



Figure 11: Left quarter panel damage from sign impact, vertical scale in tenths of meter, each increment on rods is 5 cm (2 in)

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	2	13	13	55	6	13	8	5	1	0	-197	-175
in		5.1	5.1	21.7	2.4	5.1	3.2	2.0	0.4	0.0	-77.6	-68.9

The case vehicle's left side wheelbase was extended 9 centimeters (3.5 inches) while the right side wheelbase was reduced 1 centimeter (0.4 inches). Induced damage from the impact with the Chrysler involved the lower right C-pillar and the right rear window, which disintegrated as a result of the impact. Induced damage from the street sign impact involved the left rear taillight assembly. No other induced damage was noted on the remainder of the case vehicle.

The case vehicle manufacturer's recommended tire size was P185/65R15 for the front tires and P195/60R15 for the rear tires. All the wheels were equipped with tires size P195/60R15. The case vehicle's tire data are shown in the table below.

Tire	Measured Pressure		Recommend Pressure		Tread Depth		Damage	Restricted	Deflated
	kpa	psi	kpa	psi	milli-meters	32 nd of an inch			
LF	159	23	207	30	3	4	None	No	No
RF	165	24	207	30	2	2	None	No	No
LR	165	24	207	30	5	6	None	No	No
RR	0	0	207	30	2	3	Bent rim, Tire de-beaded	Yes	Yes

Vehicle Interior: Inspection of the case vehicle's interior revealed evidence that the driver loaded his safety belt. Friction burns were observed on the driver's safety belt webbing and D-ring. The left side of the console was also loaded and cracked by the displacement of the driver as he moved right during the initial impact. The right rear door was contacted by the child safety seat, which was only secured by the top tether. Intrusions occurred at the right rear door, which intruded laterally 11 centimeters (4.3 inches) and the right rear seat back which intruded 15 centimeters (5.9 inches) laterally. There was no evidence of occupant contact or intrusion to the remainder of the case vehicle's interior. There was no evidence of deformation to the steering wheel or compression of the energy absorbing steering column.

Damage Classification: Based on the vehicle inspection, the CDCs for the case vehicle were determined to be: **02-RZEW-3** (70 degrees) for the initial impact with the Chrysler and **09-LBEN-2** (270 degrees) for the street sign impact. The WinSMASH reconstruction program, damage only algorithm, was used to reconstruct the case vehicle's Delta Vs for its right side

impact with the Chrysler (i.e., highest severity impact). The Total, Longitudinal, and Lateral Delta Vs are, respectively: 26 km.p.h. (16.2 m.p.h.), -8.9 km.p.h. (-5.5 m.p.h.), and -24.4 km.p.h. (-15.2 m.p.h.). No Delta Vs were calculated for the case vehicle's impact with the street sign because yielding object impacts are out-of-scope for the WinSMASH program. The case vehicle was towed due to damage.

AUTOMATIC RESTRAINT SYSTEM

The case vehicle'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. 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 8.5 centimeters (3.3 inches) in width. The driver's air bag had two vent ports, each approximately 4 centimeters (1.6 inches) in diameter, located close to the center of the back of the air bag at the 9:30 and 2:30 o'clock positions. The deployed driver's air bag was round with a diameter of approximately 66 centimeters (26 inches). An inspection of the driver's air bag fabric revealed no evidence of occupant contact.

The front right passenger's air bag was located in the top of the instrument panel. This air bag did not deploy because no front right occupant was present.

