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Special Crash Investigations: On-Site Child Restraint System Crash Investigation; Vehicle: 2002 Hyundai Accent; Location: Oregon; Crash Date: April 2018

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15. Supplementary Notes

Each crash represents a unique sequence of events, and generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety systems. This report and associated case data are based on information available to the Special Crash Investigation team on the date this report was submitted.

16. Abstract

This report documents the investigation of a child restraint system (CRS) used by a 2-year-old female occupant of a 2002 Hyundai Accent involved in a crash with a 2005 Chevrolet Tahoe. The two-vehicle crash occurred at night in April 2018 in Oregon. Conditions were dark, raining, and wet. The Hyundai was being driven by a 32-year-old female. The 2-year-old female occupant was seated in a forward-facing Cosco Scenera Next CRS in the second-row left position. The 2005 Chevrolet Tahoe was being driven by a belted 41-year-old male and was stopped for a traffic signal at the intersection. Other occupants of the Chevrolet included a belted 33-year-old female seated in the front-right seat and a belted 8-year-old male seated in the second-row right seat position. The Hyundai entered the intersection and, for unknown reasons, crossed over into the northbound lane, where its front plane struck the front plane of the Chevrolet. Both occupants of the Hyundai sustained police-reported "visible injuries" and were transported. The 2-year-old female occupant was hospitalized for three days and then released. Several days after the crash, she exhibited unspecified medical complications and was taken to a local hospital, where she was later pronounced deceased 18 days after the crash. The driver of the Hyundai was hospitalized for an unknown duration and then released.

17. Key Words	18. Distribution Statement
Child restraint system, air bag, deployment, injury, fatality	The document is available to the public from the National Technical Information Service, www.ntis.gov.

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Special Crash Investigations
On-Site Child Restraint System Crash
Office of Defects Investigation
Case Number: DS18015
Vehicle: 2002 Hyundai Accent
Location: Oregon
Crash Date: April 2018

BACKGROUND

This report documents the investigation of a child restraint system (CRS) used by a 2-year-old female occupant of a 2002 Hyundai Accent (**Figure 1**) involved in a crash with a 2005 Chevrolet Tahoe. Following the crash, the child was transported by ambulance to a local hospital, and she was later released to the custody of relatives. Several days after the crash, the child exhibited unspecified medical complications and was taken to a local hospital, where she was later pronounced deceased 18 days after the crash. The investigation is intended to determine the occupant's injury mechanisms and what role the manual restraints of the CRS and vehicle may have played in the occupant's injuries. This report also documents the apparent separation of the second-row folding seat back locks and what role they may have played in the child occupant's kinematics and injuries.

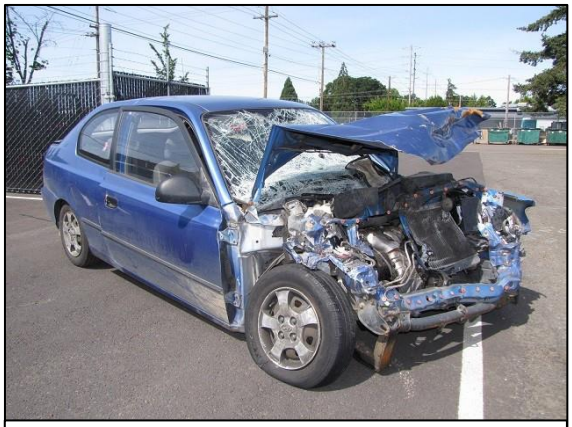


Figure 1. The 2002 Hyundai Accent.

This investigation was initiated by the Office of Defects Investigation group of the National Highway Traffic Safety Administration in April 2018 in response to a police notification stating that the CRS shell was fractured and severely damaged during the crash (**Figure 2**). The Special Crash Investigations (SCI) team was directed by NHTSA to obtain the police report and photos, and, following their submission, the case was assigned in June 2018. The Hyundai and CRS were being held in evidence by the investigating police department, and the inspections were completed in June 2018 with a police officer present.

Figure 2. Cosco Scenera Next CRS shell back support without padding.

The two-vehicle crash occurred during the evening hours in April 2018 in Oregon. Conditions were dark, raining, and wet. The Hyundai was being driven southbound by a 32-year-old female. The 2-year-old female occupant was seated in a forward-facing Cosco Scenera Next CRS in the second-row left position. The 2005 Chevrolet Tahoe was being driven northbound by a belted

41-year-old male and was stopped for a traffic signal at the intersection. Other occupants of the Chevrolet included a belted 33-year-old female seated in the front-right seat and a belted 8-year-old male seated in the second-row right seat position. The Hyundai entered the intersection and for unknown reasons crossed over into the northbound lane, where its front plane struck the front plane of the Chevrolet. Both occupants of the Hyundai sustained police-reported "visible injuries" and were transported. The 2-year-old female occupant was hospitalized before being declared deceased 18 days after the crash. The driver was hospitalized for an unknown duration before being released. The driver of the Chevrolet sustained a "complaint of pain," and the other occupants were not injured or transported. Both vehicles were towed from the scene, and the Hyundai and CRS were placed into evidence by the police. The Chevrolet was equipped with a Bosch CDR-supported Event Data Recorder (EDR) which was imaged by the police. The investigating police agency provided the SCI team with a hard copy of the PDF EDR report, included in this report as **Appendix A**.

