CRASH DATA RESEARCH CENTER
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OFFICE OF DEFECTS INVESTIGATION
CALSPAN ON-SITE AIR BAG NON-DEPLOYMENT FATAL CRASH INVESTIGATION
SCI CASE NO: CA09022

VEHICLE: 2005 CHEVROLET COBALT
LOCATION: PENNSYLVANIA
CRASH DATE: APRIL, 2009

Contract No. DTNH22-07-C-00043

Prepared for:

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

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

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15. Supplementary Note

An investigation of the two-vehicle head-on crash of a 2005 Chevrolet Cobalt and a 2001 Hyundai Sonata.

16. Abstract

This on-site investigation focused on the fatal air bag non-deployment crash of a 2005 Chevrolet Cobalt. The Chevrolet was involved in a severe head-on collision with a 2001 Hyundai Sonata that resulted in three fatalities. The 2005 Chevrolet Cobalt was equipped with dual-stage air bags for the driver and front right passenger positions that did not deploy in the crash. The vehicle's Event Data Recorder (EDR) was imaged during the SCI investigation and a non-deployment event was recovered. The driver air bag in the Hyundai Sonata deployed during the impact. The 73-year old unrestrained driver and the 13-year old unrestrained front right passenger of the Chevrolet and the 47-year old unrestrained driver of the Hyundai were all pronounced deceased at the crash site. A 12-month-old male was restrained in a forward facing convertible Child Restraint System (CRS) in the center rear position of the Chevrolet. The child sustained a critical cervical spine injury and was transported from the crash site to a pediatric trauma center via air ambulance.

The crash was identified through an internet news search by the National Highway Traffic Safety Administration's Crash Investigation Division. The news article was forwarded to the Calspan Special Crash Investigations (SCI) team on April 3, 2009. The SCI team initiated telephone follow-up with the investigating police officer on the same day. The SCI investigator conducted additional follow-up with the State Police Reconstructionist on Sunday April 5, 2009 and set-up an on-site investigation of the crash for April 6 and 7, 2009. It was determined that the vehicles had been impounded pending the conclusion of the police investigation and were available for inspection. The CRS was also available for inspection.

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BACKGROUND

This on-site investigation focused on the fatal air bag non-deployment crash of a 2005 Chevrolet Cobalt (**Figure 1**). The Chevrolet was involved in a severe head-on collision with a 2001 Hyundai Sonata that resulted in three fatalities. The 2005 Chevrolet Cobalt was equipped with dual-stage air bags for the driver and front right passenger positions that did not deploy in the crash. The vehicle's Event Data Recorder (EDR) was imaged during the SCI investigation and a non-deployment event was recovered. The driver air bag in the Hyundai Sonata deployed during the impact. The 73-year old unrestrained driver and the 13-year old unrestrained front right passenger of the Chevrolet and the 47-year old unrestrained driver of the Hyundai were all pronounced deceased at the crash site. A 12-month-old male was restrained in a forward facing convertible Child Restraint System (CRS) in the center rear position of the Cobalt. The child sustained a critical cervical spine injury and was transported from the crash site to a pediatric trauma center via air ambulance.

Figure 1: Front right oblique view of the Chevrolet.

The crash was identified through an Internet news search by the National Highway Traffic Safety Administration's Crash Investigation Division. The news article was forwarded to the Calspan Special Crash Investigations (SCI) team on April 3, 2009. The SCI team initiated telephone follow-up with the investigating police officer on the same day. The SCI investigator conducted additional follow-up with the State Police Reconstructionist on Sunday April 5, 2009 and set-up an on-site investigation of the crash for April 6 and 7, 2009. It was determined that the vehicles had been impounded pending the conclusion of the police investigation and were available for inspection. The CRS was also available for inspection.

VEHICLE DATA

2005 Chevrolet Cobalt

The 2005 Chevrolet Cobalt was identified by the Vehicle Identification Number (VIN): 1G1AL52F857 (production sequence deleted). The Cobalt was manufactured in November 2004 and was purchased new by the driver. The odometer had registered approximately 172,195 km (107,000 miles). The mileage reading was reported by the family of the deceased driver. The

four-door sedan was equipped with a power-train that consisted of a 2.2-liter, in-line 4-cylinder engine, 4-speed automatic transmission, and front-wheel drive. The braking system was comprised of power front disc and rear drum brakes with anti-lock (ABS). The manual restraint system consisted of three-point lap and shoulder belts in the five seat positions. The front safety belts were designed with retractor pretensioners. The driver and front right passenger positions were equipped with dual-stage frontal air bags. The air bags did not deploy in the frontal crash. The Cobalt was not equipped with inflatable side impact protection. The Chevrolet was equipped with Cooper Eldorado Legend 195/60R15 tires mounted on OEM alloy wheels. The vehicle manufacturer recommended front and rear tire pressure was 207 kPa (30 PSI). The specific tire data at the time of the SCI inspection was as follows:

Tire	Measured Pressure	Tread Depth	Restricted	Damage
LF	255 kPa(37 PSI)	3 mm (4/32 in)	No	None
LR	269 kPa (39 PSI)	6 mm (7/32 in)	No	None
RF	Tire flat	5 mm (6/32 in)	Yes	Punctured tread and rim fractured
RR	255 kPa (37 PSI)	6 mm (7/32 in)	No	None

The seating positions in the Chevrolet were configured with cloth-upholstered front bucket seats and a second row three-passenger folding split-bench seat (60/40) left side wide. The adjustable front head restraints were in the full-down position. The outboard positions of the rear bench seat were equipped with integrated head restraints.

2001 Hyundai Sonata

The 2001 Hyundai Sonata was identified by the following VIN: KMHWF25S31A (production number omitted). The Sonata was manufactured in October 2000 and the odometer read 131,333 km (81,609 miles) at the time of the SCI inspection. The Hyundai was powered by a 2.4-liter in-line 4-cylinder engine linked to a 4-speed automatic transmission with front-wheel drive. The braking system consisted of power front disc and rear drum brakes without ABS. The manual restraint system consisted of three-point lap and shoulder belts in all five seat positions. The front safety belts were equipped with retractor pretensioners. The Sonata was equipped with an Advanced Occupant Protection System (AOPS) for the driver and front right passenger consisting of redesigned dual stage frontal air bags and a front right occupant detection system. The driver air bag deployed in the crash. The vehicle was also equipped with front seat back mounted side impact (thorax) air bags. The Hyundai was equipped with Lemans SR P205/60R15 tires at the left front and right front positions and BF Goodrich Touring T/A P205/60R15 tires on the rear axle. The tires were mounted on the OEM five-spoke alloy wheels. The vehicle manufacturer recommended front and rear tire pressure was 207 kPa (30 PSI). The specific tire data measured at the time of the SCI inspection was as follows:

Tire	Measured Pressure	Tread Depth	Restricted	Damage
LF	241 kPa (35 psi)	3 mm (4/32 in)	Yes	None

Tire	Measured Pressure	Tread Depth	Restricted	Damage
LR	Tire Flat	6 mm (7/32 in)	No	Debeaded
RF	193 kPa (28 PSI)	3 mm (4/32 in)	Yes	None
RR	214 kPa (31 PSI)	4 mm (5/32 in)	No	None

The interior of the Hyundai consisted of cloth upholstered five-passenger seating. The front row was equipped with bucket seats with height adjustable head restraints. The driver's head restraint was adjusted in the full-down position. The front right head restraint was adjusted 2 cm (1 in) above the full-down position. The rear seat was a three-passenger bench seat with height adjustable head restraints in the outboard positions. The left head restraint was adjusted 2 cm (1 in) above the full position and the right was in the full-down position.

CRASH SITE

This two-vehicle crash occurred during the nighttime hours of April 2009. At the time of the crash it was dark without overhead artificial lighting and the weather was not a factor. The crash occurred within a straight section of an east/west 2-lane roadway that was located in a rural setting. The travel lanes measured 3.2 m (10.4 ft) in width and were separated by a double yellow centerline. The outboard edges of the travel lanes were delineated by white fog lines with narrow asphalt shoulders. A road side ditch bordered the north road edge. The point of impact was located entirely in the eastbound travel lane 15 m (49 ft) west of a hill crest. The area of the impact was evidenced by a series of gouge marks in the asphalt pavement and fluid spills. **Figure 2** is an eastbound trajectory view at the point of impact. The speed limit in the area of the crash was 89 km/h (55 mph).

Figure 2: Eastbound trajectory view at the point of impact.

At the crash site, the eastbound traffic exited a left curve and entered the straight section of the road 111 m (365 ft) prior to the point of impact. The eastbound approach to the impact had a positive 10 to 12 percent (+10 to12%) grade. The grade was measured 61 m (200 ft) prior to the impact. The road grade decreased approaching the point of impact to approximately positive three percent (+3%). The westbound traffic exited a left curve 79 m (260 ft) prior to the impact and traveled along level pavement. At the hillcrest, 15 m (49 ft) east of the impact, the westbound road grade abruptly began to descend. SCI investigator observations during the scene inspection determined that the drivers' visibility to opposite direction traffic was hampered by the rapid grade change and steep slope within 76 m (250 ft) of the point of impact. **Figures 3 and 4** are eastbound and westbound approach views taken during the SCI scene inspection. A schematic of the crash is included at the end of this report as **Figure 17.**

Figure 3: Eastbound approach view 90 m (300 ft) from the point of impact.