CHILD SAFETY SEAT

The case vehicle's back right passenger was seated in a forward-facing, convertible child safety seat with a tray shield (**Figure 12**). The child safety seat was manufactured by Evenflo, October 13, 2000. Its model name was "Secure Advantage 1". The model number was 2591134P1. The child safety seat was designed with a tray shield harness with a harness retainer clip. There were three sets of slots on the front and back of the child safety seat to thread the harness straps through, depending on the child's height and the seat's use. The harness straps were found threaded through the middle slots on the front of the child safety seat and through the bottom slots on the back of the child safety seat. In addition, the harness retainer clip was facing backward on the left side strap and the right harness strap was twisted just above the splitter plate. The tray shield was adjusted to it farthest from the child position. Instructions on the back of the child safety seat indicated that the top set of harness slots should be used if the seat was used in



Figure 12: Front view of child safety seat.

the forward facing position. If the child safety seat was used in the rear facing position, either of the middle or bottom set of slots were to be used. A harness retainer clip was found with the right harness slot attached to the left harness strap (Figure 13). Each harness strap was sewn to the crotch strap that was attached into the tray shield and buckled in a recessed buckle between the child's legs. The child safety seat was equipped with a padded tray shield that could be adjusted to three different distances from the child.



Figure 13: Child safety seat's harness straps and harness retainer clip

The child safety seat was constructed of a one piece plastic shell. A solid plastic base and the padded tray shield were attached to the plastic shell. The seat back and seat cushion were fitted with a cloth covered foam pad. The child safety seat was specified for use by children who weigh between 2.3 and 18 kilograms (5 to 40 pounds) and whose height is 66 to 101 centimeters (19 to 40 inches). The weight limit was indicated as 9 to 18 kilograms (20 to 40 pounds) for the forward facing position and 2.3 to 13.6 kilograms (5 to 30 pounds) for the rearward facing position.

Inspection of the child safety seat showed a few stress marks in the plastic on the left edge of the plastic shell and the front right portion of the child seat base. There was no evidence of stress or damage to the remainder of the child safety seat, including the harness webbing, buckle, and latch plate. Discussions with the sheriff's deputies indicated that the case vehicle's safety belt was not used to secure the child safety seat during the crash. The child safety seat was found secured only by the tether strap. In addition, the right harness strap was found detached from the harness retainer clip. Furthermore, through conversations with the child's father, it was learned that the child would frequently undo the harness retainer clip. The child's medical records also indicated that the child's mother reported the child would commonly work her way out of the child safety seat. Given the position of the harness straps in the middle slots, this may indicate that the straps were not properly adjusted for the size of the child and were uncomfortable. It is possible that the child unhooked the harness retainer clip and may have pushed the harness straps aside at some point prior to the crash, which contributed to the child being ejected from the child safety seat and through the right rear window as discussed in the following section.

CASE VEHICLE BACK RIGHT PASSENGER KINEMATICS

Immediately prior to the crash, the case vehicle's back right passenger [22-month-old, White (non-Hispanic) female; [76 centimeters and 15 kilograms (30 inches, 33 pounds)] was seated in an upright position in her forward facing child safety seat. She had her back against the seat back and her feet were dangling over the front edge of the child safety seat's cushion. The position of her hands and arms is not known. The case vehicle's seat was not adjustable.

The back right passenger was most likely not secured in her child safety seat. In addition, the child safety seat was improperly secured in the case vehicle. As mentioned previously, it was reported by the child's mother and father that the back right passenger would frequently unclip the harness retainer clip. The harness straps would not be secure on the child in this condition and could possibly come off the child's shoulders during the crash. In addition, with the tray shield adjusted to it furthest from the child position, it is also possible that the child had additional room to move around in the seat and may have pushed the harness straps aside and off her shoulders at some point prior to the crash. It is also possible the harness straps were not properly secured when the child was placed in the child safety seat. In any case, it is unlikely the child would have been ejected from the child safety seat during the crash had the harness straps and harness retainer clip been securely fastened. In addition, the case vehicle's back right safety belt was not used to secure the child safety seat in the vehicle. According to the investigating sheriff's deputies, only the top tether strap was used to secure the child safety seat in the vehicle (**Figures 14 and 15**). This condition would allow the bottom of the child safety seat to move off the case vehicle's seat during the crash and allow the child safety seat to roll to the right and upward against the door. This would set up the condition for the subsequent ejection of the improperly restrained back right passenger as described in the following paragraph.

