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CALSPAN ON-SITE CHILD RESTAINT SYSTEM CRASH INVESTIGATION
SCI CASE NO: CA09054

VEHICLE: 2002 GMC ENVOY

LOCATION: NEW YORK

CRASH DATE: AUGUST 2009

Contract No. DTNH22-07-C-00043

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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.

TECHNICAL REPORT STANDARD TITLE PAGE

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16. Abstract

This on-site investigation focused on two Child Restraint Systems (CRS's) and the injury sources for the two child passengers in a 2002 GMC Envoy sport utility vehicle that was involved in a rollover crash. The crash occurred when the GMC departed an interstate highway during nighttime hours. The Envoy was occupied by a 20-year-old unrestrained male driver, a 20-year-old unrestrained female front right passenger, a 2-year-old female second row left passenger restrained within a forward-facing convertible CRS and a 2-month-old male positioned unrestrained within a rear-facing infant CRS. The GMC was equipped with redesigned frontal air bags and front seat-mounted side impact air bags. None of the air bags deployed during the rollover crash. The vehicle was not equipped with Inflatable Curtain air bags or Electronic Stability Control.

The driver and 2-year-old child were not injured in the crash. The front right passenger sustained non-life threatening injuries and was transported by ground ambulance to a local hospital. The 2-month-old child was found on the second row right floor area and had suffered an unspecified head injury. The child was pronounced deceased upon arrival at the hospital.

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BACKGROUND

This on-site investigation focused on two Child Restraint Systems (CRS's) and the injury sources for the two child passengers in a 2002 GMC Envoy sport utility vehicle (**Figure 1**) that was involved in a rollover crash. The crash occurred when the GMC departed an interstate highway during nighttime hours. The Envoy was occupied by a 20-year-old unrestrained male driver, a 20-year-old unrestrained female front right passenger, a 2-year-old female second row left passenger restrained within a forward-facing convertible CRS and a 2-month-old male positioned unrestrained within a rear-facing infant CRS. The GMC was equipped with redesigned frontal air bags and front seat-mounted side impact air bags. None of the air bags deployed during the rollover crash. The vehicle was not equipped with Inflatable Curtain air bags or Electronic Stability Control.

Figure 1: Right side view of the 2002 GMC Envoy.

The crash occurred when the driver fell asleep and the vehicle drifted onto the left shoulder at a shallow angle. The GMC crossed through the shoulder and departed the inboard shoulder to the left. As the vehicle crossed the rumble strips, the driver awoke and applied a rapid clockwise steering input in an attempt to regain the travel lane. The aggressive steering input induced a clockwise yaw to the vehicle. The GMC traversed through the travel lanes, departed the right shoulder, traveled down an embankment, tripped, and rolled over. The vehicle came to rest on its wheels adjacent to the tree line located north of the interstate travel lanes. The driver and 2-year-old child were not injured in the crash. The front right passenger sustained non-life threatening injuries and was transported by ground ambulance to a local hospital. The 2-month-old child was found on the second row right floor area and had suffered an unspecified head injury. The child was pronounced deceased upon arrival at the hospital.

This crash was identified by the Calspan Special Crash Investigations (SCI) team through local news media coverage of the August, 2009 crash. The police crash reconstructionist also called

the SCI team to report the crash and informed the SCI team that the vehicle and CRS's were available for inspection. The notification was forwarded to the Crash Investigation Division of the National Highway Traffic Safety Administration on August 3, 2009 and an on-site investigation was assigned the same day. The GMC, child safety seats and crash site were inspected on August 4, 2009. The GMC's Event Data Recorder (EDR) was imaged during the inspection and is included at the end of this report as **Attachment A**.

VEHICLE DATA

2002 GMC Envoy

The 2002 GMC Envoy was manufactured in September 2001 and identified by the Vehicle Identification Number (VIN): 1GKDS13S522 (production sequence deleted). The odometer read 186,515 km (115,899 miles) at the time of the SCI inspection. The trip odometer indicated 671 km (417 miles). The four-door, rear-wheel drive sport utility vehicle was powered by a 4.2-liter, V-6 engine linked to four-speed automatic transmission. The vehicle was equipped with four-wheel antilock brakes. The manual restraint systems consisted of 3-point lap and shoulder safety belts in the five seat positions. The GMC was equipped with redesigned driver and front right passenger air bags and front seat-mounted side impact air bags. The GMC was outfitted with Bridgestone Dueller HT P245/65R17 tires in the left front, left rear and right front positions. The right rear tire was a Michelin Cross Terrain P245/65R17 tire. The vehicle manufacturer's recommended cold tire pressure was 221 kPa (32 PSI) front and rear. The specific measured tire data at the time of the SCI inspection was as follows:

Position	Measured Tire Pressure	Measured Tread Depth	Tire/Wheel Damage
Left Front	255 kPa (37 PSI)	3 mm (4/32 in)	Debris in rim bead
Left Rear	Tire flat	5 mm (6/32 in)	Sidewall cut, Debris in wheel rim, tire debeaded
Right Front	Tire flat	4 mm (5/32 in)	Tire debeaded
Right Rear	55 kPa (8 PSI)	6 mm (7/32 in)	Debris in rim bead

CRASH SITE

The crash occurred during the nighttime hours of August 2009 in a rural setting. At the time of the crash, it was dark without artificial lighting. The weather conditions were clear and dry. The crash occurred in a large radius right curve on the westbound lanes of a limited access interstate highway. **Figure 2** is a westbound trajectory view of the GMC. The posted speed limit was 105 km/h (65 mph). The roadway was configured with two 3.7 m

Figure 2: Westbound trajectory view of the GMC.

(12 ft) lanes. The travel lanes were delineated by solid edge lines and were bordered by paved shoulders. The inboard (south) shoulder measured 1.7 m (5.6 ft) in width. The width of the outboard (north) shoulder measured 3.5 m (11.5 ft). Rumble strips that measured 0.4 m (1.3 ft) in width were cut into both shoulders. The north road side sloped away from the travel lanes to a tree line located 10.6 m (29.5 ft) north of the pavement edge. The terrain adjacent to the tree line was approximately 1.5 m (5 ft) below the elevation of the road.

Physical evidence that was related to the trajectory and rollover crash of the GMC was identified during the SCI scene inspection. On the south road side, a rotating tire mark was observed departing the road shoulder. This mark was attributed to the left front tire and was oriented approximately 5 degrees left of the direction of the travel lane. It measured 25 m (82 ft) in length and travelled past a delineator post located 1.9 m (6.2 ft) south of the pavement edge. A scuff mark was noted to the delineator from an impact with the GMC's left mirror. Immediately west of the delineator, the tire mark began to arc back to the right. The tracking rotating tire mark transitioned into a yaw mark with the left rear tire off-tracking outside of the left front tire. Two yaw marks were observed reentering the westbound lanes, **Figure 3**. The left rear yaw mark measured 50 m (164 ft) in length. These marks resulted from an aggressive right steering input by the driver.

Figure 3: View of the GMC's left rear yaw mark.

On the north side of the interstate, furrowing tire marks were observed in the sloped road side beyond the departure point. Refer to **Figure 4**. These marks were indicative of a tripped rollover event. At the base of the slope, a matted area in the terrain was observed. This area was related to the touchdown of the vehicle's roof during the second-quarter turn of the rollover. Three trees within the tree line sustained impact damage (**Figure 5**) and interrupted the rollover of the vehicle. A 10 cm (4 in) diameter tree was fractured approximately 1.5 m (5 ft) above the ground. A 38 cm (15 in) diameter tree was impacted by the left rear axle and was subsequently cut down post-crash. Impact damage was noted to a 10 cm (4 in) diameter tree adjacent to the final rest location of the vehicle. These trees stopped the GMC from entering the tree line, altered its rotation and redirected the vehicle back to the west.

Figure 4: View from the road departure along the trajectory path of the GMC.

Figure 5: View of the tree impacts.

CRASH SEQUENCE

Pre-Crash

The GMC was westbound in the inboard travel lane driven by a 20-year-old unrestrained male. The vehicle was occupied by the 20-year-old unrestrained female front right passenger, the 2-year-old female second row left passenger and the 2-month-old male second row right passenger. The 2-year old female was secured in a forward-facing CRS. The 2-month old male was unsecured in a rear-facing CRS. The GMC contained multiple personnel belongings as this family was travelling from their Vermont home to Indiana for a mid-west vacation. The trip odometer reading of 671 km (417 miles) was consistent with the trip duration relative to the crash location. The driver reported to the investigating police officer that he had fallen asleep immediately prior to the crash. The GMC drifted onto the inboard shoulder and into the median due to the right curvature of the road. The Event Data Recorder (EDR) data imaged during the SCI inspection indicated the vehicle was traveling 109 km/h (68 mph) five seconds prior to Algorithm Enable (AE). **Figure 17**, at the end of this report, is a schematic of the crash.