Figure 4: Westbound approach view 60 m (200 ft) from the point of impact.

CRASH SEQUENCE

Pre-Crash

The 2005 Chevrolet Cobalt was eastbound driven by the 73-year old unrestrained female. The Cobalt was occupied by the 13-year old unrestrained female front right passenger and the 12-month-old male restrained in a forward facing manner within a Cosco convertible CRS in the second row center position. The 2001 Hyundai Sonata was westbound driven by the 47-year old unrestrained male. He was the vehicle's sole occupant.

The Chevrolet Cobalt approached the crash site with a straight trajectory and was ascending the positive grade of the road. The EDR reported speed was 77 km/h (48 mph) five seconds prior to the Algorithm Enable (AE). The driver steered to the left immediately prior to the impact in an attempt to avoid the crash. The steering input was evidenced by the right offset impact configuration. The Hyundai exited the westbound left curve 79 m (260 ft) from the point of impact. During its approach, the Hyundai crossed the centerline and was entirely in the eastbound lane. A 7 m (23 ft) long skid mark that led to the point of impact was identified during the police investigation. This mark was attributed to the right front tire of the Hyundai and was an indicator that the driver applied the brakes before the impact.

The police investigation revealed that the driver of the Hyundai was operating the vehicle under the influence of alcohol. The driver's autopsy revealed his Blood Alcohol Content (BAC) was 0.24 percent. As he approached the crash site, he reportedly was talking on his cellular phone to a friend. During the conversation, the friend reported that the phone call suddenly terminated. The sudden end to the conversation prompted the friend to call the police and alert them that a crash may have just occurred.

Crash

The front plane of the Hyundai impacted the front plane of the Chevrolet in a slight offset right configuration. The severity of the impact caused the driver air bag in the Hyundai to deploy. The frontal air bags in the Chevrolet did not deploy. The vehicles pitched down and the front structures deformed. The westbound momentum of the Hyundai halted the forward movement of the Chevrolet and reversed its direction. The offset collision caused the vehicles to rotate

clockwise (CW) as they separated. The Hyundai rotated approximately 200 degrees clockwise and slid to rest on the south road edge. The Hyundai came to rest facing southeast 9.6 m (31 ft) from the impact. The Chevrolet rotated approximately 30 degrees CW and slid to rest on the north roadside. The vehicle slid through the road side ditch and came to rest on the back slope 17.5 m (57 ft) from the impact. **Figure 5** is an on-scene police image of the point of impact and final rest positions of the vehicles.

Figure 5: On-scene police image of the crash site.

The Damage Algorithm of the WINSMASH model was used to calculate the severity (delta-V) of the crash. The total calculated delta-V of the Chevrolet was 102 km/h (63.3 mph). The longitudinal and lateral components of the delta-V were -100 km/h (-62.1 mph) and 18 km/h (11.1 mph), respectively. The total calculated delta-V of the Hyundai was 100 km/h (62.1 mph). The longitudinal and lateral components of its delta-V were -98 km/h (–60.9 mph) and 17 km/h (10.6 mph), respectively. The maximum total delta-V recorded by the Event Data Recorder (EDR) in the Chevrolet was 86.1 km/h (53.5 mph). The maximum delta-V was reached 120 milliseconds after Algorithm Enable (AE). The maximum EDR recorded longitudinal and lateral delta V components were -82.9 km/h (-51.5 mph) and -22.9 km/h (-14.2 mph), respectively.

Post-Crash

The police and ambulance personnel responded to the crash site. The front seated occupants in both vehicles were pronounced deceased at the scene as a result of blunt force trauma. The center rear safety belt that secured the CRS was cut and the 12-month-old child and CRS were removed together from the vehicle through the left rear door. The child was then removed from the CRS and transported by helicopter to a pediatric trauma center located approximately 121 km (75 miles) from the crash site. He was admitted in serious but stable condition for a cervical spine injury. Both vehicles were towed from the crash site and impounded as part of the police investigation.

2005 CHEVROLET COBALT

Exterior Damage

The 2005 Chevrolet Cobalt sustained severe damage from the off-set frontal collision with the Hyundai. **Figures 6 and 7** are an overhead and right side view of the deformation. The width of the direct contact damage measured 117 cm (46.1 in). The direct contact began 51 cm (20.1 in) left of center and extended to the right corner. The combined direct and induced damage extended across the entire 132 cm (52.0 in) end width. The damage pattern was biased to the right indicative of the offset impact configuration and the evasive left steering by the Chevrolet's driver. The damaged components included but were not limited to the front bumper fascia, bumper reinforcement beam, upper and lower radiator supports, headlight assemblies, fenders, right A-pillar, and the right front suspension components. As the vehicles crushed, the right wheel was displaced rearward into the wheelhouse and right cowl. The wheel rim fractured.

The right A-pillar was deformed rearward 40 cm (15.8 in) and the lower third of the pillar deformed to a vertical orientation. The front right door was compressed 19 cm (7.5 in) and buckled outboard. The right roof side rail was buckled to the right B-pillar location. The upper aspect of right front shock absorber tower deformed rearward 53 cm (21.0 in). The right wheelbase was reduced 41 cm (16.1 in). The left wheelbase lengthened by 8 cm (3.1 in) due to body distortion of the Cobalt. The residual crush profile documented along the bumper reinforcement was as follows: C1 = 7 cm (2.8 in), C2 = 40 cm (15.7 in), C3 = 73 cm (28.7 in), C4 = 81 cm (31.9 in), C5 = 89 cm (35.0 in), C6 = 79 cm (31.1 in). The maximum crush was 89 cm (35.0 in) at C5. The left front and right side doors were jammed closed by the impact. The left front and right front doors were opened by rescue personnel evidenced by extrication damage to the respective B-pillar areas. The right rear door compressed rearward and overlapped the quarter panel and C-pillar. The maximum overlap measured 2 cm (1 in). The windshield was fractured and the right front door glazing disintegrated during the crash. The left side, backlight, and right rear door glazing were intact. The Collision Deformation Classification (CDC) of the Cobalt was 12-FDEW5.

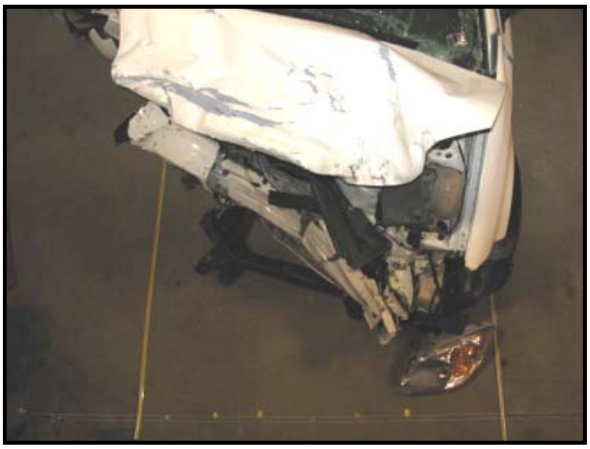

Figure 6: Overhead view of the Cobalt's frontal damage.

Figure 7: Right lateral view of the frontal damage.

Interior Damage

The interior of the Chevrolet sustained severe center and right frontal intrusion as a result of the exterior crash force. The unrestrained Row 1 occupants translated forward and contacted the vehicle's interior forward of their respective seat positions in response to the frontal impact force. This pattern was evidenced by multiple occupant contact points. **Figure 8** is a left lateral view of the front interior.

Figure 8: Left lateral view of the front interior.

The following table identifies the longitudinal intrusion of the Cobalt.

Position	Component	Intrusion
Row 1 Left	Toe pan	15 cm (6 in)
Row 1 Center	Instrument panel	7 cm (2.8 in)
Row 1 Right	A-pillar	33 cm (13 in)
Row 1 Right	Instrument panel	39 cm (15.5 in)
Row 1 Right	Toe pan	70 cm (27.5 in)

The driver seat was located in a mid-track position and was jammed in place by the floor pan deformation. The seat back was reclined 10 degrees aft of vertical. The horizontal distance between the seat back and the driver air bag module measured 57 cm (22.4 in).

The 4-spoke steering wheel was rotated approximately 160 degrees counterclockwise. The steering wheel rim was deformed forward in the 4 to 8 o'clock sectors. The maximum rim deformation was 2 cm (0.8 in) in the 6 o'clock sector. The driver loaded the steering assembly and compressed the column forward into the instrument panel 9 cm (3.5 in). A head contact was noted to the left aspect of the driver sun visor. The contact measured 15 cm x 10 cm (6 in x 4 in). A left lower extremity contact to the bolster was noted 24 cm (9.5 in) left of the steering column. The right lower extremity contacted the bolster immediately below the steering column. The lower extremity contacts did not fracture the flexible bolster panel; however, deformation of the steel backer structure behind the panel was noted.