SUMMARY

Crash Site

The crash site was a four-leg intersection of a north/south roadway and an east/west roadway. The intersection was configured with three-phase overhead traffic signals for all directions of travel. (**Figure 3**). The southbound approach to the intersection was configured with a right-turn lane, a bike lane, two through lanes, and a left-turn lane. The northbound approach was configured with a right-turn lane, a bike lane, two through lanes, and two left-turn lanes. The north/south roadway was straight and level. The asphalt surface was in good condition. The through lanes were separated by dashed white painted stripes, and the turn lanes were bordered by solid white painted stripes. The painted stripes were clearly visible and in good condition. This roadway was illuminated by overhead street lamps. The posted speed limit was 89 km/h (55 mph). Conditions at the time of the crash were dark with illumination, raining, and wet. A crash diagram is included at the end of this report.

Figure 3. Crash site, the 2002 Hyundai Accent southbound approaching.

Pre-Crash

The Hyundai was traveling southbound in the third lane from the right at an estimated speed of 67 km/h (42 mph)[1] as it entered the intersection. The southbound overhead traffic signal phase at the time of the crash was presumed to be in the red phase as the police report indicated the driver of the Hyundai disregarded the traffic signal. For unknown reasons, while traversing the intersection, the Hyundai crossed over and entered the northbound lanes. The police indicated that they documented no evidence of pre-impact braking by the Hyundai. The Chevrolet was stopped for a traffic signal in the second-left turn lane from the right. The vehicle's EDR-reported vehicle speed was 0 mph, the percent throttle was 0, and the brake switch circuit state was "Off" at T- 1 seconds to algorithm enable (AE).

[1] See Appendix B for speed calculations.

Crash

The front plane of the Hyundai struck the front plane of the Chevrolet in a head-on configuration. The Hyundai deposited a gouge mark measuring 42 cm (16.5 in) long located 1.3 m (4.3 ft) south of the stop line in the second northbound left-turn lane. The Hyundai was displaced slightly rearward and came to rest in the southbound lane approximately 1 m (3 ft) north of the point of impact (POI). The Chevrolet initiated a clockwise rotation of approximately 45 degrees and was displaced rearward coming to rest partially in the southbound lane approximately 3 m (10 ft) southwest of the POI and facing south (**Figure 4**).

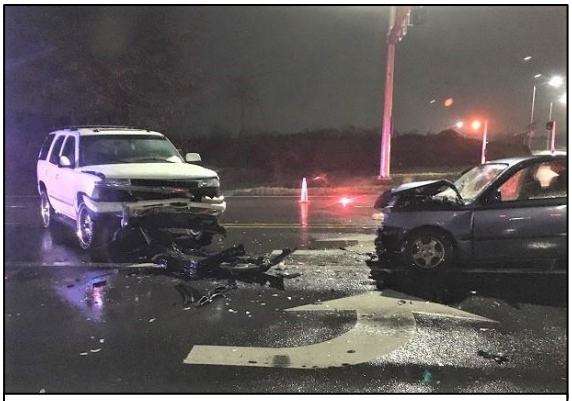


Figure 4. Post-crash final rest view, looking east (police photo).

For the Hyundai, the "damage with CDC-only" algorithm of the WinSMASH program calculated a total delta V of 65 km/h (41 mph), longitudinal delta V of -65 km/h (-41 mph), lateral delta V of 0 and a barrier equivalent speed of 69 km/h (43 mph). The results fit the model and appeared borderline.

For the Chevrolet, the "damage with CDC-only" algorithm of the WinSMASH program calculated a total delta V of 31 km/h (19 mph), longitudinal delta V of -31 km/h (-19 mph), lateral delta V of 0 and a barrier equivalent speed of 27 km/h (17 mph). The Chevrolet's EDR reported a maximum SDM[2] recorded velocity change of -20.63 km/h (-12.82 mph). The results fit the model and appeared borderline.

Post-Crash

The driver of the Hyundai sustained moderate severity injuries to her right arm and leg. EMS was notified at 2110 hours and arrived on-scene at 2127 hours. She was extricated from the vehicle by rescue personnel. She was assessed with a Glasgow Coma Scale (GCS) score of 12. EMS departed the scene at 2135 hours and arrived at the hospital at 2144 hours. The driver of the Hyundai was tested for alcohol and drugs in the field and at the hospital. She was determined to have a blood alcohol concentration of .17 g/dl. She was treated for an unknown duration and then released.

The second-row left child occupant sustained moderate injuries. EMS was notified at 2110 hours and arrived on scene at 2116 hours. She was extricated from the vehicle by rescue personnel. She was assessed with a GCS score of 10 at 2129 hours and then 8 at 2130 hours. It was noted that she had abrasions to her left forehead, and that vomit was present on her lips and on the CRS webbing. EMS departed the scene at 2120 hours. While en route she would open her eyes in response to verbal stimuli and had a GCS score of 10. She arrived at the hospital at 2130 hours. She was released after three days and placed in the custody of relatives. Thirteen days later she developed new symptoms that required her return to the hospital and then a trauma center. She remained on life support until brain death criteria were established 18 days post-crash. The cause of death was reported as "closed head injuries (delayed death)."

[2] Sensing diagnostic module.

None of the occupants of the Chevrolet were transported. Both vehicles were towed due to damage, and the Hyundai and CRS were placed into evidence by the police.

2002 HYUNDAI ACCENT

Description

The 2002 Hyundai Accent was a 3-door hatchback identified by the Vehicle Identification Number (VIN) KMHCF35G22Uxxxxxx. The vehicle was manufactured in March 2002, and the mileage was 142,578 km (88,594 mi) as last reported by a vehicle history report. According to the Carfax report, the vehicle had not been involved in any reported crashes prior to October 2016, after which no further information was available. The vehicle was equipped with a 1.5-liter, 4-cylinder, gasoline engine; a front-wheel drive; a manual transmission; and a tilt steering column. The vehicle manufacturer recommended 175/70R13 tires with a recommended pressure of 207 kPa (30 psi) for the front and rear. The Hyundai was equipped with Michelin Defender XT tires, manufactured in September 2015, of the recommended size on the front and rear.