Crash

The left mirror of the GMC struck the delineator post resulting in the fracture of the mirror (Event 1). As the vehicle crossed the rumble strips, the driver awoke and applied a rapid clockwise (CW) steering input in an attempt to regain the travel lane. The rear tires of the GMC broke traction and the vehicle initiated a CW yaw. The GMC crossed through the travel lanes evidenced by the tire marks at the scene and departed the north roadside. The left side tires of the GMC furrowed into the sloped roadside and tripped the vehicle into a left side leading rollover (Event 2). The vehicle rolled two-quarter turns and impacted the ground with its roof evidenced by the matted area of the road side. The GMC rolled two additional quarter turns back onto its wheels. At this time, the left front fender impacted a 10 cm (4 in) diameter tree (Event 3), closely followed by an impact of the left rear wheel to the 38 cm (15 in) diameter tree (Event 4). This impact was evidenced by tree bark embedded into the wheel rim and a cut to the tire's

sidewall, **Figure 6**. The distance from trip to final rest of the interrupted 4-quarter turn rollover was 14 m (46 ft).

The GMC rotated rapidly CW as a result of the left rear wheel to tree impact. During its rotation, the GMC's right rear corner contacted the referenced tree (Event 5) evidenced by deformation to the quarterpanel and bark embedded in right rear window frame. After approximately 180 degrees of rotation, the right front fender impacted the 10 cm (4 in) tree and the GMC came to rest adjacent to the tree facing west.

Figure 6: Left rear wheel damage.

Post-Crash

The police and ambulance personnel responded to the crash site. Upon their arrival, the occupants of the GMC had exited the vehicle through the front window openings. An unknown individual was giving CPR to the 2-month-old male occupant. The driver reported to the police investigator that the 2-month-old was found within the second row floor area, forward of the right position. He had suffered an unspecified head injury and was unresponsive. Resuscitative measures were applied during transport to a local hospital where the child was pronounced deceased. An autopsy was not conducted. The driver and 2-year-old female were not injured during the crash event. The front right passenger was transported to a local hospital with non-life threatening injuries. The GMC was towed from the crash site and impounded by the police where it was inspected for this SCI investigation.

2002 GMC ENVOY

Exterior Damage

The left, top and right side planes of the GMC sustained impact damage consistent with the four-quarter turn rollover and impacts into the tree line. The GMC's left mirror was fractured (Event 1) and fragments were observed adjacent to the delineator post during the police investigation. As a consequence of the rollover (Event 2), the roof impacted the ground and buckled the B-pillars inboard. The roof deformed downward. The roof deformation created a gap at the top junction between the door frames and the roof side rail. The gap at the top of the front left door measured 11 cm (4.5 in). The gap at the top of the front right door measured 18 cm (7 in). The gap at the left and right rear doors measured 23 cm (9 in) and 27 cm (10.5 in), respectively. The maximum vertical deformation was located at the right B-pillar location and measured 13 cm (5 in), **Figure 7**.

The left front fender, immediately forward of the wheel opening, was deformed over a 10 cm (4 in) region as a result of the tree impact (Event 3). The maximum lateral crush was 3 cm (1 in). The trailing edge of the left sill forward of the left rear wheel opening was deformed forward 8 cm (3 in) during the tree impact (Event 4). Tree bark was embedded into the left rear wheel rim. The left rear tire was cut and debeaded. A 36 cm (14 in) area of the right quarter panel was deformed laterally a maximum of 3 cm (1 in) as a result of contact with the 38 cm (15 in) diameter tree (Event 5). Tree bark was noted within the contact area. The right fender exhibited a 20 cm (8 in) region of damage forward of the axle location as a result of the tree impact (Event 6). The maximum crush in this contact pattern measured 11 cm (4.5 in). Two regions of non-horizontal impact damage from an identified source were observed along the right sill. The maximum crush within each of these regions was 10 cm (4 in).

The Collision Deformation Classifications (CDC) for each of the events in this crash sequence are listed in the following table.

Event #	Collision Deformation Classification
1	12LPES1
2	00TDDO3
3	09LFEN2
4	09LBEN2
5	03RBEN1
6	03RFEN2

Figure 7: View of the maximum deformation at the right B-pillar location.

Figure 8: Overall view of the damaged right plane.

There was no change in the wheelbase dimensions. The windshield was in place and fractured. The left and right front glazing were open at the time of the inspection and were believed to have been opened post-crash by the occupants in order to exit the vehicle. The second row left glazing was disintegrated. The remainder of the side glazing was intact. All four doors were jammed shut at the time of the SCI inspection. The rear doors were forced open at the impound yard to facilitate the interior inspection. The CRS's had not been moved prior to SCI inspection.