The case vehicle's driver did not make any pre-crash avoidance maneuvers. As a result, the back right passenger's pre-impact body position did not change just prior to impact. The case vehicle's impact with the Chrysler caused the back right passenger to continue forward but primarily to the right within the child seat along a path opposite the case vehicle's 70 degree direction of principal force as the case vehicle decelerated longitudinally and was accelerated laterally to the left. The right side of the child safety seat impacted the intruding right rear door armrest (**Figure 16**), which caused the back right passenger's right femur to load against the right side of the child safety seat, fracturing her right



Figure 14: Top tether strap and fastener

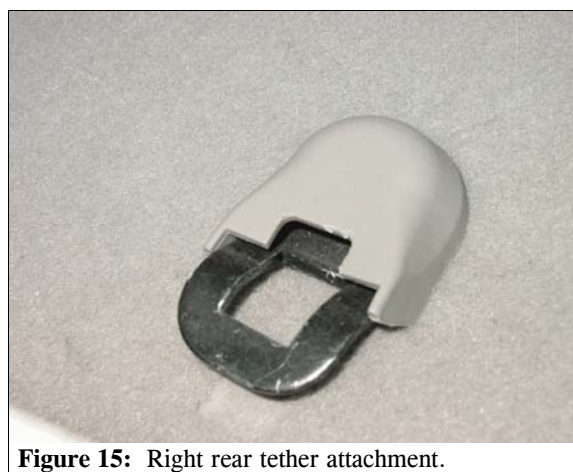


Figure 15: Right rear tether attachment.



Figure 16: Case vehicles right rear door interior damage from child safety seat contact.

femur. The base of the child safety seat most likely moved off the seat and the child safety seat rolled to the right and upward against the right rear door. As the child seat moved upward and rolled right, the lateral force of the crash caused the back right passenger to come out of the harness straps, and she was ejected through the broken right rear window. The back right passenger landed on her face causing several brain injuries and facial fractures. She came to final rest in the field on the northeast corner of the intersection near the right rear corner of the case vehicle.

CASE VEHICLE BACK RIGHT PASSENGER INJURIES

The police crash report indicated that the back right passenger sustained an “A” (incapacitating) injury. The back right passenger was transported by ambulance to a local hospital and then airlifted to a children’s hospital where she was hospitalized for 12 days. The table below shows the back right passenger’s injuries and injury mechanisms.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Nonanatomic brain injury; initially awake with GCS=15 but deteriorated to GCS=7 with response to painful stimuli;	severe 160804.4,0	Ground	Probable	Emergency room records
	during the hospitalization this occupant sustained a seizure				Hospitalization records
2	cerebral contusions to right frontal and anterior right temporal lobes, not further specified	serious 140604.3,1	Ground	Probable	Hospitalization records
3	Hematoma, subdural, small, 4 mm (<0.2 in) over left frontal and parietal lobes, 2 mm (<0.1 in) over right frontal lobe, and overlying right tentorium and anterior bilateral middle cranial fossa	critical 140654.5,3	Ground	Probable	Hospitalization records
4	Brain edema, mild, with elevated intracranial pressure and surgical placement of an intracranial pressure bolt	serious 140662.3,1	Ground	Probable	Hospitalization records
5	Hemorrhage, subarachnoid, small, along right convexity, including right frontal and parietal lobes	serious 140684.3,1	Ground	Probable	Hospitalization records

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
6	Fracture, closed, comminuted, left orbit, including lamina papyracea ¹ ; inferior orbital wall {floor}; and anterior, medial, and posterolateral left maxillary sinus with lateral displacement of globe and without ocular injury	serious 251204.3,2	Ground	Probable	Hospitalization records
7	Fracture, closed, comminuted, right orbit, including lamina papyracea, inferior orbital wall {floor}, and medial maxillary sinus	serious 251204.3,1	Ground	Probable	Hospitalization records
8	Fracture, posteriorly displaced, nasal bridge, nasal bones, and nasal septum ²	moderate 251004.2,4	Ground	Probable	Hospitalization records
9	Fracture, comminuted, transmetaphyseal, distal right femur–near right knee	serious 851822.3,1	Child safety seat’s side surface	Probable	Hospitalization records
10	Contusions lungs including left lower lobe and posterior right upper lobe without hemo- and/or pneumothorax	severe 441410.4,3	Ground	Probable	Emergency room records
11	Dislocation {knocked out} three front incisor teeth–“D”, “E”, and “F”	minor 251406.1,8	Ground	Probable	Hospitalization records
12	Fractured tooth–incisor “G” requiring surgical removal	minor 251404.1,8	Ground	Probable	Hospitalization records
13 14 15	Fracture, closed, left 2 nd through 4 th metatarsals, not further specified	moderate 852200.2,2 852200.2,2 852200.2,2	Right side interior surface rearward of right “B”-pillar	Possible	Hospitalization records

