

# INDIANA UNIVERSITY

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## ON-SITE ROLLOVER INVESTIGATION

CASE NUMBER - IN10040  
LOCATION - INDIANA  
VEHICLE - 2008 GMC ENVOY  
CRASH DATE - October 2010

Submitted:

May 17, 2011



Contract Number: DTNH22-07-C-00044

Prepared for:

U.S. Department of Transportation  
National Highway Traffic Safety Administration  
National Center for Statistics and Analysis  
Washington, D.C. 20590-0003

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

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

**Technical Report Documentation Page**

1. <i>Report No.</i> IN10040	2. <i>Government Accession No.</i>	3. <i>Recipient's Catalog No.</i>	
4. <i>Title and Subtitle</i> On-Site Rollover Investigation Vehicle - 2010 GMC Envoy Location - Indiana		5. <i>Report Date:</i> May 17, 2011	
		6. <i>Performing Organization Code</i>	
7. <i>Author(s)</i> Special Crash Investigations Team #2		8. <i>Performing Organization Report No.</i>	
9. <i>Performing Organization Name and Address</i> Transportation Research Center Indiana University 501 South Madison Street, Suite 105 Bloomington, Indiana 47403-2452		10. <i>Work Unit No. (TRAIS)</i>	
		11. <i>Contract or Grant No.</i> DTNH22-07-C-00044	
12. <i>Sponsoring Agency Name and Address</i> U.S. Department of Transportation (NVS-411) National Highway Traffic Safety Administration National Center for Statistics and Analysis Washington, D.C. 20590-0003		13. <i>Type of Report and Period Covered</i> Technical Report Crash Date: October 2010	
		14. <i>Sponsoring Agency Code</i>	
15. <i>Supplementary Notes</i> On-site rollover investigation involving a 2008 GMC Envoy.			
16. <i>Abstract</i> This on-site investigation focused on the rollover of a 2008 GMC Envoy, which occurred following an impact with a 2000 Saturn SL1. The GMC was occupied by an unrestrained 52-year-old male driver. He was westbound on a 2-lane rural roadway negotiating a left curve. The Saturn was occupied by an unrestrained 56-year-old male driver. He was traveling east negotiating the curve when his vehicle entered the GMC's lane of travel. The front plane of the Saturn impacted the left plane of the GMC. The impact caused the GMC to rotate counter clockwise and depart the north side of the roadway where it rolled over, right side leading, four quarter turns. The GMC's rollover/side impact Inflatable Curtain (IC) air bag deployed during the rollover. The driver of the GMC sustained minor injuries and was transported by ambulance to a hospital where he was treated in the emergency room and released. Both vehicles were towed from the crash scene.			
17. <i>Key Words</i> Rollover Motor Vehicle Traffic Crash Injury Severity		18. <i>Distribution Statement</i> General Public	
19. <i>Security Classif. (of this report)</i> Unclassified	20. <i>Security Classif. (of this page)</i> Unclassified	21. <i>No. of Pages</i> 25	22. <i>Price</i>

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This on-site investigation focused on the rollover of a 2010 GMC Envoy (**Figure 1**). The vehicle was equipped with rollover/side impact Inflatable Curtain (IC) air bags that deployed as a result of the crash. This crash was brought to our attention by the National Highway Traffic Safety Administration (NHTSA) on October 22, 2010 by the sampling activities of the National Automotive Sampling System (NASS)-General Estimates System (GES). Final cooperation to inspect the vehicle was confirmed with the insurance company on December 16, 2010 and this investigation was assigned on December 17, 2010. The crash involved the GMC and a 2000 Saturn SL1. The crash occurred in October, 2010, at 0550 hours, in Indiana and was investigated by the local sheriff's department. The GMC was inspected on December 28, 2010. The Saturn and crash scene were inspected on December 29, 2010. An interview with the driver of the GMC was completed on January 3, 2010. This report is based on the police crash report, vehicle and crash scene inspections, exemplar vehicle inspections, driver interview, medical records, occupant kinematic principles, and evaluation of the evidence.