Interior Damage

The interior of the GMC sustained moderate severity damage from passenger compartment intrusions and occupant contacts. The intrusions into occupant compartment are identified in the following table:

Position	Component	Magnitude	Direction
Row 1 Left	Roof	5 cm (2 in)	Vertical
Row 1 Center	Roof	5 cm (2 in)	Vertical
Front Right	Roof	8 cm (3 in)	Vertical
Row 2 Left	Roof	15 cm (6 in)	Vertical
Row 2 Center	Roof	18 cm (7 in)	Vertical
Row 2 Right	Roof	23 cm (9 in)	Vertical
Row 2 Left	Side rail	11 cm (4.5 in)	Vertical
Row 2 Right	Side rail	20 cm (8 in)	Vertical
Row 2 Left	B-pillar	13 cm (5 in)	Vertical
Row 2 Right	B-pillar	18 cm (7 in)	Vertical

A possible occupant contact from the driver's lower extremities was noted to the knee bolster. This contact consisted of a scuff mark located 11 to 23 cm (4.5 to 9 in) left of the knee bolster centerline and 1 to 5 cm (0.5 to 2 in) below the top aspect. A second possible contact point was noted to the map light located inboard of the left side rail over the front left seating position. This component was slightly displaced within its housing from contact with the driver's head. There were multiple small areas throughout the interior that were soiled from displaced food items possibly masking any additional contact points. No occupant contacts were noted from the rear seat passengers. **Figure 9** is an overall view of the second row.

The front seats were adjusted to a mid-track position with the seat backs in a slightly reclined position. The front seats were equipped with height adjustable head restraints that were adjusted to the full-down position at the time of the SCI inspection. The second row was configured with a split bench seat (60/40) left side wide with height adjustable head restraints for the outboard positions. These head restraints were in the full-down position. An aftermarket mirror was mounted to the rear right head restraint using Velcro straps. The longitudinal measurement

between the front seat backs and rear seat back was 79 cm (31 in) at the left side and 74 cm (29 in) at the right side.

The interior of the GMC contained numerous items including a cooler filled with food, a portable play-pen, a stroller, an aftermarket DVD player, a laptop computer, and clothing **(Figure 10)**. Additionally, the police investigator indicated that some of the family's possessions had been released prior to the SCI inspection. The total weight of the items was estimated to be approximately 136 kg (300 lbs). These items were displaced throughout the interior of the vehicle during the crash sequence; therefore, the pre-crash location of the items is unknown. The cooler was found open and empty between the second row CRS's. The lid and contents of the cooler were dispersed throughout the vehicle.

Figure 9: Overall view of the second row after removal of the left CRS (displaced cooler, lid and right CRS on the seat cushion).

Figure 10: Cargo area contents.

Air Bag Systems and Event Data Recorder

The GMC Envoy was equipped with redesigned front air bags for the driver and front right passenger and front seat-mounted side impact air bags. The air bags did not deploy during the crash sequence. The vehicle was not equipped with Inflatable Curtains and did not have rollover sensing capabilities.

The air bags systems in the vehicle were controlled and monitored by a Sensing Diagnostic control Module (SDM) that had Event Data Recording (EDR) capabilities. The EDR was imaged at the time of the SCI inspection with the Bosch Crash Data Retrieval (CDR) hardware and software version 3.1. The CDR tool was connected to the diagnostic link and the data was imaged utilizing the vehicle's (intact) electrical system. The data was reanalyzed and reported with version 3.4 of the software. The data is included as **Attachment A**.

The EDR recorded a non-deployment event that was related to the crash. The data was recorded on ignition cycle 14617 and was imaged on cycle 14623. The event recording was complete. At the time of the crash, the driver's safety belt was recorded as not buckled. The recorded speed of the GMC was 109 km/h (68 mph) five seconds prior to Algorithm Enable (AE). The driver applied the brakes one second prior to AE.

Manual Restraint Systems

The 2002 GMC Envoy was equipped with integrated manual 3-point lap and shoulder safety belts for the front seating positions. The driver's safety belt was configured with a sliding latch plate, and an Emergency Locking Retractor (ELR). The driver did not utilize his safety belt in the crash. There was no physical evidence on the webbing or hardware to support belt use. Furthermore the EDR indicated that the driver's safety belt was unbuckled at the time of AE.

The front right safety belt was configured with a sliding latch plate and a switchable ELR/Automatic Locking Retractor (ALR). The front right safety belt was not used during this crash, which was supported by the lack of evidence on the safety belt.

The three second row belt systems were equipped manual 3-point lap and shoulder safety belts that utilized switchable ELR/ALR. The center safety belt was integrated into the seat. The outboard belts were used to install CRS's at the time of the crash. The second row bench seat was not equipped with the LATCH anchors. The federally regulated installation of LATCH in vehicles began late in the 2002 model year.