The front right seat was adjusted to a mid-track position and was jammed. The seat back angle measured two degrees aft of vertical and had deformed forward. A backpack containing a bowling ball and accessories was found immediately behind the front right seat back. This object was displaced forward from the trunk by the force of the impact. The object fractured the right hinge of the split-folding rear bench seat. Displaced small hand tools were found in the mid aspect of the instrument panel. Inspection of the trunk revealed that it contained fishing tackle, books and multiple miscellaneous small items.

The unrestrained front right occupant responded to the frontal impact with a forward trajectory and contacted the right instrument panel with her chest. The outboard aspect of the panel was fractured. Body fluid transfers were noted over a 48 cm x 30 cm (19 in x 12 in) contact area. Refer to **Figure 9**. Her lower extremities contacted the glove box door. A 10 cm (4 in) wide head contact was identified on the inboard aspect on the right sun visor.

Figure 9: Right instrument panel contact evidence and the non-deployed passenger air bag.

Manual Safety Belt Systems

The Chevrolet was equipped with manual 3-point lap and shoulder safety belts for the five seat positions. All belt systems utilized continuous loop webbing with sliding latch plates. The

driver's belt was equipped with an Emergency Locking Retractor (ELR), a retractor mounted pretensioner, and a height adjustable D-ring that was in full-up position at the time of the SCI inspection. An inspection of the driver's safety belt revealed historical usage evidence consistent with the age of the vehicle. There was no identified crash related evidence to the webbing or the friction surfaces of the latch plate and D-ring. The retractor pretensioner did not actuate during the crash. The SCI inspection of the driver's safety belt and front left interior determined the driver was not restrained at the time of the crash. The imaged EDR data also indicated the driver's safety belt was unbuckled at the time of the crash.

The front right safety belt system utilized a switchable ELR/Automatic Locking Retractor (ELR/ALR), a retractor pretensioner, and a height adjustable D-ring that was in full-up position. Historical usage evidence was also present on the front right belt system. There was no crash related evidence of use. The front right passenger was determined to be unrestrained at the time of the crash based on the safety belt and front right interior inspection. The front right safety belt was not monitored by the EDR.

The three rear belt systems utilized switchable ELR/ALR retractors. The rear center safety belt was used to install the convertible CRS in the forward facing mode. The lap and shoulder belt webbing was routed through the forward facing belt path of the child safety seat. The webbing was cut post-crash by rescue personnel in order to remove the seat. The cut section of the belt webbing measured 77 cm (30.3 in), **Figure 10**. The balance of the webbing had spooled back into the retractor. The cut webbing contained a 45 cm (17.7 in) section that was loaded from its interaction with the belt path of the CRS. The loading began 13 cm (5.1 in) above the seat bight. The latch plate was found fastened in the center rear buckle. Extensive frictional abrasions were noted to both sides of the latch plate friction surface. These abrasions occurred as a result of the CRS loading of the webbing during the crash event. Refer to the *Child Restraint System* section of this report regarding further information regarding the use of the CRS.

Figure 10: View of the center rear safety belt.

Air Bag Systems

The frontal air bag system in the Chevrolet Cobalt consisted of dual-stage driver and front right passenger air bags that did not deploy as a result of the crash. The cause of the non-deployment could not be determined. The driver air bag was located in the center hub of the steering wheel rim. The front right air bag module was a top-mount design located in the right aspect of the instrument panel. The vehicle was not equipped with side impact air bags. The frontal air bag system was controlled by a Sensing Diagnostic Module (SDM) that was located under the center console between the front seats. The SDM had Event Data Recorder (EDR) capabilities that could capture data at the time of a crash. The SDM was removed by the police investigator and was imaged by the SCI investigator at the time of the inspection.

The only known service to the air bag system was conducted in November 2005. At that time the vehicle was serviced by the dealer for General Motors recall # 05046A (NHTSA ID# 10016003). The recall involved a correction to the wiring of the air conditioning system and to the wiring of the driver air bag module. In a moderate severity crash, the driver air bag would fully deploy instead of at a reduced level as described in the owner's manual. The purpose of the recall service was to correct that issue. The Chevrolet's odometer reading was 31,834 km (19,781 miles) at the time of the service

Event Data Recorder

The Bosch Crash Data Retrieval hardware and software version 3.1 were used to image the EDR. The data was imaged by connecting the hardware directly to the SDM and powering up the module via the 12-volt adapter. The module was removed and powered up remotely due to the electrical system damage sustained as a result of the impact.

The EDR recorded a single Non-Deployment Event that was related to this crash. There were no other events prior to, or after the recorded Non-Deployment and the event recording was complete. The data was stored on Ignition Cycle 18419. At the time of the recording, the Air Bag warning lamp was "Off" and had been "Off" continuously for 655200 seconds (7.5 days). The driver's safety belt was not buckled. There were no stored Diagnostic Trouble Codes. The speed of the Cobalt two seconds prior to the event was 76 km/h (47 mph). The maximum recorded total delta-V was 86.1 km/h (53.5 mph) at 120 milliseconds after Algorithm Enable (AE). The cause of the air bag non-deployment in this severe crash could not be determined. The imaged CDR data file is included at the end of this report as Attachment A.

Child Restraint System

The 12-month-old male child was restrained by the five-point harness system of a Cosco Scenera S convertible CRS in the second row center position of the Cobalt, **Figure 11**. The CRS was restrained to the vehicle by the center three-point belt webbing routed through the forward facing belt path. The adjustable foot was in the extended position for forward facing use.

Figure 11: View of the Cosco CRS.

The CRS was manufactured on September 10, 2008 and was identified by the Model No: 22123 BVL, Serial No: WC A485784. In the forward facing mode, the seat was rated for a child with a height of 85 to 110 cm (34 to 43 in) and weight of 10 to 18 kg (22 to 40 lb). In the rear facing mode, the seat was rated for use by infants weighing 2.3 to 16 kg (5 to 35 lb) with a height of 48 to 91 cm (19 to 36 in). The height and weight of the child at the time of the crash was unknown. The CRS was equipped with the Lower Anchors and Tether for CHildren (LATCH). The LATCH system was not in use.

The shell was designed with four slots for adjustment of the harness straps. The straps were positioned in the second row from the top. The left strap was twisted one turn and the strap was roped in the chest retainer clip and left buckle. There was no residual evidence of loading to the harness. The chest retainer clip and buckle were operational. Examination of the upper shell was unremarkable for damage. Minor abrasions from interaction with the vehicle's safety belt were noted adjacent to the slot of the forward facing belt path.

2001 HYUNDAI SONATA

Exterior Damage

The 2001 Hyundai Sonata sustained severe frontal damage as a result of the impact with the Chevrolet **(Figures 12 and 13)**. The width of the direct damage extended across the entire 147 cm (58 in) frontal end width of the Sonata. The right bias of the impact and extent of crush deformed the left front corner 23 cm (9 in) to the right. The bumper reinforcement and forward components deformed into the engine compartment. The front right wheel assembly crushed rearward into the lower A-pillar. The upper aspect of the A-pillar deformed and was near vertical. The rake angle measured 80 degrees from horizontal. The roof was buckled vertically above the front right position. The rake angle of the undeformed left upper A-pillar measured 35 degrees. The rearward displacement of the right upper shock absorber tower measured 65 cm (25.6 in). The left upper shock tower was displaced 10 cm (4.1 in). The residual frontal crush documented along the bumper reinforcement was as follows: C1 = 46 cm (18.1 in), C2 = 86 cm (33.9 in), C3 = 94 cm (37.0 in), C4 = 104 cm (40.9 in), C5 = 117 cm (46.1 in), C6 = 110 cm (43.3 in). The maximum crush was 117 cm (46.1 in) at C5. The right wheelbase was reduced 86 cm (33.8 in). The left wheelbase was reduced 12 cm (4.7 in). The front right door crushed 48 cm (19 in), bowed outboard and was jammed closed. The right rear door and the left doors remained closed during the impact. These were opened by the first responders and could not be relatched due to body deformation. The windshield was fractured. The front left and front right glazings disintegrated. The rear left, backlight and rear right glazings were intact. The CDC of the Hyundai was 12-FDEW5.

Figure 12: Front view of the Hyundai.

Figure 13: Right lateral view of the frontal deformation.

Interior Damage

The interior of the Hyundai sustained severe right side intrusion. **Figure 14** is a right lateral view across Row 1. The right floor pan deformed and buckled vertically. The tow pan was crushed rearward to the leading edge of the front right seat cushion. The intrusion of the right instrument panel measured 51 cm (20 in). The horizontal distance from the front right seat back to the face of the instrument panel measured (17 in). The right floor pan deformed due to the extent of frontal crush. The floor pan deformation resulted in the inboard displacement of the front right seat relative to its original location. The upper aspect of the front right seat back and head restraint rotated inboard approximately 30 cm (12 in). The front right head restraint was raised at the time of the crash. The outboard aspect of the head restraint was raised 5 cm (2 in). However, the inboard aspect of the head was raised approximately 4 cm (1.5 in). The inboard aspect was lower due to a possible rebound head contact by the driver (**Figure 15**).