The Hyundai was configured with two rows of seating for five occupants. The front row was equipped with bucket seats with adjustable head restraints and folding backs. For unknown reasons, the driver's head restraint had been removed from the seat back. The seat cushion appeared to be in the middle track position, and the seat back was slightly reclined. The second row of seats were configured with a bench seat with folding back and integral head restraints for the left and right positions. The left- and right-seat positions were also equipped with Lower Anchors and Tethers for Children (LATCH) hardware to be used for installing CRSs. The middle seat position was equipped with a tether anchor. The tether anchors for this vehicle were located on the rear aspect of the cargo compartment between the deck and the rear hatch. The LATCH components in this vehicle were not used at the time of the crash. The CRS located in the second row was installed using a lap and shoulder belt.

Exterior Damage

The Hyundai sustained severe damage to the front plane caused by the impact with the Chevrolet (**Figure 5**). A difference in the opposing vehicles' bumper heights caused the Hyundai's front plane to underride the Chevrolet's front plane. The underride caused damage to the Hyundai at bumper level and above bumper level. The front-bumper fascia was displaced from the vehicle, and the backing bar was used to measure direct damage and crush. Direct damage was distributed from bumper corner to bumper corner and measured 115 cm (45.3 in). The Field L was distributed from bumper corner to bumper corner and measured 96 cm (37.8 in). Twelve measurements were taken at bumper level by the Nikon Total Station, and the Faro Blitz program computed crush measurement in six increments as follows: C_1 = 11 cm (4.3 in), C_2 = 43 cm (16.9 in), C_3 = 49 cm (19.3 in), C_4 = 51 cm (20.1 in), C_5 = 50 cm (19.7 in), and C_6 = 43 cm (16.9 in). The Hyundai sustained above bumper crush to the radiator and upper support structure. Fourteen

Figure 5. Front-plane damage, the 2002 Hyundai Accent.

measurements were taken at above bumper level by the Nikon Total Station, and the Faro Blitz program computed crush measurement in six increments as follows: C_1 = 19 cm (7.5 in), C_2 = 5 cm (2.0 in), C_3 = 24 cm (9.5 in), C_4 = 22 cm (8.7 in), C_5 = 28 cm (11.0 in), and C_6 = 38 cm (15.0 in). The above bumper crush did not meet the criteria for averaging and the final crush results were represented by the bumper level crush. A maximum crush of 51 cm (20.1 in) was located 40 cm (15.7 in) left of the front-right bumper corner and the Collision Deformation Classification (CDC) for the Hyundai in Event 1 was 12FDEW3.

The vehicle sustained additional exterior damage during the crash. The hood was crumpled, the grille was displaced, and the headlamp assemblies were disintegrated. The left-front fender was crumpled, the right-front fender was displaced entirely, and the frame rails were bent downward. The transmission was fractured and leaked fluid, and was displaced rearward and downward. The engine block was fractured and leaked oil. The brake fluid reservoir leaked fluid, and both front CV joint boots were torn loose. The electrical system was compromised, and the vehicle's turn signals and tail lamps could not be tested.

Child Restraint System

The 2-year-old female was seated in a forward-facing Cosco Scenera Next CRS installed in the second-row left position. The CRS was a convertible seat configured with a 5-point harness and LATCH system. According to the police, the LATCH components were not used to install the seat. Prior to police arriving on-scene, emergency responders removed the occupant from the CRS to be transported to the hospital. The CRS was later removed from the Hyundai by the police, taken to the police station, and inspected by SCI at the evidence facility.

The Scenera was identified by the model number CC140-CCX and the manufacture date of October 26, 2016. The vehicle inspection documented occupant loading damage to the seat belt at that position, so it was determined that the CRS was installed forward-facing using the lap and shoulder belt in the second-row seat position. The CRS forward-facing belt path exhibited wear marks from historical usage. The seat belt was cut by responders during post-crash activities. According to the owner's manual and labels appearing on the CRS, occupant weight, height, and age parameters for using the CRS in a forward-facing orientation were as follows:

- 22 – 40 lbs (10.1 – 18 kg)
- 29 – 43 in (73.6 – 110 cm)
- at least 1 year old

The 2-year-old female occupant met the weight, height, and age parameters.

The CRS inspection documented significant damage in the form of cracks to the shell (**Figure 6**). A vertically placed fracture measuring 23 cm (9.1 in) was documented on the left aspect of the back support. A multi-directional fracture measuring 26 cm (10.2 in) vertically and 16 cm (6.3 in) laterally, documented in the middle section of the back support in the area of the harness loops, resulted in a section of the shell to break away entirely. The displaced section caused slack in the harness shoulder straps compromising their ability to provide restraint for the occupant. The seating area of the shell, the harness system, and the LATCH components of the CRS were not damaged. It was not known if the damage was caused by occupant loading, rear-seat back intrusion, or a combination of the two.

Interior Damage

The Hyundai sustained interior damage resulting from impact forces, air bag deployments, and occupant contacts. The windshield was fractured, and the left and right doors were shifted rearward. Both frontal air bags deployed. Evidence of driver contacts and loading was documented on the frontal air bag, steering wheel rim, lower IP, and windshield. The deployed frontal air bag was torn from top to bottom on the left edge. The steering column was collapsed forward stopping in contact with the IP. The steering wheel rim was compressed vertically 7 cm (2.8 in) to form an oval shape and was bent forward 5 cm (2.0 in) at the upper half and 7 cm (2.8 in) at the lower half. Scuff marks caused by contact from the driver's left and right knees were documented on the lower left IP on either side of the steering column. A large fracture revealing a spider web pattern to the upper left sector of the windshield indicated a likely head contact. No evidence of loading was present on the driver's seat belt, which suggested that the driver was likely unbelted.