At the time of the SCI inspection, the second row left belt was routed through the forward-facing belt path of the convertible CRS. Due to the vehicle damage in the area of the C-pillar, the retractor was locked. The webbing remained in the pre-crash extended position. There was 163 cm of (64 in) of exposed webbing. During the crash, the loading resulted in two areas of creasing to the webbing. The first area was located near the lower belt path and began 20 cm (7.8 in) above the anchor and extended upward 5 cm (2 in). The second area of creasing measured 10 cm (4 in) and began 136 cm (53.5 in) above the anchor. This section of the webbing was located near the inboard aspect of the installed CRS. The latch plate and D-ring were free of frictional abrasions.

The second row right belt had been used to install the base of the rear-facing infant CRS to the vehicle. The belt webbing was locked in the extended position post-crash due the deformation of the C-pillar. The extended portion of the webbing measured 145 cm (57 in) in length. Frictional abrasions were noted on the latch plate and creasing was observed on the lap portion of the webbing. The creasing was located from 22 to 36 cm (8.5 to 14 in) above the anchor. The remainder of the belt system was unremarkable.

CHILD RESTRAINT SYSTEM DATA

Recaro Como Convertible CRS

Figure 11: Recaro Como CRS.

The 2-year-old female was restrained within the 5-point harness system of a Recaro Como CRS **(Figure 11)**. The seat's date of manufacture was 10/19/2007 and was identified by the Model No. 331-01-MM14. The CRS was a convertible seat designed for a child weighing 2 to 32 kg (5 to 70 lb) and could be used in two modes. In the rear facing mode, the seat was designed for an infant weighing 2 kg to 16 kg (5 lb to 35 lb). In the forward-facing mode, the CRS was designed to be used by a child with weight of 9 kg to 32 kg (20 lb to 70 lb). The seat could be used by children up to 127 cm (50 in) in height. The CRS had an adjustable base. It was adjusted to a slightly reclined position. When placed on the vehicle's seat, the angle of the CRS shell measured 40 degrees aft of vertical. The instructions indicated the base should be in the fully upright position when used in the forward-facing mode. The CRS was designed with the Lower Anchors for Tethers and Children (LATCH) system. The LATCH system was not in use. The 5-point harness straps were in the middle slot of a five slot adjustment. The harness retainer clip and two-piece buckle were operational. There was no impact damage or stress marks to the CRS.

The CRS was located in the GMC's second row left seat position and had not been moved prior to the SCI inspection. The vehicle's safety belt was routed through the forward-facing belt path. Minor frictional evidence was observed at the belt path slot. The CRS was restrained by the buckled safety belt with excess slack. At the time of the SCI inspection, the CRS could be moved 10 cm (3.8 in) fore/aft and laterally up to 18 cm (7 in).

Baby Trend Flex Loc CRS

Figure 12: Baby Trend Flex Loc CRS.

The 2-month-old male was positioned in a rear-facing manner within a Baby Trend Flex Loc **(Figure 12)** infant CRS in the second row right position. The seat was identified by the Model No. 6381. The date of manufacture was 04/11/2007. The CRS was designed with a detachable base and was rated for use by an infant weighing 2 to 10 kg (5 to 22 lb) with a height less than 72 cm (28.5 in). The CRS was an appropriate choice for use considering the age and 5 kg (12 lb) weight of the 2-month old male.

Figure 13 is a right interior view depicting the post-crash position the CRS and the base. At the time of the SCI inspection, the CRS was detached from the base and resting in

the center of the GMC's second row. The empty cooler was on top of the carrier. The CRS base was still restrained by the vehicle's safety belt; however, the base had rotated 90 degrees about the belt and was upside down resting against the seat back.

The base was restrained in a rear-facing manner with the belt webbing across the belt path and routed under the two metallic belt guides, **Figure 14**. Two rolled-up towels were located under base at the vehicle seat bight. The uncompressed height of the towels was 18 cm (7 in). It appeared that these towels were used during the installation to adjust the recline angle of the CRS.

Figure 13: Post-impact position of the rear facing CRS and the second row interior.

Figure 14: View of the CRS base and vehicle safety belt.

The CRS was removed from the vehicle and inspected. The CRS carrier shell latched into the base as designed and had a positive locking sound. The latching mechanism was free of damage. There was no damage or stress marks to the either the CRS shell or the base.

The CRS had a 5-point harness system. The harness was adjusted to the top slots of a three slot adjustment. The harness retainer clip and three-piece buckle operated properly. The left harness retainer clip was located 15 cm (6 in) below the top slot. The right clip was located 17 cm (6.8 in) below top slot, **Figure 15**. The clips were misaligned relative to the slots. The latch plates were each located 15 (6 in) above the shell when buckled into the center buckle. There was no loading evidence to the harness straps. Based on the child's reported post-crash location, it was determined that he was unrestrained at the time of the crash.

Figure 16 is a right view of the CRS repositioned in the second row right position for reference. The base was positioned on the towels and CRS snuggly wedged between the seat bight and the front right seat back. The carrier handle was in contact with the front right seat back. An imprint of the carrier handle was noted to the upper aspect of the front seat.