¹ The following terms are defined in DORLAND’S ILLUSTRATED MEDICAL DICTIONARY as follows:

lamina (lam/i-na): layer: a thin flat plate or stratum of a composite structure. The term is often used alone to mean the lamina arcus vertebrae.

lamina ar/cus ver/tebrae: lamina of the vertebral arch: either of the pair of broad plates of bone flaring out from the pedicles of the vertebral arches and fusing together at the midline to complete the dorsal part of the arch and provide a base for the spinous process.

lamina papyr/cea: *l. orbitalis ossis ethmoidalis.*

lamina orbita/lis os/sis ethmoida/lis: orbital lamina of ethmoid bone: a thin plate of bone laterally bounding the ethmoid labyrinth on either side and forming part of the medial wall of the orbit; called also *l. papyracea.*

² This occupant’s hospitalization records described her facial fractures as a “central facial smash” with her central face depressed.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
16	Laceration, stellate, approximately 10 cm (3.9 in) in total, forehead and into subcutaneous tissue {down to bone}	moderate 290604.2,7	Ground	Probable	Hospitalization records
17	Laceration left eyelid and orbital rim, full thickness requiring surgical repair	minor 297602.1,2	Ground	Probable	Hospitalization records
18	Avulsion, partial, {degloving}, extensive, nose	minor 290802.1,4	Ground	Probable	Hospitalization records
19	Laceration, multiple, deep, left cheek	minor 290600.1,2	Ground	Probable	Hospitalization records
20	Laceration mouth including 1 cm (0.4 in) maxillary anterior vestibule	minor 243099.1,8	Ground	Probable	Hospitalization records
21	Laceration {tears} gingiva, not further specific	minor 243204.1,8	Ground	Probable	Hospitalization records
22	Abrasions face, not further specified	minor 290202.1,9	Ground	Probable	EMS treatment record

CASE VEHICLE DRIVER KINEMATICS

The case vehicle's driver [30-year-old, White (non-Hispanic) male; 188 centimeters and 91 kilograms (74 inches, 200 pounds)] was seated in an upright position with his back against the seat back, his left foot on the floor, his right foot on the accelerator, and his hands in an unknown position. His seat track was located in its rearmost position, the seat back was slightly reclined, and the tilt steering column was located in its center position.

Based on the vehicle inspection, the case vehicle's driver was restrained by his manual, three-point, lap-and-shoulder, safety belt system. Friction burns were found on the case vehicle's safety belt webbing and "D"-ring indicating evidence of loading and usage of the safety belt in this crash.

The driver did not make any pre-crash avoidance maneuvers. As a result, the driver's pre-impact body position did not change just prior to impact. The case vehicle's impact with the Chrysler caused the driver to continue forward and to the right along a path opposite the case vehicle's 70 degree direction of principal force as the case vehicle decelerated longitudinally and accelerated laterally to the left. The driver's right thigh or hip impacted and cracked the case vehicle's center console. The driver remained restrained in his seat as the case vehicle rotated clockwise and approached the impact with the street sign. He moved to the left along a path opposite the case vehicle's 270 degree direction of principal force when the case vehicle's left

quarter panel impacted the street sign, and the left side of his body likely impacted the driver’s door. He remained restrained in his seat as the case vehicle came to final rest and exited the vehicle under his own power through the driver’s door.