**Figure 1:** The damaged 2010 GMC Envoy

## CRASH CIRCUMSTANCES

**Crash Environment:** This crash occurred at dawn, under cloudy, drizzling weather conditions on a 2-lane, undivided rural roadway. The trafficway was wet bituminous and traversed in a general east-west direction. The westbound lane was 3 m (9.8 ft) in width, while the eastbound lane was 3.5 m (11.5 ft) in width. The roadway pavement markings consisted of double yellow center lines. The grade for the GMC was negative 8.3% and the grade for the Saturn was positive 8.3%. Both lanes were bordered by gravel shoulders. The roadway was curved to the left for the GMC and curved to the right and the Saturn. The speed limit was 48 km/h (30 mph). The site of the crash was rural and there was no other traffic. The Crash Diagram is on page 10 of this report.

**Pre-Crash:** The GMC was occupied by an unrestrained 52-year-old male driver. The driver was westbound negotiating a left curve (**Figure 2**). The Saturn was occupied by an unrestrained 56-year-old male driver. He was traveling east approaching the curve and intended to continue eastbound. As the Saturn's driver negotiated the curve, his vehicle entered the GMC's travel lane. The GMC's driver steered to the right and braked in an attempt to avoid the crash. The GMC was



**Figure 2:** GMC's westbound approach to impact

approximately half way onto the north shoulder when the impact occurred. The GMC's Event Data Recorder (EDR) reported 2.5 sec of pre-crash data, while the Saturn's EDR recorded 5 seconds of pre-crash data. Both vehicle's pre-crash data are presented in the following tables.

#### Chevrolet's Pre-Crash Data

Time	-2.5 sec	-2.0 sec	-1.5 sec	-1.0 sec	-0.5 sec
Speed	36 mph (58 km/h)	36 mph (58 km/h)	36 mph (58 km/h)	35 mph (56 km/h)	31 mph (50 km/h)
Engine Speed	896 rpm	896 rpm	896 rpm	896 rpm	832 rpm
Percent Throttle	0	0	0	0	0
Brake Switch Circuit State	On	Off	Off	On	On

#### Saturn's Pre-Crash Data

Time	-5 sec	-4 sec	-3 sec	-2 sec	-1 sec
Speed	58 mph (58 km/h)	47 mph (58 km/h)	13 mph (58 km/h)	0 mph (0 km/h)	0 mph (0 km/h)
Engine Speed	1984 rpm	1472 rpm	960 rpm	704 rpm	512 rpm
Percent Throttle	0	0	0	0	0
Brake Switch Circuit State	Off	On	On	On	On

**Crash:** The left plane of the GMC was impacted by the front left corner of the Saturn (event 1). The GMC rotated counterclockwise approximately 15 degrees and entered a ditch where it rolled over, right side leading, four quarter turns. Both IC air bags deployed during the rollover. The driver's frontal air bag in the Saturn also deployed during the crash. The GMC came to final rest on its wheels in the ditch heading south. The Saturn came to final rest on the roadway heading southeast.

**Post-Crash:** The police were notified of the crash at 0552 hours and arrived on scene at 0601 hours. Emergency medical and rescue services also responded to the crash scene. The driver of the GMC was displaced into the front right seating area during the rollover. Rescue personnel mechanically opened the right front door and extricated the driver from the vehicle. He was transported by ambulance to a local hospital where he was treated in the emergency room and released. The driver of the Saturn was not injured and was not transported.