Figure 15: View of the CRS harness.

Figure 16: Right view of the repositioned CRS.

DRIVER DEMOGRAPHICS

Age/Sex:	20-year-old/Male
Height:	Unknown
Weight:	Unknown
Seat Position:	Mid-track position
Restraint Use:	None
Usage Source:	SCI vehicle inspection
Egress from Vehicle:	Exited unassisted
Mode of Transport from Scene:	Ground ambulance to a local hospital
Type of Medical Treatment:	Examined and released

Driver Injury

Injury	***Injury Severity (AIS 90/98 update)***	***Injury Source***
Not injured	N/A	N/A

Source: Emergency Room records

Driver Kinematics

The unrestrained 20-year-old male driver was seated in a mid-track position. Based on the imaged EDR, he was operating the vehicle at a recorded speed of 109 km/h (68 mph) five seconds prior to Algorithm Enable (AE). The driver fell asleep and awoke to the sound of the rumble strips. He applied a rapid clockwise (CW) steering input in an attempt to regain the travel lane. The vehicle began a CW yaw and traversed the travel lane and entered the north roadside, traveled down an embankment, tripped and began to rollover. The driver was displaced within the front left area. He contacted the knee bolster and the map light during the rollover sequence. The driver came to rest in the front left seating area and was not injured.

FRONT RIGHT PASSENGER DEMOGRAPHICS

Age/Sex:	20-year-old/Female
Height:	Unknown
Weight:	Unknown
Seat Position:	Mid-track position
Restraint Use:	None
Usage Source:	SCI vehicle inspection
Egress from Vehicle:	Exited unassisted
Mode of Transport from Scene:	Ground ambulance to local hospital
Type of Medical Treatment:	Examined in the Emergency Room and then transferred to a regional trauma center for further evaluation

Front Right Passenger Injury

Injury	***Injury Severity (AIS 90/98 update)***	***Injury Source***
Left upper arm abrasion	Minor (790202.1,2)	Unknown
Cervical spine tenderness	Not codeable under AIS rules	Unknown
Abdominal tenderness	Not codeable under AIS rules	Unknown

Source: Emergency Room records. Trauma center records were not available.

Front Right Passenger Kinematics

The 20-year-old unrestrained female was seated in an unknown posture in a mid-track position. As the vehicle rolled over, the passenger responded to the impact forces with a vertical and lateral trajectory within the front right area of the vehicle Although no occupant contact points were identified to the interior of the vehicle, she sustained a left upper abrasion from an unknown interior contact. The front right passenger was transported to a local hospital where she was evaluated. The passenger complained of abdominal and cervical pain. Diagnostic X-rays taken in the Emergency room ruled out skeletal fracture. As a precaution the passenger was transferred to a regional trauma center via helicopter for further evaluation. The medical records from the trauma center were not available.

SECOND ROW LEFT PASSENGER DEMOGRAPHICS

Age/Sex:	2-year-old/Female
Height:	Unknown
Weight:	Unknown
Seat Position:	Not adjustable
Restraint Use:	5-point harness in a forward-facing convertible CRS

Usage Source:	SCI vehicle inspection
Egress from Vehicle:	Assisted from vehicle by the driver
Mode of Transport from Scene:	Ground ambulance to a local hospital
Type of Medical Treatment:	Examined and released

Second Row Left Passenger Injury

Injury	*Injury Severity (AIS 90/98 update)*	*Injury Source*
Not injured	N/A	N/A

Source: Emergency Room records

Second Row Left Passenger Kinematics

The 2-year-old female was restrained in a forward-facing mode by the 5-point harness of a convertible CRS. At the onset of the rollover, the safety belt retractor locked. The child responded to the non-horizontal forces of the rollover by loading the harness straps. The combined mass of the CRS and child loaded the vehicle's belt system. The child remained in contact with the harness and rode down the force of the rollover crash. She was protected by the shell of the CRS from lateral contact with the interior of the vehicle. She came to rest restrained within the CRS and was removed from the CRS by the driver. The child was transported to a local hospital and examined. She was not injured.

SECOND ROW RIGHT PASSENGER DEMOGRAPHICS

Age/Sex:	2-month-old/Male
Height:	Unknown
Weight:	5 kg (12 lb)
Seat Position:	Not adjustable
Restraint Use:	Unrestrained, positioned within in a rear facing CRS
Usage Source:	SCI vehicle inspection
Egress from Vehicle:	Removed by driver
Mode of Transport from Scene:	Ground ambulance to a local hospital
Type of Medical Treatment:	Fatally injured, pronounced deceased upon arrival

Second Row Right Passenger Injury

Injury	*Injury Severity (AIS 90/98 update)*	*Injury Source*
Unspecified head injury, unresponsive to stimuli, GCS=3	Critical (160824.5,0)	Unidentified interior object

Source: Emergency Room records. No autopsy was conducted.