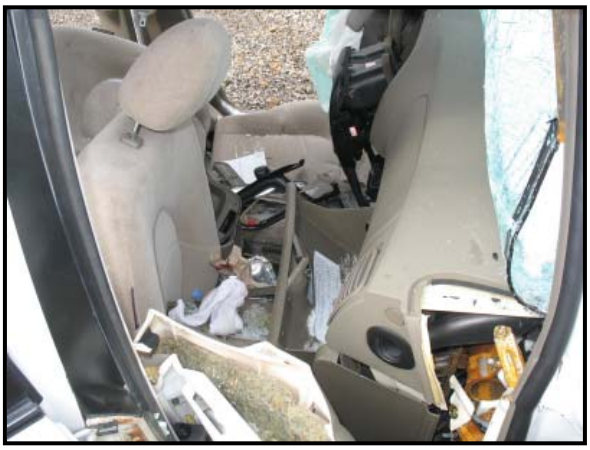

Figure 14: Hyundai front right interior.

Figure 15: View of the Hyundai's front right head restraint.

Figure 16 is a left lateral view of the driver compartment. The driver seat was adjusted to a full rear track position. The seat cushion was deformed vertically downward from driver loading. The seat back was reclined 45 degrees at the time of the SCI inspection and appeared to have been moved to that position by the first responders. The center aspect of the toe pan intruded to the brake pedal, an estimated 10 cm (4 in). There was no left instrument panel intrusion.

Figure 16: Left lateral view of the Hyundai's intrusion.

The steering wheel was rotated approximately 80 degrees clockwise at the time of the inspection. The steering column was fully compressed into the instrument panel due to driver loading. The top aspect of the steering wheel rim was intact with the brow of the instrument panel. The shear capsule separation measured 9

cm (3.5 in). The steering wheel rim was deformed forward in the 2 to 9 o'clock sectors. The maximum rim deformation measured 5 cm (2 in).

The unrestrained driver contacted the deployed driver air bag with his chest and loaded the steering wheel/column. This loading separated the shear capsules and fully compressed the column. The driver's lower extremities contacted and fractured the knee bolster covering, and deformed the metal backer structure. These lower extremity contacts were located 24 cm (9.5 in) left and 20 cm (8 in) right of the steering column centerline.

The center aspect of the rear bench seat was deformed forward 15 cm (6 in). The folding rear seat back was loaded from behind by the contents of the trunk during the impact. The temporary spare tire was found loose within the trunk and appeared to have been dislodged from its mount by the crash force.

Manual Safety Belt Systems

The Hyundai was equipped with manual 3-point lap and shoulder safety belts for the five seat positions. The belt systems consisted of continuous loop webbing with sliding latch plates. The driver's belt was equipped with an ELR, a retractor mounted pretensioner, and a height adjustable D-ring that was in full-up position at the time of the SCI inspection. Historical usage evidence that consisted of scratch marks to the latch plate was present. The driver did not use the safety belt during the crash which was supported by the lack of crash related loading evidence. Additionally, the retractor pretensioner did not actuate.

The front right safety belt system utilized a switchable ELR/ALR, a retractor pretensioner, and a height adjustable D-ring that was in full-up position at the time of the SCI inspection. The three rear belt systems utilized switchable ELR/ALR. The front right and rear seats were not occupied during the crash.

Air Bag Systems

The Hyundai Sonata was equipped with an Advanced Occupant Protection System (AOPS) that included dual-stage frontal air bags with front right occupant detection. The driver air bag deployed from an H-configuration module located in the center of the steering wheel rim. The cover flaps were asymmetrical. The width and height of the upper flap measured 15 cm x 10 cm (6 in x 3.8 in). The lower flap dimensions were 15 cm x 6 cm (6 in x 2.5 in). The air bag measured 66 cm (26 in) in diameter in its deflated state. The bag was vented by two 3 cm (1 in) diameter ports and was tethered by two internal straps. The excursion of the air bag from the module measured 22 cm (8.5 in). The face of the air bag by scuffed in the 2 to 4 o'clock sector by driver loading. The scuffed area measured 18 cm x 10 cm (7 in x 4 in). A 5 cm x 5 cm (2 in x 2 in) area of body fluid was noted within the scuffed in region at the 4 o'clock sector. The air bag was soiled due to post-crash exposure to the elements at the 6 o'clock sector.

The front right air bag was a top mount design located in the right aspect of the instrument panel. The deployment of this module was suppressed by the occupant detection system in the unoccupied front right seat. The Sonata was also equipped with front seat back mounted side impact air bags. The side air bags did not deploy during the crash.

DRIVER DEMOGRAPHICS
2005 Chevrolet Cobalt

Age/Sex:	73-year-old/Female
Height:	168 cm (66 in)
Weight:	71 kg (157.5 lb)
Seat Track Position:	Mid-track
Safety Belt Usage:	None used
Usage Source:	SCI vehicle inspection
Egress from Vehicle:	Extricated and removed by rescue personnel
Type of Medical Treatment:	None, pronounced deceased at scene

DRIVER INJURIES
2005 Chevrolet Cobalt

Injury	***Injury Severity (AIS 90/Update 98)***	***Injury Source***
Near complete transection of the brain stem at the pontomedullary junction	Maximum (140218.6,8)	Windshield header
Bilateral flail chest (involving left ribs; 2 thru 5 anterolaterally, 6 thru 8 laterally and 10 anterolaterally, right ribs; 3 thru 5 anteriorly, 3 thru 8 posterolaterally, 3 thru 6 posteromedially and 9 and 10 laterally, with bilateral lung contusions	Critical (450266.5,3)	Steering wheel/column
Right and left subarachnoid hemorrhage	Serious (140684.3,1) (140684.3,2)	Windshield header
Bilateral pleural lacerations (with approximately 25 to 50cc of blood in each cavity)	Serious (441800.2,3)	Steering wheel/column
Left proximal humerus fracture, both comminuted and displaced	Serious (752604.3,2)	Left instrument panel
Right mid-ilium transverse and displaced fracture	Serious (852604.3,1)	Knee bolster (indirect)
Sternal fracture, both transverse and comminuted (at the manubrial sternal joint)	Moderate (450804.2,4)	Steering wheel/column
C3 vertebral body , complete through and through transverse fracture across the body (up to 1.5cm in width, with direct view of the spinal cord)	Moderate (650230.2,6)	Windshield header, indirect
Left anterior upper neck abrasion (transversely oriented V-shaped (3x3cm)in the submental region, inferior to the anterior left mandible)	Minor (390202.1,2)	Windshield, possible
Left upper eyelid contusion (4.5 x 2cm)	Minor (297402.1,2)	Windshield header

Injury	*Injury Severity (AIS 90/Update 98)*	*Injury Source*
Left upper eyelid abrasion	Minor (297202.1,2)	Windshield header
Right upper eyelid contusion (5.5 x 2.5cm)	Minor (297402.1,1)	Windshield header
Right upper eyelid abrasion	Minor (297202.1,1)	Windshield header
Left ocular conjunctiva hemorrhage (0.5cm in greatest dimension)	Minor (240416.1,2)	Windshield header
Right medial lower forehead abrasion (at the medial margin of the right eyebrow,0.6cm)	Minor (290202.1,7)	Windshield header
Right medial lower forehead contusion	Minor (290402.1,7)	Windshield header
Medial chin, 1.3 cm abrasion (in the submental region)	Minor (290202.1,8)	Windshield
Medial chin, 1.3 cm contusion (in the submental region	Minor (290402.1,8)	Windshield
Left breast 7 cm contusion (on the upper outer quadrant)	Minor (490402.1,2)	Steering wheel rim
Medial mid chest abrasion (3.5cm)	Minor (490202.1,4)	Steering wheel rim
Right upper abdominal (3cm)contusion	Minor (590402.1,1)	Steering wheel rim
Multiple bilateral upper extremity contusions Left arm contusion 5 cm (anteroproximal aspect)	Minor (790402.1,3)	Left instrument panel
Multiple bilateral upper extremity abrasions Left arm abrasion 5 cm (anteroproximal aspect)	Minor (790202.1,3)	Left instrument panel
Multiple bilateral lower extremity contusions, abrasions and lacerations Right proximal thigh, scattered contusions (20 x 20 cm area, with the largest up to 9cm) lateral and postero-lateral aspect, Proximal bilateral shin abrasions, left curvilinear 2.5cm and right 2.5cm proximal shin	Minor (890402.1,1) (890202.3,1) (890602.1,1)	Lower instrument panel
Left 5th toe contusion (dorsal aspect 1.6 cm)	Minor (890402.1,2)	Foot controls

Source: Autopsy

DRIVER KINEMATICS

2005 Chevrolet Cobalt

The 73-year-old female driver of the Chevrolet was seated in a mid-track position with an unknown posture. She was not restrained by the manual lap and shoulder safety belt system. At impact, the driver responded to the 12 o'clock direction of force by initiating a forward trajectory. Her knee's contacted the knee bolster evidenced by the deformation of the steel knee bolster backer structure. As the vehicles continued to crush, the front of the Cobalt pitched slightly downward while the driver continued her forward motion. During her forward trajectory, the driver's head struck the windshield header evidence by a brownish colored transfer. The initial head contact resulted in the soft tissue facial injuries and brain hemorrhages. The driver's unrestrained torso loaded the cervical spine forcing the neck into hyper-extension. The loading of the cervical spine exceeded the limits of the anatomy resulting in the fatal trauma. The driver's chest contacted and loaded the steering wheel resulting in column compression and steering wheel rim deformation. The loading of the steering wheel/column resulted in the bilateral flail chest and the pleural lacerations. The unrestrained contact to the front interior resulted in the multiple soft tissue injuries. The driver then rebounded back into the front left seat where she came to final rest. She was pronounced deceased at the scene.