#### CASE VEHICLE

The 2008 GMC Envoy was a 2-wheel drive, 4-door, sport utility vehicle (VIN: 1GKDS13S082-----) that was manufactured in May 2008. It was equipped with a 4.2-liter, L-6 engine, 4-speed automatic transmission, 4-wheel anti-lock disc brakes with electronic brake force distribution, traction control, rollover sensing, electronic stability control, adjustable pedals, and an EDR. The front row was equipped with bucket seats, adjustable head restraints, integral lap-

and-shoulder safety belts with retractor-mounted pretensioners, dual-stage driver and front right passenger frontal air bags, and rollover/side impact IC air bags that provided protection for the front and second rows. The second row was equipped with a split bench with folding backs, adjustable head restraints, lap-and-shoulder safety belts, and Lower Anchors and Tethers for Children (LATCH) in the outboard seating positions. The odometer reading at the SCI inspection was 107,215 kilometers (66,620 miles). The specified wheelbase was 287 cm (113 in).

**CASE VEHICLE DAMAGE**

**Exterior Damage Event 1:** The GMC sustained damage on the left plane during the impact with the front plane of the Saturn. The left doors, quarter panel, and side of the rear bumper fascia were directly damaged. The direct damage began 95 cm (37.4 in) rear of the left front axle and extended 250 cm (98.4 in) rearward along the lower doors (**Figure 3**) and onto the side of the rear bumper fascia. Crush measurements were taken at the lower door level and the residual maximum crush was 4 cm (1.6 in) occurring at C<sub>3</sub>. The left side wheelbase was unchanged and there was no induced damage. The sill height was 40 cm (15.7 in). The height of the maximum door crush was 50 cm (19.7 in) and the door sill differential was 0 cm.



Figure 3: Left plane damage on GMC

Units	Event	Direct Damage		Field L	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>	C <sub>6</sub>	Direct	Field L
		Width CDC	Max Crush								±D	±D
cm	1	250	4	250	0	0	4	3	3	0	-73	-73
in		98.4	1.6	98.4	0.0	0.0	1.6	1.2	1.2	0.0	-28.7	-28.7

**Damage Classification Event 1:** The GMC’s Collision Deformation Classification (CDC) was 12LZES1 (350 degrees). The WinSMASH program could not be used to calculate Delta V on this impact since sideswipe type impacts are out of scope for the. The severity of the damage was minor.

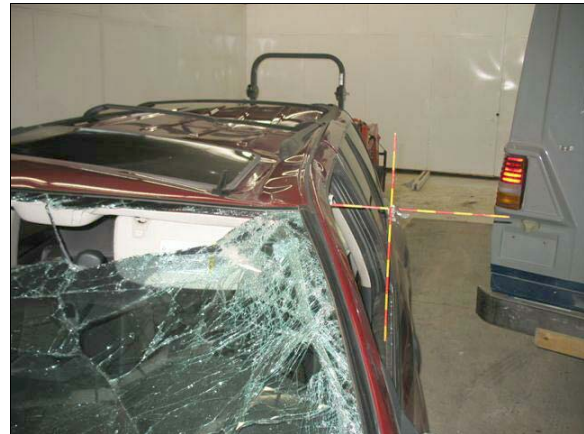
**Exterior Damage Event 2:** The GMC sustained damage on both side planes and the top plane during the rollover. The direct damage on the left plane began on the fender, 44 cm (17.3 in) rear of the left front axle and extended 26 cm (10.2 in) rearward onto the left front door. The damage resumed 97 cm (38.2 in) rear of the left front axle, extending 200 cm (78.7 in) rearward along the left A pillar and left front window frame.

Direct damage on the right plane began 44 cm (17.3 in) forward of the right front axle and extended rearward 60 cm (23.6 in) along the fender. The damage resumed 60 cm (23.6 in) rear of the right front axle at the base of the A-pillar, and extended 115 cm (45.3 in) rearward on the front door and window frame. Grass and dirt was deposited in the space between the front window and window frame.

Direct damage on the top plane consisted of light scratches, 75 cm (29.5 in) rear of the left front axle, immediately forward of the sunroof glazing. Direct contact extended 262 cm (103 in) along the left side luggage rack rail which was bent inward. There were scratches on the right roof side rail near the right A-pillar and on the right rear portion of the roof. There was no discernable damage from the rollover on the hood. The maximum vertical crush was 10 cm (3.9 in) and occurred on the roof near the left front corner of the sunroof (**Figure 4**). The maximum lateral crush was 3 cm (1.2 in) and occurred at the left roof side rail over the center of the left front door (**Figure 5**).