Figure 6. Fractures, back support of the CRS.

The second-row left seat belt used to anchor the CRS to the seat revealed evidence of usage and loading at the webbing and latch plate. The webbing had been cut by responders during post-crash activities. The plastic trim of the latch plate revealed thermal and loading damage caused at impact. The CRS shell exhibited significant shell fracturing caused during the crash, which is discussed further in the child restraint system section of this report.

Second-Row Seat Back

The second-row seat back presented several issues relevant to the investigation. The left- and right-seat back folding locks apparently separated at some time. The seat back was bowed forward in the center section and bent into a curved shape intruding longitudinally forward reducing the space in the second row (**Figure 7**). The source of the damage was likely loading from displaced cargo of an unknown nature. If the damage occurred during the crash, the resulting intrusion into the second row likely caused damage to the CRS shell and possibly contributed to the injuries sustained by the 2-year-old female occupant.

Figure 7. Second-row seat back, the 2002 Hyundai Accent.

The second-row width measured 134 cm (52.8 in) in width. The seat back measured 120 cm (47.2 in) in width and 65 cm (25.6 in) in height. Maximum longitudinal deformity was located 50 cm (19.7 in) from the right edge and measured 17 cm (6.7 in) causing the seat back to bow forward in the center. Intrusion of the seat back into the second row when measured at the seat cushion was as follows: left (15 cm [5.9 in]), center

(25 cm [9.8 in]), and right (21 cm [8.3 in]). In its post-crash state, the left-seat back latch was positioned 10 cm (3.9 in) forward of the left post, and the right latch was positioned 20 cm (7.9 in) forward of the corresponding post. Neither post was damaged. The seat back angle measured 10 degrees from vertical. The left release button extended above the seat back 3 cm (1.2 in), and the right button was nearly flush with the seat back. With the release button down, the seat is locked in place (**Figure 8**). When the release buttons were pushed or pulled on, there was little, if any, movement of the latching mechanisms.

Figure 8. Exemplar second-row seat, the 2002 Hyundai Accent. (Arrow points to right-seat back latch.)

The investigator pushed the left- and right-seat back rearward, but the latching mechanisms were misaligned and did not reach the posts. The left post showed evidence that it was at least partially engaged with the latching mechanism; the right post showed little evidence of engagement (**Figure 9**). Based on the available information, it appeared that the left latch was attached to the post but separated from the post when the seat back was loaded and displaced forward. The evidence indicated that, while the right latch may have been in the closed position, it may not have been mechanically engaged with the post contributing to the destabilization of the seat back at impact with the other vehicle.

The brackets attaching the seat back to the floor were examined and determined to be unremarkable. The pre-impact condition of the seat back is not known. The source of damage is presumed to be loose cargo in the rear cargo area shifting forward and contacting the seat back at impact. On-scene police photos showed various clothes and bags in the cargo area but no large or heavy objects. The same items were present during the vehicle inspection. The investigating police officer was present during the inspection and indicated that no large or heavy objects were found in the bags, clothing, or cargo area.

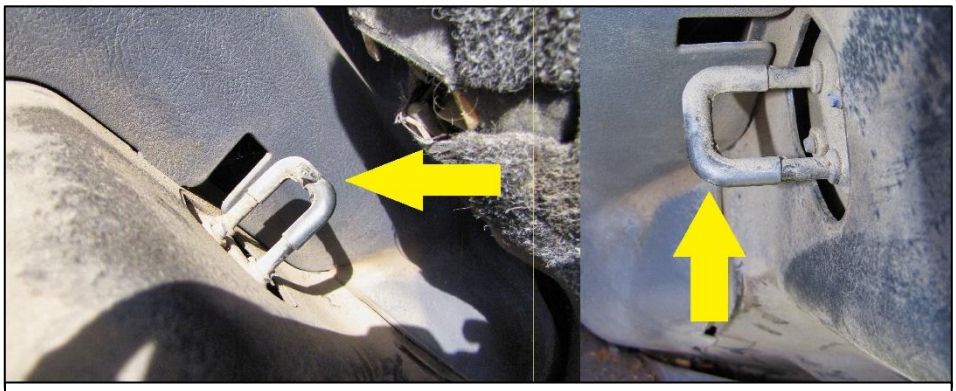


Figure 9. Left- and right-rear seat latch posts for the second-row seat, the 2002 Hyundai Accent.

Manual Restraint Systems

The front row was equipped with driver and front right passenger lap and shoulder seat belts. The driver's belt was equipped with a continuous loop belt webbing, a sliding latch plate, an emergency locking retractor (ELR), and an adjustable D-ring in the full-down position. The front-row belts were configured with retractor-mounted seat belt pretensioners. During the inspection, the driver's shoulder belt was found in the stowed position. The latch plate and webbing revealed wear caused by historical usage but did not reveal evidence of driver loading.

Figure 10. Latch plate, second-row left seat belt, the 2002 Hyundai Accent.

The second-row left seat belt was used to anchor the CRS to the seat. It was routed through the forward-facing belt path of the CRS shell. The belt was configured with a switchable automatic locking retractor/ELR, a sliding latch plane, and a non-adjustable D-ring. The latch plate and webbing revealed wear caused by historical usage. The buckle was unremarkable. The latch plate revealed pronounced evidence of occupant loading caused at impact with the other vehicle (**Figure 10**). The belt webbing was cut by responders during post-crash activities.