CASE VEHICLE DRIVER INJURIES

According to the police crash report, the driver sustained “C” (possible) injuries. However, the driver stated he was not injured during the crash and was not treated. The driver rode in the ambulance with the back right passenger to the hospital.

OTHER VEHICLE

The 1997 Chrysler Sebring JXi was a front wheel drive, two-door convertible (VIN: 3C3EL55H1VT-----). The Chrysler was equipped with driver and right front passenger air bags, which deployed, and four wheel, anti-lock brakes. The Chrysler was towed from the crash scene due to damage.

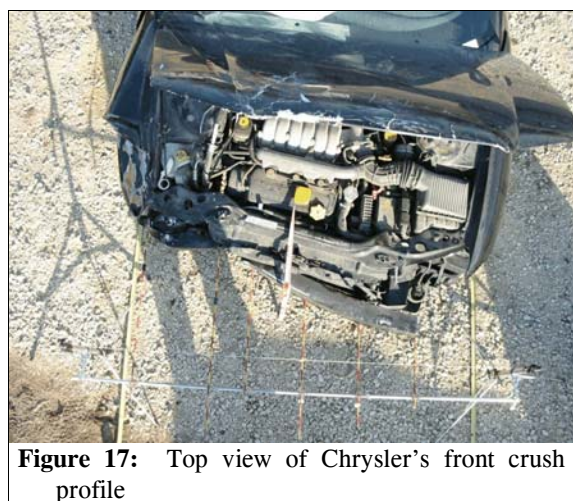


Figure 17: Top view of Chrysler’s front crush profile

Exterior Damage: The Chrysler’s impact with the case vehicle involved the front plane. The front bumper, bumper fascia, hood, grille, radiator, both turn signal and headlamp assemblies, and the right fender were directly damaged and crushed rearward. Though the bumper fascia was not found, it appeared the direct damage extended across the entire front bumper. The direct damage length was determined to be 138 centimeters (54.3 inches). The crush measurements were taken at the bumper level, and the residual maximum crush was measured as 44 centimeters (17.3 inches) occurring at C₆ (Figure 17). The table below shows the Chrysler’s front 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	138	44	123	1	12	25	39	43	44	0	0
in		54.3	17.3	48.4	0.4	4.7	9.8	15.4	16.9	17.3	0.0	0.0

The Chrysler’s left side wheelbase was extended 1 centimeter (0.4 inches) while the right side wheelbase was reduced by 6 centimeters (2.4 inches). Induced damage involved only the right fender and windshield.

The Chrysler’s recommended tire size was P205/65R15 or P215/55R16. The Chrysler was equipped with tires sized P215/60R16. The Chrysler’s tire data are shown in the table below.

Tire	Measured Pressure		Recommend Pressure		Tread Depth		Damage	Restricted	Deflated
	kpa	psi	kpa	psi	milli-meters	32 nd of an inch			
LF	179	26	207	30	3	4	No	No	No
RF	186	27	207	30	3	4	None	Partial	No
LR	165	24	207	30	5	6	None	No	No
RR	165	24	207	30	5	6	None	No	No

Damage Classification: Based on the vehicle inspection, the CDC for the Chrysler was determined to be: **11-FDEW-3 (340 degrees)**. The WinSMASH reconstruction program, damage only algorithm, was used to reconstruct the Chrysler's Delta Vs for the front impact with the case vehicle. The Total, Longitudinal, and Lateral delta Vs are respectively: 22.0 km.p.h (13.8 m.p.h.), -20.7 km.p.h. (-12.9 m.p.h.), and 7.5 km.p.h. (4.7 m.p.h.). The crash fit the reconstruction model and the results appeared reasonable. The Chrysler was towed due to damage.

Chrysler's Occupants: According to the police crash report, the Chrysler's driver [40-year-old, White (non-Hispanic) male] was restrained by his manual, three-point, lap-and-shoulder, safety belt system. The driver sustained police reported "C" (possible) injuries, but was not transported by ambulance to the hospital.