Second Row Right Passenger Kinematics

The 2-month-old male was positioned in a rear-facing CRS in an unknown manner. Given that the CRS was not damaged during the crash and the fact that the child was displaced onto the floor, it was probable that the child was not restrained. During the rollover sequence, the child was displaced from the CRS and his head was impacted by a loose interior object. This impact resulted in the unspecified head injury that resulted in his death. The child was displaced onto the floor area forward of his original seat position where he was found by the driver. He was unresponsive at the scene.

The time line for EMS response is reported below. Upon EMS arrival, the police were already on-scene and administering CPR to the infant. Life supportive measures were continued during ground transport to the emergency room of a local hospital that was located 8 km (5 miles) from the crash site. The status of the infant remained unchanged during the transport. Medical services continued after arrival in the Emergency Room during the infant's evaluation. He was pronounced deceased 8 minutes after arrival. No autopsy was conducted.

	Time (hours)
Crash time	0231
Call received and en route to scene	0244
At scene	0257
Transport from scene	0311
Arrival at hospital	0316
Time of Death	0324

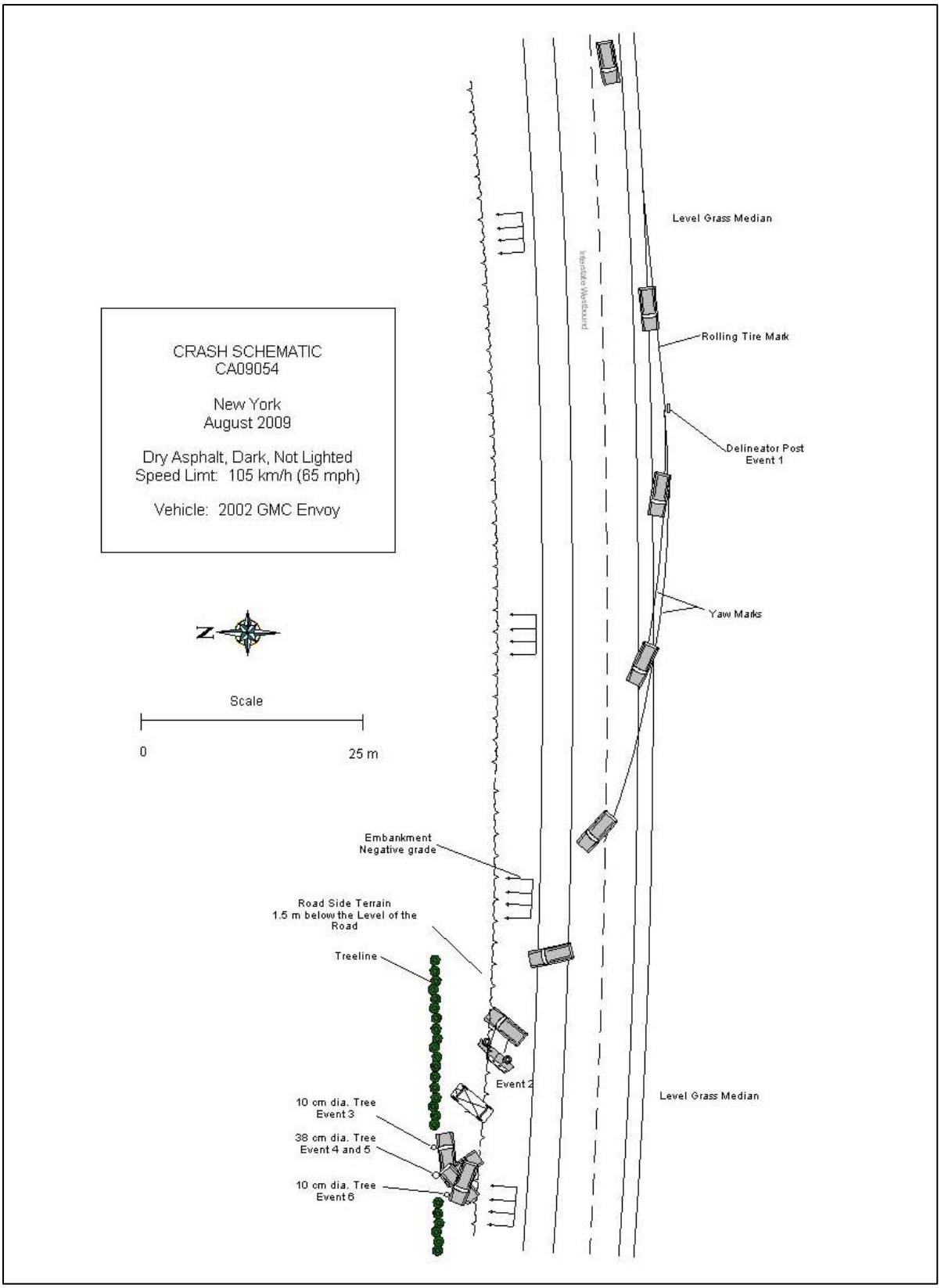

Figure 17: Crash schematic.