Figure 11. Driver's air bag, the 2002 Hyundai Accent (police photo at scene).

Supplemental Restraint Systems

The Hyundai's Supplemental Restraint Systems (SRSs) included driver's and passenger's depowered frontal air bags and front-row seat belt pretensioners. The vehicle history from CARFAX reported no previous crashes prior to October 2016, after which no further information was available.

Figure 12. Driver's air bag, the 2002 Hyundai Accent.

The driver's frontal air bag deployed from the steering wheel hub (**Figure 11**). The air bag measured 58 cm (22.8 in) in diameter and was configured with two vent ports and two tethers. The air bag cover flaps were unremarkable. The lower flap was covered by a 7.6 x 7.6 cm (3.0 x 3.0 in) vinyl sticker. The upper edge of the sticker was located 1.2 cm (0.5 in) above the seam between the upper and lower flaps. Blood deposits were present on the right lower aspect of the back panel. The air bag revealed a tear on the upper aspect of the front panel measuring 20 cm (7.9 in) and another tear on the left aspect extending from top to bottom (**Figure 12**). Given the

deformation of the steering column and steering wheel and the unbelted status of the driver, the source of the tears was determined to be driver loading at deployment. There was no evidence present or indication that the air bag inflator had ruptured. The passenger's frontal air bag deployed from the top IP. The air bag and cover flaps were unremarkable.

NHTSA Recalls and Investigations

A VIN search on www.safercar.gov last queried in June 2020 revealed no open recalls for the Hyundai.

2002 HYUNDAI ACCENT OCCUPANTS

Driver Demographics

Age/sex:	32 years/female
Height:	Unknown
Weight:	73 kg (160 lbs)
Eyewear:	Unknown
Seat type:	Bucket
Seat track position:	Middle
Manual restraint usage:	Lap and shoulder seat belt not used
Usage source:	Vehicle inspection
Air bags:	Frontal air bag deployed
Alcohol/drug data:	BAC .17 g/dl
Egress from vehicle:	Assisted from vehicle by EMS
Transport from scene:	Ambulance to hospital
Type of medical treatment:	Hospitalization for an unknown duration and then released

Driver Injuries

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Component (IPC)	IPC Confidence Level
1	Right lower leg fracture	852002.2	Toe pan	Probable
2	Right lower arm fracture	751800.2	Left instrument panel	Possible
3	Puncture wound, right lower leg	810800.1	Brake pedal	Probable

Source: EMS records.

Driver Kinematics

The unbelted 32-year-old female driver was seated in an unknown posture and operating the Hyundai while under the influence of alcohol. At impact with the other vehicle, her frontal air bag deployed, and she was displaced forward in response to the direction of force overloading the air bag with her chest and causing the fabric to tear in two areas. Her torso continued to be displaced forward collapsing the steering column and deforming the steering wheel rim. The driver's lower extremities were displaced forward, and her left and right knees contacted the

lower left IP on either side of the steering column. Her head continued to be displaced forward as she moved forward and upward out of her seated position. A fracture to the upper left aspect of the windshield suggested that the driver's head made contact there. An EMS technician reported that the driver's forehead was covered in blood but did not identify a specific injury. Her right foot contacted the toe pan, and she sustained a lower leg fracture. The side of her right leg possibly contacted the brake, causing a puncture wound. Following the crash, the driver was assisted from the vehicle by EMS. She was transported by ambulance to a local hospital, where she was hospitalized for an unknown duration and then released.

Second-Row Left Occupant Demographics

Age/sex:	2 years/female
Height:	91 cm (35 in)
Weight:	18 kg (39 lbs)
Eyewear:	None
Seat type:	Bench with folding back
Seat track position:	Not adjustable
Manual restraint usage:	Lap and shoulder seat belt with CRS and 5-point harness
Usage source:	Vehicle inspection, police report
Air bags:	None available
Egress from vehicle:	Removed from vehicle due to age
Transport from scene:	Ambulance to hospital
Type of medical treatment:	Hospitalized for 3 days and released; returned to hospital 13 days later; hospitalized for 5 additional days and declared deceased 18 days after crash

Second-Row Left Occupant Injuries

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Component (IPC)	IPC Confidence Level
1	Right-sided subdural hematoma (initial evaluation)	140629.3	Driver's seat back	Probable
2	Abrasions, left forehead	210202.1	Driver's seat back	Probable
3	Abrasion, chest	410202.1	CRS webbing	Probable
	Contralateral left-sided subdural hematoma and bleed (second visit)	Not codeable		

Source: autopsy report and post organ harvesting.

Second-Row Left Occupant Kinematics

The occupant was restrained in a forward-facing CRS with a 5-point harness system. At impact with the other vehicle, the occupant was displaced forward loading the CRS harness and shell. The second-row seat back was displaced forward applying pressure on the seat belt components

and CRS and causing fractures to the CRS shell. The combination of seat back displacement, CRS damage, and slack in the harness shoulder straps compromised the ability of the CRS to provide proper restraint for the occupant. The occupant's torso, neck, and head were likely displaced further in a hyper-extension dynamic and impacting the driver's seat back with her head (**Figure 13**). Following the crash, the occupant was removed from the CRS and vehicle by responders and transported by ambulance to a local hospital. She was released after three days to the custody of relatives. Thirteen days later, she exhibited medical complications and returned to the hospital, where she was pronounced deceased 18 days after the crash.

Figure 13. Driver's seat back, 2002 Hyundai Accent.