FRONT RIGHT PASSENGER DEMOGRAPHICS

2005 Chevrolet Cobalt

Age/Sex:	13-year-old/Female
Height:	160 cm (63.5 in)
Weight:	70 kg (155 lb)
Seat Track Position:	Mid-track
Safety Belt Usage:	None used
Usage Source:	SCI vehicle inspection
Egress from Vehicle:	Extricated and removed by rescue personnel
Type of Medical Treatment:	None, pronounced deceased at scene

FRONT RIGHT PASSENGER INJURIES

2005 Chevrolet Cobalt

Injury	***Injury Severity (AIS 90/ Update 98)***	***Injury Source***
Through and through transection of the cervical spinal cord of the upper cervical region inferior to the medulla with pulpified shredded focally hemorrhagic margins	Critical (640240.5,6)	Windshield header
Complete circumferential through and through transection of the descending thoracic aorta	Critical (420210.5,4)	Right instrument panel
Left posterior liver lobe laceration (pulpified in the subcapsular region)	Critical (541828.5,1)	Seat back
Right subdural hemorrhage (thin over the lateral aspect of the right cerebral hemisphere)	Severe (140652.4,1)	Windshield header

Injury	*Injury Severity (AIS 90/ Update 98)*	*Injury Source*
Multiple right side rib fractures (anteriorly at the sternum affecting the right ribs 1 thru 4, laterally in a linear array affecting the right ribs 4 thru 9 and right ribs 1 thru 9 in the vicinity of the costovertebral articulation) with bilateral hemothorax	Severe (450252.4,1)	Right instrument panel
Bilateral pulmonary contusions	Severe (441410.4,3)	Right instrument panel
Rotary dislocation between the 1st and 2nd cervical vertebrae	Serious (650206.3,6)	Windshield header
Right patchy subarachnoid hemorrhage (most prevalent over the lateral aspect of the right parietal lobe superior to the Sylvian fissure)	Serious (140684.3,1)	Windshield header
Left subarachnoid hemorrhage (on the left tracking along the sulci on the lateral aspect of the left parietal lobe superior to the Sylvian fissure)	Serious (140684.3,2)	Windshield header
Incomplete alantooccipital disarticulation (with posterior displacement of the dens of the axis and its accompanying articulation with the atlas into the spinal canal creating traumatic impingement in this region with the resultant spinal cord transection)	Serious (650208.2,6)	Windshield header, indirect
Right femoral neck fracture	Serious (851812.3,1)	Lower right instrument panel
Left displaced ulna fracture	Serious (753204.3,2)	Right instrument panel
Left displaced radius fracture	Serious (752804.3,2)	Right instrument panel
Right pleural lacerations (between the right 4th and 5th ribs in the inter-coastal musculature, and similarly between the right 8th and 9th ribs) with 400 cc of predominately non-clotted blood on the right, and 400cc of non-clotted blood on the left	Moderate (441800.2,1)	Right instrument panel
Pericardium laceration (on the right basal aspect in a through and through fashion, 5 cm in maximal dimension)	Moderate (441602.2,4)	Right instrument panel

Injury	*Injury Severity (AIS 90/ Update 98)*	*Injury Source*
Multiple splenic lacerations (two parallel generally transverse irregular ragged lacerations on the anterolateral surface of the spleen, each approximately 3 cm in maximal dimension present over an area 4 x 3 cm)	Moderate (544222.2,2)	Seat back
Mandible fracture (midline) (with associated laceration of the inner aspect of the lower lip in the midline, 2cm in maximal dimension and extensive laceration of the gingival mucosa between the right and left incisors)	Moderate (250612.2,9)	Windshield
Nasal skeleton fracture (with associated 2 x 1 cm gaping laceration that extends into superficial and deep soft tissue)	Moderate (251004.2,4)	Windshield header
Nasal bridge contusion	Minor (290402.1,4)	Windshield header
Right lower eyelid abrasion (0.4cm medial aspect)	Minor (297202.1,1)	Windshield header
Left central upper eyelid abrasion (1.1 x 0.4 cm transversly oriented)	Minor (297202.1,2)	Windshield header
Nasal bridge abrasion , Right cheek abrasion (inferomedial aspect, 0.5 cm transversely oriented)Left cheek abrasions (patterned over an area 3.5 x 1.2 cm and is longitudinally oriented)	Minor (290202.1,4) (290202.1,1) (290202.1,2)	Windshield header
Right medial lip 0.7 cm transverse abrasion, left lower lip(along vermillion) 1.7cm abrasion, right side of chin, multiple parallel abrasions, (1.8 cm over an area of 6.5 x 3 cm)	Minor (290202.1,8)	Windshield
Left medial lower lip contusion	Minor (290402.1,8)	Windshield
Tongue laceration (to the ventral aspect, midline)	Minor (243400.1,8)	Non-contact, impact force
Right shoulder abrasion (over lateral 1/3 of clavicle, 8 x 5cm)	Minor (790202.1,1)	Right instrument panel
Right shoulder contusion(over lateral 1/3 of clavicle, 8 x 5cm)	Minor (790402.1,1)	Right instrument panel

Injury	*Injury Severity (AIS 90/ Update 98)*	*Injury Source*
Whole chest abrasions (right breast, 3.5cm and 2.5 lower right breast) left breast 7.5 cm abrasion, and mid chest 15 x 7 cm abrasion	Minor (490202.1,0)	Right instrument panel
Superior abdominal abrasions (lateral) (over a 5cm area)	Minor (590202.1,7)	Right instrument panel
Perineum laceration (superficial sagittal 3.5 x 1 cm) with abrasion	Minor (543222.1,8)	Seat cushion
Perineum contusion	Minor (543210.1,8)	Seat cushion
Bilateral buttock abrasions and contusions; left inferior, medial aspect 8 x 2 cm, parasagitally oriented and right inferior aspect extending onto the posteromedial aspect, with extension into the proximal right thigh, 7 x 3 cm	Minor (890202.1,3) (890402.1,3)	Seat cushion
Right buttock laceration (superficial) with extension into the right proximal thigh	Minor (890602.1,1)	Seat cushion
Back abrasions (right posterolateral central aspect, 3.5 cm curvilinear abrasion and right lower back, at the superior margin of the right buttock 3 x 3 cm)	Minor (690202.1,8)	Seat back
Right lower back contusion	Minor (690402.1,8)	Seat back
Bilateral arm contusions; dorsum left forearm, 3.5 cm, left 2nd metacarpophalangeal joint, 3cm contusions ; dorsum right hand, 1st thru 4th digits, an 8 x 11 cm, dorsum right wrist, 9.5 x 6 cm, dorsum right forearm, 2.5cm, medial right forearm 6 cm area(4 closely grouped contusions), ventral right wrist, 3 cm, right hand , thenar eminence of the palmar aspect, 4 x 3 cm, anterior most proximal right arm at the axillary apex, 3 cm contusion	Minor (790402.1,3)	Right instrument panel
Right arm abrasions; right anterolateral distal arm extending into the lateral right antecubital fossa, 6 x 3 cm, right elbow, medial aspect, 0.6 cm, ventral mid right forearm, 5 cm abrasion	Minor (790202.1,1)	Right instrument panel