ATTACHMENT A
2002 GMC Envoy 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	1GKDS13S522******
User	
Case Number	
EDR Data Imaging Date	
Crash Date	
Filename	CA09054 CDR.CDR
Saved on	Tuesday, August 4 2009 at 12:43:07 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). It contains 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 longitudinal 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 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 Changeis 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.
-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

-Driver's Belt Switch Circuit Status indicates the status of the driver's 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 senieos:
    -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.

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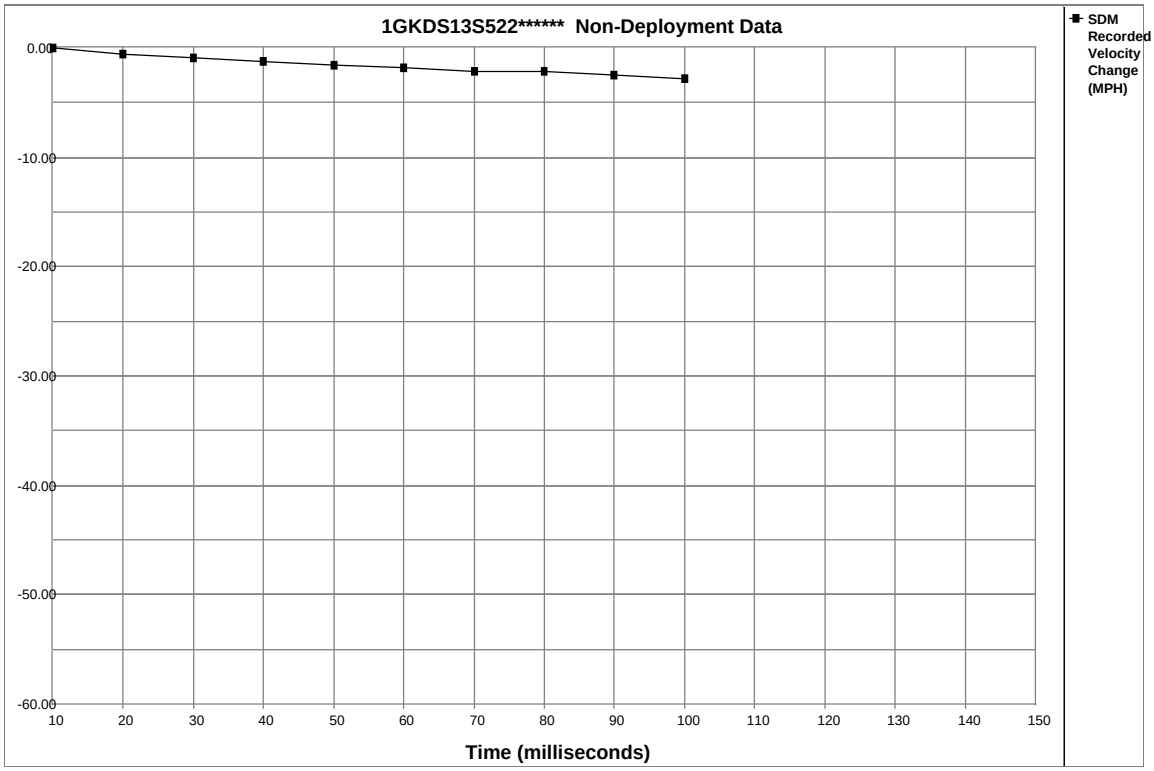
System Status At Non-Deployment

SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	UNBUCKLED
Ignition Cycles At Non-Deployment	14617
Ignition Cycles At Investigation	14623
Maximum SDM Recorded Velocity Change (MPH)	-2.87
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	100
Crash Record Locked	No
Event Recording Complete	Yes
Multiple Events Associated With This Record	No
One Or More Associated Events Not Recorded	No

Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle
-5	68	1920	0
-4	68	1920	0
-3	68	1856	0
-2	62	1728	0
-1	52	1536	0

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



Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Recorded Velocity Change (MPH)	0.00	-0.62	-0.93	-1.24	-1.55	-1.86	-2.17	-2.17	-2.48	-2.79	N/A	N/A	N/A	N/A	N/A