2005 CHEVROLET TAHOE

Vehicle Data

The 2005 Chevrolet Tahoe was a full-size light pickup identified in the police report using the VIN 1GNEK13T65Jxxxxxx. The vehicle was equipped with an 8-cylinder, 5.3-liter, gas engine; a rear-wheel drive; and hydraulic brakes.

Exterior Damage

On-scene police images indicate the Chevrolet sustained moderate front plane damage (**Figure 14**). Damage at bumper level appeared to be distributed laterally from corner to corner. The estimated CDC for the Chevrolet was 12FDEW1.

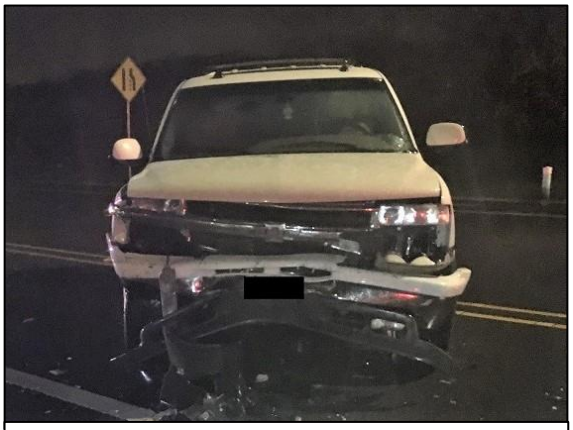


Figure 14. Front-plane damage, the 2005 Chevrolet Tahoe (police photo).

Event Data Recorder

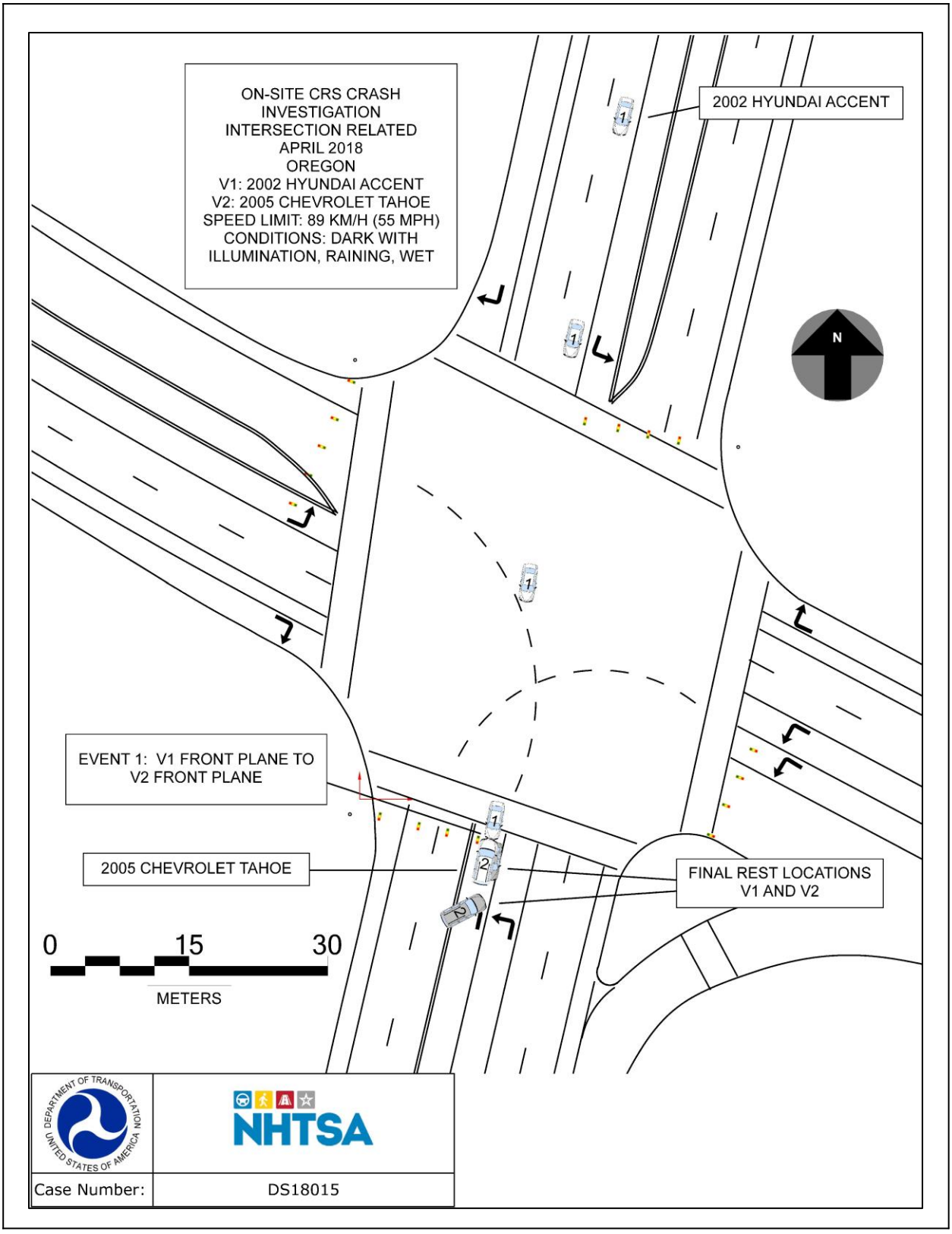
The Chevrolet's EDR was imaged by the investigating police department prior to their releasing the vehicle. SCI obtained a printed PDF copy of the report which is included in this report as **Appendix A**. The EDR was imaged and reported using software version 17.6. The report included System Status, and Pre-Crash and Post-Crash data. The EDR captured one deployment event, which was the front-plane impact with the Hyundai. It reported a maximum longitudinal delta V of -12.82 mph (-20.63 km/h). The pre-crash data at T-1 second is presented in the table below:

Seconds Before AE	Vehicle Speed (mph)	Engine Speed (rpm)	Percent Throttle	Brake Switch Circuit State
-1	0	384	0	ON

Occupant Data

The police report indicated that the driver of the Chevrolet was a belted 41-year-old male, the front-right position occupant was a belted 33-year-old female, and the second-row right position occupant was a belted 8-year-old male. Following the crash, the driver complained of pain, and the other occupants were not injured. None of the occupants were transported.