Injury	*Injury Severity (AIS 90/ Update 98)*	*Injury Source*
Left medial popliteal fossa (back of knee) 2.5 cm contusion	Minor (890402.1,2)	Right front seat cushion
Bilateral leg contusions; anterior left kneecap, obliquely oriented 3 cm, medial mid left thigh, 2.5 cm; right medial distal thigh 8 x 6 cm contusion	Minor (890402.1,3)	Lower right instrument panel
Right thigh abrasions (scattered and clustered across the anterior, anteromedial and anterolateral linear abrasions over a 32 x 20 cm area)	Minor (890202.1,1)	Lower right instrument panel
Bilateral shin lacerations; right anterior proximal shin, 9 x 3.5 cm oblique gaping laceration; left anterior mid shin, longitudinally oriented 18 x 7 cm gaping laceration, with deep extension into underlying soft tissue structures	Minor (890602.1,3)	Lower right instrument panel
Bilateral ankle and foot contusions; left medial, anteromedial anterior, anterolateral and lateral contusions over area of 20 x 15 cm; right medial ankle, dorsum of the right foot, lateral right ankle, an area of 20 cm in maximal dimension	Minor (890402.1,3)	Toe pan
Left ankle and foot abrasions; left medial, anteromedial anterior, anterolateral and lateral abrasions over area of 20 x 15 cm	Minor (890202.1,2)	Toe pan

Source: Autopsy

FRONT RIGHT PASSENGER KINEMATICS

2005 Chevrolet Cobalt

The 13-year-old female was seated in the front right seating position and was not restrained by the safety belt. Her seat track was adjusted to a mid-track position and the seatback was in a slightly reclined position. The front right passenger responded to the frontal crash forces by initiating a forward trajectory. Her head contacted the windshield header which was evidence by a dark colored transfer. As her head engaged the header, her chest contacted and loaded the right instrument panel. The instrument panel exhibited areas of deformation that was attributed to occupant contact. The passenger's neck was forced rearward and hyper-extended resulting in the fatal neck trauma. The chest contact to the instrument panel resulted in the multiple rib fractures and the aortic transection.

As the right front passenger was in contact with the frontal components, the trunk contents which included tools and a bowling ball struck the rear of the second row seatback. The contents

fractured the hinge of the right split-folding seat back. The contents entered the passenger compartment and struck the rear aspect of the front right seatback.

The force of the crash displaced the engine rearward against the cowl resulting in severe intrusion of the instrument panel and right toe pan. The intrusion occurred as the passenger continued loading the instrument panel. These intruding components probably accentuated the injuries to the passenger's torso and resulted in injuries to her lower extremities. First responders pronounced the passenger deceased at the crash site.

ROW 2 CENTER PASSENGER DEMOGRAPHICS
2005 Chevrolet Cobalt

Age/Sex:	12-month-old/Male
Height:	Unknown
Weight:	Unknown
Seat Track Position:	Not adjustable
Safety Belt Usage:	Forward facing convertible CRS with five-point harness
Usage Source:	SCI vehicle inspection
Egress from Vehicle:	Removed by rescue personnel
Type of Medical Treatment:	Hospitalized for 33 days in a pediatric trauma center

ROW 2 CENTER PASSENGER INJURIES
2005 Chevrolet Cobalt

Injury	***Injury Severity (AIS 90/Update 98)***	***Injury Source***
Complete cord syndrome (with no fracture/dislocation) (paraplegia with no sensation) T1 thru T12	Critical (640422.5,7)	Non-contact, hyper-flexion
Right and left intraventricular hemorrhages (small amount of blood in the posterior horns of the lateral ventricles)	Severe (140678.4,1) (140678.4,2)	Non-contact, hyper-flexion
Cord contusion NFS (C7)	Serious (640200.3,6)	Non-contact, hyper-flexion
Left orbital floor fracture (mildly inferiorly displaced) with fractures of the left lacrimal gland and left maxilla posterior to the nasal bone. The fracture extends through the medial wall of the left maxillary sinus	Serious (251204.3,2)	Head flexion with contact to left lower extremity
Left orbit hematoma (large) (along the medial inferior aspect)	Minor (297402.1,2)	Head flexion with contact to left lower extremity
Left cheek hematoma (large)	Minor (290402.1,2)	Head flexion with contact to left lower extremity
Chest contusions	Minor (490402.1,9)	CRS harness straps

Source: Discharge Summary

ROW 2 CENTER PASSENGER KINEMATICS
2005 Chevrolet Cobalt
The 12-month-old male was seated in the center rear position and was restrained by the integrated five-point harness system of a Cosco convertible CRS. The CRS was installed in the forward facing mode and secured with the vehicle's lap and shoulder belt system. At impact, the inertia locking mechanism locked the safety belt retractor. The child (and safety seat) responded to the 12 o'clock direction of the impact by initiating a forward trajectory. The child's shoulders contacted and loaded the internal five-point harness system of the CRS. As the child loaded the harness, his torso rode down the force of the impact, decelerated, and became restrained. The inertia of the child's head caused the neck to flex forward. The hyper-flexion of the neck resulted in spinal cord injury and brain hemorrhages. As the head flexed down, his head probably contacted his left lower extremity resulting in the orbit fracture and facial injuries. There were no other identified points of contact to the CRS or to the vehicle's interior to account for these injuries. The child then rebounded to rest in the CRS.

The child was found restrained within the CRS by first responders. He was removed from the vehicle while still in the seat and then placed into an ambulance. The child was then transported to a landing zone and transported to a pediatric trauma center by air ambulance. He was hospitalized for 33 days.

DRIVER DEMOGRAPHICS
2001 Hyundai Sonata

Age/Sex:	47-year-old/Male
Height:	171 cm (67.5 in)
Weight:	125 kg (276 lb)
Seat Track Position:	Full-rear track
Safety Belt Usage:	None used
Usage Source:	SCI vehicle inspection
Egress from Vehicle:	Extricated and removed by rescue personnel
Type of Medical Treatment:	None, pronounced deceased at scene

DRIVER INJURIES
2001 Hyundai Sonata

Injury	***Injury Severity (AIS 90/Update 98)***	***Injury Source***
Near complete brain stem transection (at the pontomedullary junction)	Maximum (140218.6,8)	Non-contact, hyper-flexion
Through and through spinal cord transection of the upper cervical spinal cord; Atlanto-Occiptal disarticulation with stenotic impingement into the spinal canal	Critical (640240.5,6)	Non-contact, hyper-flexion
Through and through complete transaction of the proximal descending thoracic aorta	Critical (420210.5,4)	Steering wheel/column

Injury	*Injury Severity (AIS 90/Update 98)*	*Injury Source*
Multiple bilateral rib fractures (left 3 thru 7 anteriorly, right 2 thru 5 in a linear oblique array anteriorly and then proceeding anterolaterally) with hemothorax (left: 1200 cc, right: 100 cc)	Critical (450242.5,3)	Steering wheel/column
Right lung contusions(mid lateral right upper lobe, 7cm ,the anteroinferior right upper lobe, 4 cm, the lateral basal mid right middle lobe, 7.5 cm, the lateral apical 1/3 of the right lower lobe, 4 cm , and the lateral basal right lower lobe, 5 cm in maximum dimension)	Serious (441406.3,1)	Steering wheel/column
Right and left subarachnoid hemorrhage; present over the posterior cerebellar hemispheres and on the posterior cerebellar hemispheric poles bilaterally, as well as on the base of the occipital lobes, right greater than the left	Serious (140466.3,6) Cerebellar (140684.3,1) (140684.3,2) Cerebral	Rebound into the front right head restraint
Liver lacerations (multiple linear roughly parallel transverse and oblique lacerations on the lateral aspect of the right lobe, up to 11 cm in length, present over a longitudinal area 12 cm in length, with focal extension into the superficial hepatic parenchyma. Also on posterior aspect, 2 gaping transverse lacerations up to 4.5 cm in length, 2 cm in depth	Moderate (541822.2,1)	Steering wheel rim
Right distal ulna dislocation (associated with an overlying 2 cm dorsomedial distal right forearm laceration from which the head of the dislocated ulna protrudes partially)	Moderate (751430.2,1)	Left instrument panel
Right forearm laceration (distal, over dislocated ulna head)	Minor (790602.1,1)	Left instrument panel
Right hand contusions (2^{nd}, 3^{rd} and 4^{th}digit)	Minor (790402.1,1)	Left instrument panel
Right hand abrasions(2^{nd}, 3^{rd} and 4^{th}digit)	Minor (790202.1,1)	Left instrument panel
Right thigh, knee and mid-shin abrasions	Minor (890202.1,1)	Knee bolster
Right thigh, knee and shin contusions	Minor (890402.1,1)	Knee bolster
Right knee laceration (gaping 4 x 2 cm)	Minor (890602.1,1)	Knee bolster

Injury	*Injury Severity (AIS 90/Update 98)*	*Injury Source*
Right foot contusions (medial aspect of the mid right foot 6 cm, and the right 1st toe at the medial base, 2.5 cm)	Minor (890402.1,1)	Foot controls
Left medial proximal left calf contusion (3cm)	Minor (890402.1,2)	Seat cushion

Source: Autopsy

DRIVER KINEMATICS

2001 Hyundai Sonata

The 47-year-old male driver of the Hyundai was seated in a full-rear track position and was not restrained by the manual belt system. The police investigation revealed the driver was intoxicated with a BAC of 0.24. While operating the vehicle, the driver was talking on a cellular phone with a friend. That individual stated to the police investigator that the driver was commuting back to their residence. During the conversation, the call abruptly ended causing her to contact the police and alert them to a possible crash.

At impact with the Chevrolet, the driver's frontal air bag deployed and the unrestrained driver was displaced forward by the 12 o'clock impact force. The vehicle pitched down during the impact. The driver's knees contacted the bolster evidenced by the fractured knee bolster panel and deformation of the steel backer. The driver contacted the deployed air bag with his chest and loaded the steering assembly through the inflated air bag. The driver bottomed out the bag and the loading forces resulted in bending of the steering wheel rim and compression of the steering column. Complete separation of the shear capsules was noted during the interior inspection. The chest loading resulted in multiple rib fractures, lung contusions and the aortic transection. The loading of the steering wheel rim resulted in the liver lacerations. As the driver's chest decelerated from the loading of the steering assembly, the inertia of the head forced the neck into hyper-flexion. The hyper-flexion resulted in the identified fatal non-contact injuries of the upper cervical spine and brain stem. As the driver rebounded, the rotation of the vehicle caused the driver to be displaced to the right. His head possibly contacted and deformed the inboard aspect of the right head restraint. This rebound contact resulted in the posterior subarachnoid hemorrhages. The driver was found within the front left seating area and was pronounced deceased.

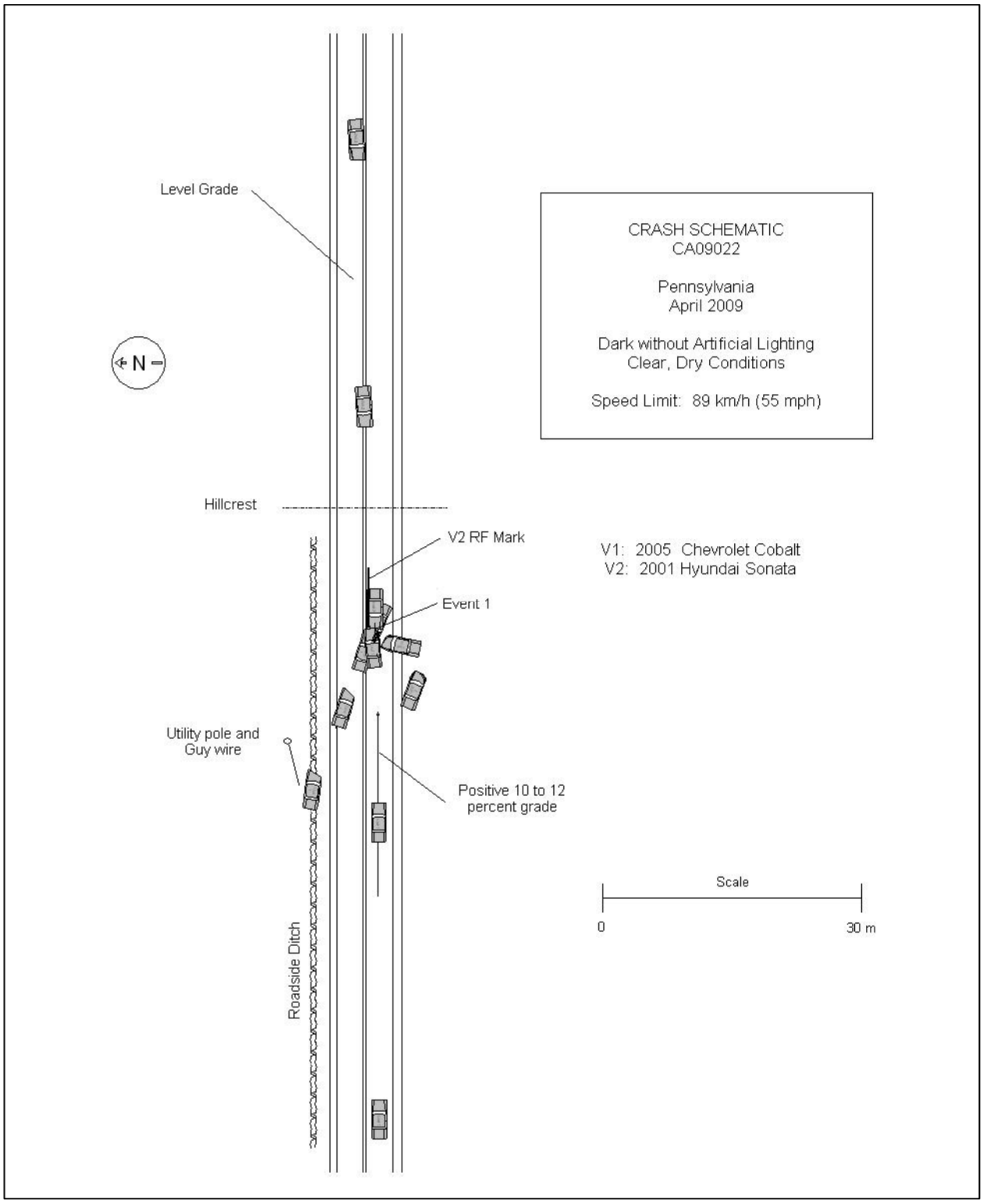

Figure 17: Crash schematic.

ATTACHMENT A

2005 Chevrolet Cobalt EDR Data

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	1G1AL52F857******
User	
Case Number	
EDR Data Imaging Date	
Crash Date	
Filename	CA09022 CDR.CDR
Saved on	Monday, April 6 2009 at 04:13:54 PM
Collected with CDR version	Crash Data Retrieval Tool 3.1
Reported with CDR version	Crash Data Retrieval Tool 3.4
EDR Device Type	airbag control module
Event(s) recovered	Non-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). The minimum SDM Recorded Vehicle Velocity Change, that is needed to record a Non-Deployment Event, is five MPH. A Non-Deployment Event may contain Pre-Crash and Crash data. The SDM can store up to one Non-Deployment Event. This event can be overwritten by an event that has a greater SDM recorded vehicle velocity change. 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 Deployment Event #2, 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 of 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 may contain Pre-Crash and Crash data. The SDM can store up to two different Deployment Events. If a second Deployment Event occurs any time after the Deployment Event, the Deployment Event #2 will overwrite any non-locked Non-Deployment Event. 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 Velocity Change reflects the change in velocity that the sensing system experienced during the recorded portion of the event. SDM Recorded Vehicle 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 220 milliseconds of data after deployment criteria is met and up to 70 milliseconds before deployment criteria is met. For Non-Deployment Events, the SDM can record up to the first 300 milliseconds of data after algorithm enable. Velocity Change data is displayed in SAE sign convention.

-The CDR tool displays time from Algorithm Enable (AE) to time of deployment command in a deployment event and AE to time of maximum SDM recorded vehicle velocity change in a non-deployment event. Time from AE begins when the first air bag system enable threshold is met and ends when deployment command criteria is met or at maximum SDM recorded vehicle velocity change. Air bag systems such as frontal, side, or rollover, may be a source of an enable. The time represented in a CDR report can be that of the enable of one air bag system to the deployment time of another air bag system.

-Maximum Recorded Vehicle Velocity Change is the maximum square root value of the sum of the squares for the vehicle's combined "X" and "Y" axis change in velocity.

-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.

-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 is present to send the pre-crash data

-Driver's and Passenger's Belt Switch Circuit Status indicates the status of the seat belt switch circuit, except: The Passenger Belt Switch Circuit Status for 2005 vehicles is available only on the Cadillac STS. The Passenger Belt Switch Circuit Status for 2006 Chevrolet Cobalt Sport Coupe (AP) model vehicles, with the option package that includes Recaro brand seats (RPO ALV), always reports a default value of "Buckled," because there is no passenger belt switch with the Recaro seat option.
-The Time Between Non-Deployment to Deployment Events is displayed in seconds. If the time between the two events is greater than five seconds, "N/A" is displayed in place of the time. If the value is negative, then the Deployment Event occurred first. If the value is positive, then the Non-Deployment Event occurred first.
-If power to the SDM is lost during a crash event, all or part of the crash record may not be recorded.
-The ignition cycle counter relies upon the transitions through OFF->RUN->CRANK power-moding messages, on the GMLAN communication bus, to increment the counter. Applying and removing of battery power to the module will not increment the ignition counter.
-Steering Wheel Angle data is displayed as a positive value when the steering wheel is turned to the right and a negative value when the steering wheel is turned to the left, except for Cadillac STS model vehicles with StabiliTrak 3.0 systems (RPO JL7). For Cadillac STS model vehicles with StabiliTrak 3.0 systems (RPO JL7), when the steering wheel is turned to the right, a negative value will be displayed and when the steering wheel is turned to the left, a positive value will be displayed. The Steering Wheel Angle data is reported in 16 degree increments.

Data Source:
All SDM recorded data is measured, calculated, and stored internally, except for the following:
-Vehicle Status Data (Pre-Crash) is transmitted to the SDM, by various vehicle control modules, via the vehicle's communication network.
-The Belt Switch Circuit is wired directly to the SDM.