CRASH DIAGRAM



APPENDIX A: 2005 Chevrolet Tahoe Event Data Recorder (EDR) Report[3]

[3] The Bosch CDR Report contained in this technical report was imaged by the investigating police department. Only a PDF copy of the Bosch CDR report was provided by the police, and the hexadecimal data contained in the report has been deleted due to the potential personal identifiable information contained (vehicle identification number) in the report.

BOSCH

CDR CRASH DATA RETRIEVAL

IMPORTANT NOTICE: Robert Bosch LLC and the manufacturers whose vehicles are accessible using the CDR System urge end users to use the latest production release of the Crash Data Retrieval system software when viewing, printing or exporting any retrieved data from within the CDR program. Using the latest version of the CDR software is the best way to ensure that retrieved data has been translated using the most current information provided by the manufacturers of the vehicles supported by this product.

CDR File Information

User Entered VIN	1GNEK13T65J
User	
Case Number	
EDR Data Imaging Date	
Crash Date	
Filename	
Saved on	
Imaged with CDR version	Crash Data Retrieval Tool 17.6
Imaged with Software Licensed to (Company Name)	
Reported with CDR version	Crash Data Retrieval Tool 17.6
Reported with Software Licensed to (Company Name)	
EDR Device Type	Airbag Control Module
Event(s) recovered	Deployment

Comments

No comments entered.

Data Limitations

Recorded Crash Events:

There are two types of Recorded Crash Events. The first is the Non-Deployment Event. A Non-Deployment Event records data but does not deploy the air bag(s). It contains Pre-Crash and Crash data. The SDM can store up to one Non-Deployment Event. This event may be overwritten by another Non-Deployment Event. This event will be cleared by the SDM, after approximately 250 ignition cycles. This event can be overwritten by a second Deployment Event, referred to as a Deployment Level Event, if the Non-Deployment Event is not locked. The data in the Non-Deployment Event file will be locked, if the Non-Deployment Event occurred within five seconds before a Deployment Event. A locked Non Deployment Event cannot be overwritten or cleared by the SDM. The second type of SDM recorded crash event is the Deployment Event. It also contains Pre-Crash and Crash data. The SDM can store up to two different Deployment Events, if they occur within five seconds of one another. If multiple Non-Deployment Events occur within five seconds prior to a Deployment Event, then the most severe Non-Deployment Event will be recorded and locked. If multiple Non-Deployment Events precede a Deployment Event, and occur within five seconds of each other (but not necessarily all within five seconds of the Deployment Event), then the most severe of the Non-Deployment Events (which may have occurred more than five seconds prior to the Deployment Event) will be recorded and locked. If a Deployment Level Event occurs within five seconds after the Deployment Event, the Deployment Level Event will overwrite any non-locked Non-Deployment Event. If multiple Non-Deployment Events occur within five seconds prior to a Deployment Event, and one or more of those events was a Pretensioner Deployment Event, then the most recent Pretensioner Deployment Event will be recorded and locked. Deployment Events cannot be overwritten or cleared by the SDM. Once the SDM has deployed an air bag, the SDM must be replaced.

Data:

-SDM Recorded Vehicle Longitudinal Velocity Change reflects the change in longitudinal velocity that the sensing system experienced during the recorded portion of the event. SDM Recorded Vehicle Longitudinal Velocity Change is the change in velocity during the recording time and is not the speed the vehicle was traveling before the event, and is also not the Barrier Equivalent Velocity. For Deployment Events, the SDM will record 100 milliseconds of data after Deployment criteria is met and up to 50 milliseconds before Deployment criteria is met. For Non-Deployment Events, the SDM can record up to the first 150 milliseconds of data after algorithm enable. Velocity Change data is displayed in SAE sign convention.
-Event Recording Complete will indicate if data from the recorded event has been fully written to the SDM memory or if it has been interrupted and not fully written.
-SDM Recorded Vehicle Speed accuracy can be affected by various factors, including but not limited to the following:
  -Significant changes in the tire's rolling radius
  -Final drive axle ratio changes
  -Wheel lockup and wheel slip
-Brake Switch Circuit Status indicates the open/closed state of the brake switch circuit.
-Pre-Crash data is recorded asynchronously. The 1.0 second Pre-crash data value (most recent recorded data point) is the data point last sampled before AE. That is to say, the last data point may have been captured just before AE but no more than 1.0 second before AE. All subsequent Pre-crash data values are referenced from this data point.
-Pre-Crash Electronic Data Validity Check Status indicates "Data Invalid" if:
  -The SDM receives a message with an "invalid" flag from the module sending the pre-crash data

-No data is received from the module sending the pre-crash data
-No module present to send the pre-crash data