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Multiple Event Data

Associated Events Not Recorded	0
An Event(s) Preceded the Recorded Event(s)	No
An Event(s) was in Between the Recorded Event(s)	No
An Event(s) Followed the Recorded Event(s)	No
The Event(s) Not Recorded was a Deployment Event(s)	No
The Event(s) Not Recorded was a Non-Deployment Event(s)	No

System Status At AE

Vehicle Identification Number	**1AL52F*5*******
Low Tire Pressure Warning Lamp (If Equipped)	OFF
Vehicle Power Mode Status	Accessory
Remote Start Status (If Equipped)	Inactive
Run/Crank Ignition Switch Logic Level	Inactive
Brake System Warning Lamp (If Equipped)	OFF

System Status At 1 second

Transmission Range (If Equipped)	Fourth Gear
Transmission Selector Position (If Equipped)	Fourth Gear
Traction Control System Active (If Equipped)	No
Service Engine Soon (Non-Emission Related) Lamp	OFF
Service Vehicle Soon Lamp	OFF
Outside Air Temperature (degrees F) (If Equipped)	59
Left Front Door Status (If Equipped)	Closed
Right Front Door Status (If Equipped)	Closed
Left Rear Door Status (If Equipped)	Unused
Right Rear Door Status (If Equipped)	Unused
Rear Door(s) Status (If Equipped)	Closed

Pre-crash data

Parameter	-2 sec	-1 sec
Reduced Engine Power Mode	OFF	OFF
Cruise Control Active (If Equipped)	No	No
Cruise Control Resume Switch Active (If Equipped)	No	No
Cruise Control Set Switch Active (If Equipped)	No	No

Pre-Crash Data

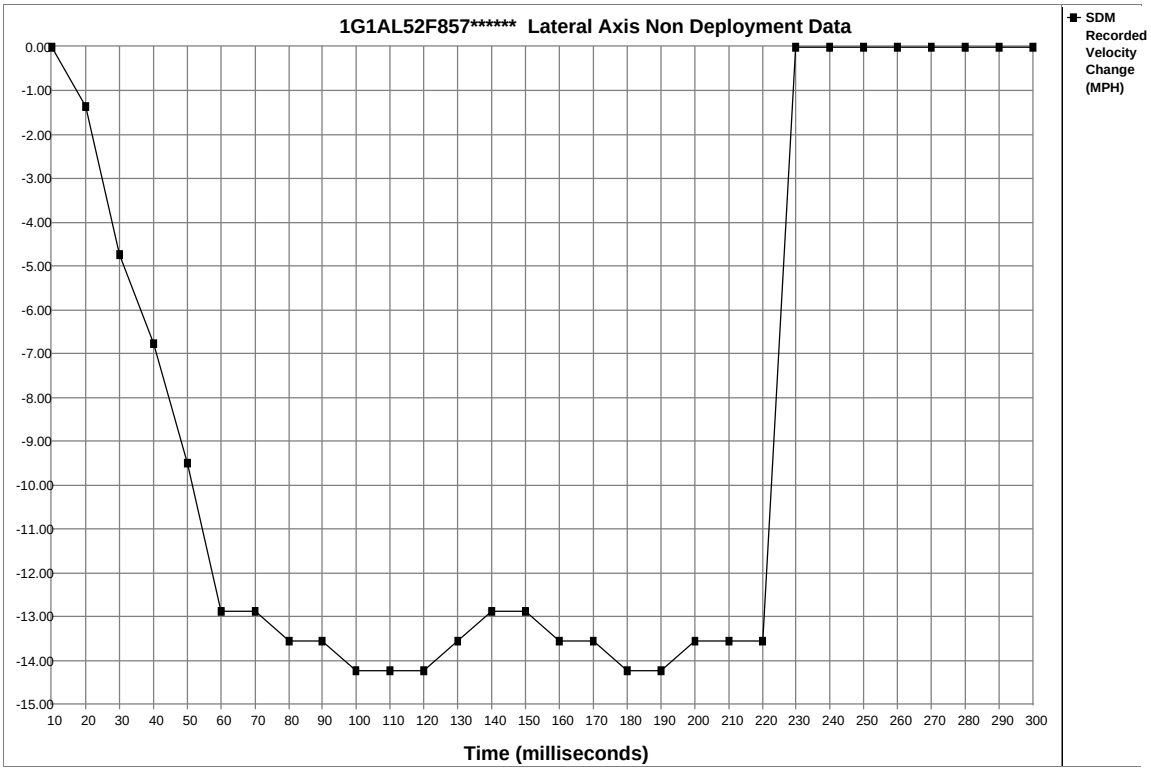
Parameter	-5 sec	-4 sec	-3 sec	-2 sec	-1 sec
Vehicle Speed (MPH)	48	48	47	47	0
Engine Speed (RPM)	2624	2624	2560	2560	0
Percent Throttle	Invalid	Invalid	Invalid	Invalid	Invalid
Accelerator Pedal Position (percent)	Invalid	Invalid	Invalid	Invalid	Invalid
Antilock Brake System Active (If Equipped)	No	No	No	No	No
Lateral Acceleration (feet/s²)(If Equipped)	Invalid	Invalid	Invalid	Invalid	Invalid
Yaw Rate (degrees per second) (If Equipped)	Invalid	Invalid	Invalid	Invalid	Invalid
Steering Wheel Angle (degrees) (If Equipped)	0	0	0	0	0

Parameter	-5 sec	-4 sec	-3 sec	-2 sec	-1 sec
Vehicle Dynamics Control Active (If Equipped)	Invalid	Invalid	Invalid	Invalid	Invalid

System Status At Non-Deployment

Ignition Cycles At Investigation	18419
SIR Warning Lamp Status	OFF
SIR Warning Lamp ON/OFF Time (seconds)	655200
Number of Ignition Cycles SIR Warning Lamp was ON/OFF Continuously	1395
Ignition Cycles At Event	18419
Ignition Cycles Since DTCs Were Last Cleared	254
Driver's Belt Switch Circuit Status	UNBUCKLED
Diagnostic Trouble Codes at Event, fault number: 1	N/A
Diagnostic Trouble Codes at Event, fault number: 2	N/A
Diagnostic Trouble Codes at Event, fault number: 3	N/A
Diagnostic Trouble Codes at Event, fault number: 4	N/A
Diagnostic Trouble Codes at Event, fault number: 5	N/A
Diagnostic Trouble Codes at Event, fault number: 6	N/A
Maximum SDM Recorded Velocity Change (MPH)	53.44
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	120
Driver First Stage Deployment Loop Commanded	No
Driver Second Stage Deployment Loop Commanded	No
Driver Side Deployment Loop Commanded	No
Driver Pretensioner Deployment Loop Commanded	No
Driver (Initiator 1) Roof Rail/Head Curtain Loop Commanded	No
Driver (Initiator 2) Roof Rail/Head Curtain Loop Commanded	No
Driver Knee Deployment Loop Commanded	No
Passenger First Stage Deployment Loop Commanded	No
Passenger Second Stage Deployment Loop Commanded	No
Passenger Side Deployment Loop Commanded	No
Passenger Pretensioner Deployment Loop Commanded	No
Passenger (Initiator 1) Roof Rail/Head Curtain Loop Commanded	No
Passenger (Initiator 2) Roof Rail/Head Curtain Loop Commanded	No
Passenger Knee Deployment Loop Commanded	No
Driver Anchor Pretensioner Deployment Loop Commanded (If Equipped)	No
Second Row Left Pretensioner Deployment Loop Commanded	No
Third Row Left Roof Rail/Head Curtain Loop Commanded	No
Passenger Anchor Pretensioner Deployment Loop Commanded (If Equipped)	No
Second Row Right Pretensioner Deployment Loop Commanded	No
Third Row Right Roof Rail/Head Curtain Loop Commanded	No
Second Row Center Pretensioner Deployment Loop Commanded	No
Crash Record Locked	No
Vehicle Event Data (Pre-Crash) Associated With This Event	Yes
Deployment Event Recorded in the Non-Deployment Record	No
Event Recording Complete	Yes

Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
SDM Longitudinal Axis Recorded Velocity Change (MPH)	-2.03	-6.78	-16.26	-25.75	-33.21	-37.95	-42.69	-46.08	-48.12	-50.83	-50.83	-51.50	-51.50	-51.50	-51.50
Time (milliseconds)	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
SDM Longitudinal Axis Recorded Velocity Change (MPH)	-51.50	-51.50	-50.83	-50.83	-50.83	-50.83	-50.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00



Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
SDM Lateral Axis Recorded Velocity Change (MPH)	0.00	-1.36	-4.74	-6.78	-9.49	-12.88	-12.88	-13.55	-13.55	-14.23	-14.23	-14.23	-13.55	-12.88	-12.88
Time (milliseconds)	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
SDM Lateral Axis Recorded Velocity Change (MPH)	-13.55	-13.55	-14.23	-14.23	-13.55	-13.55	-13.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00