-Engine Speed is reported at two times the actual value in the following vehicles, if the vehicle is equipped with a 6.6L Duramax diesel engine (RPO LB7, LBZ, LLY, or LMM):
-2001-2006 Chevrolet Silverado
-2007 Chevrolet Silverado Classic
-2001-2006 GMC Sierra
-2007 GMC Sierra Classic
-2006-2007 Chevrolet Express
-2006-2007 GMC Savana
-2003-2009 Chevrolet Kodiak
-2003-2009 GMC Topkick
-Driver's and Passenger's Belt Switch Circuit Status indicates the status of the seat belt switch circuit. If the vehicle's electrical system is compromised during a crash, the state of the Driver's Belt Switch Circuit may be reported other than the actual state.
-The Time between Non-Deployment to Deployment Events is displayed in seconds. If the time between the two events is greater than 25.4 seconds, "N/A" is displayed in place of the time.
-If power to the SDM is lost during a crash event, all or part of the crash record may not be recorded.
-Multiple Events will indicate whether one or more associated events preceded the recorded event.
-Multiple Events Not Recorded can be used in the following scenarios:
-If a single event is recorded, this parameter will indicate whether one or more associated events prior to the recorded event was not recorded due to insufficient record space (because there were more events than there were available event records).
-If two associated events are recorded, this parameter for the first event will indicate whether one or more associated events prior to the first event was not recorded due to insufficient record space.
-If two associated events are recorded, this parameter for the second event will indicate whether one or more associated events between the first and second events was not recorded due to insufficient record space.
-All data should be examined in conjunction with other available physical evidence from the vehicle and scene.

Data Source:
All SDM recorded data is measured, calculated, and stored internally, except for the following:
-Vehicle Speed, Engine Speed, and Percent Throttle data are transmitted by the Powertrain Control Module (PCM), via the vehicle's communication network, to the SDM.
-Brake Switch Circuit Status data is transmitted by either the ABS module or the PCM, via the vehicle's communication network, to the SDM.
-The Belt Switch Circuit is wired directly to the SDM.

Hexadecimal Data:
Data that the vehicle manufacturer has specified for data retrieval is shown in the hexadecimal data section of the CDR report. The hexadecimal data section of the CDR report may contain data that is not translated by the CDR program. The control module contains additional data that is not retrievable by the CDR tool.

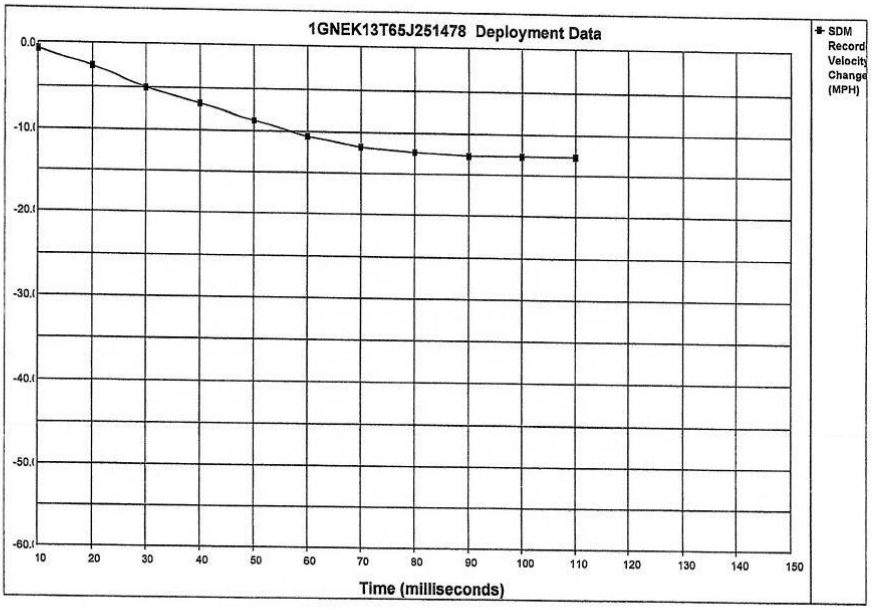
01027_SDMGF_r007

System Status At Deployment

SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	BUCKLED
Passenger's Belt Switch Circuit Status	BUCKLED
Passenger Seat Position Switch Circuit Status	Rearward
Ignition Cycles At Deployment	27461
Ignition Cycles At Investigation	27462
Maximum SDM Recorded Velocity Change (MPH)	-12.82
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	87.5
Driver 1st Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	10
Driver 2nd Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	N/A
Passenger 1st Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	10
Passenger 2nd Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	N/A
Time Between Non-Deployment And Deployment Events (sec)	N/A
Frontal Deployment Level Event Counter	1
Event Recording Complete	Yes
Multiple Events	No
Multiple Events Not Recorded	No

Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle
-5	0	512	0
-4	0	512	0
-3	0	512	0
-2	0	448	0
-1	0	384	0

Seconds Before AE	Brake Switch Circuit State
-8	ON
-7	ON
-6	ON
-5	ON
-4	ON
-3	ON
-2	ON
-1	ON



Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Recorded Velocity Change (MPH)	-0.62	-2.48	-4.96	-6.82	-8.68	-10.54	-11.78	-12.40	-12.71	-12.71	-12.71	N/A	N/A	N/A	N/A

APPENDIX B: Speed at Impact From Delta V Calculations

Appendix B. Speed at Impact from Delta V Calculations

$\Delta V_1 = -\Delta V_2 * W_2/W_1$
$\Delta V_1 = -12.82 * 4828/2101$
$\Delta V_1 = -29.45$ mph

Inline closing speed = $(|\Delta V_1| + |\Delta V_2|)* (1/(1+e))$ [using 0.01 for restitution]
Inline closing speed = 42.27 * .99
Inline closing speed = 41.84 mph

V_1 impact speed = Inline closing speed - V_2 impact speed
V_1 impact speed = 41.84 - 0
V_1 impact speed = 41.84 mph

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U.S. Department
of Transportation

**National Highway
Traffic Safety
Administration**

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