**Damage Classification Event 2:** The CDC for the rollover was 00TZDO3 for the rollover. The WinSMASH program could not be used to calculate Delta V since rollovers are out of scope for the program. Based on the extent of the roof crush, the severity of the rollover damage was moderate.

The vehicle manufacturer's recommended tire size was P245/65R17. The GMC was equipped with tires of the recommended size. The vehicle's tire data are shown in the table below.



**Figure 4:** Vertical maximum crush to roof of the GMC



**Figure 5:** The max lateral crush to the GMC's left roof side rail



Tire	Measured Pressure		Vehicle Manufacturer's Recommended Cold Tire Pressure		Tread Depth		Damage	Restricted	Deflated
	kPa	psi	kPa	psi	milli-meters	32 <sup>nd</sup> of an inch			
LF	207	30	207	30	6	8	None	No	No
LR	207	30	241	35	4	5	None	No	No
RR	Flat	Flat	241	35	3	4	Tire de-beaded	No	Yes
RF	Flat	Flat	207	30	6	7	None	No	Yes

**Vehicle Interior:** The inspection of the GMC's interior revealed that the center console was slightly displaced from contact by the driver's right hip. The right front door arm rest was cracked from driver contact when he was displaced into the front right seat area during the rollover. There was no deformation of the steering wheel and no compression of the energy absorbing steering column.

The GMC's right front door was mechanically opened by rescue personnel for removal of the driver. The remaining doors and tailgate remained closed and operational. All of the window glazing was either fixed or closed prior to the crash. The right and left front window glazing was disintegrated during the crash. The windshield was cracked and had separated from the bonding at the top due to weathering. The remaining glazing was undamaged.

There were seven intrusions of the passenger compartment. The most severe intrusions into the driver's space involved the roof, left roof side rail, and left B-pillar. The roof and roof side rail intruded vertically 9 cm (3.5 in) and 14 cm (5.5 in), respectively, while the B-pillar intruded laterally 6 cm (2.4 in).

## ROLLOVER DISCUSSION

The GMC's rollover mitigation features consisted of a rollover sensor, and Electronic Stability Control (ESC). The NHTSA has given the vehicle a three star rollover rating on a five star scale and a Static Stability Factor of 1.17<sup>1</sup>. The Static Stability Factor (SSF) is a calculation based on the vehicle's track width and height of its center of gravity. The result of the calculation is a measure of a vehicle's resistance to roll over. A higher SSF indicates a more stable vehicle. The majority of passenger vehicles have an SSF of 1.30 to 1.50<sup>2</sup>. The test vehicle also did not tip-up during the dynamic steering maneuver test in which the test vehicle was put through a fish-hook shaped steering maneuver (i.e., hard left and hard right steer) at between 56 km/h-80km/h (35-50 mph).

<sup>1</sup> [www.safercar.gov](http://www.safercar.gov), 1/7/11

<sup>2</sup> "Trends in the Static Stability Factor of Passenger Cars, Light Trucks, and Vans", NHTSA Technical Report, DOT HS 809 868, June 2005

The GMC's rollover was initiated when the vehicle departed the roadway and traveled into the ditch. Dirt was entrapped in the bead of the right front tire and the right rear tire was debaded, indicating that the vehicle tripped and rolled over, right side leading, as the right side tires furrowed into the ground. The damage on the vehicle indicated that it rolled over four quarter turns. The specific location of rollover initiation and the distance traveled during the rollover could not be determined since the ground was snow covered at the SCI inspection. The vehicle's final rest position and heading was based on the non-scaled police crash schematic.

#### **EVENT DATA RECORDER**

The GMC's EDR was imaged using version 3.5.1 of the Bosch Crash Data Retrieval (CDR) software via connection to the diagnostic link connector. The imaged data was read and reported with version 3.8 of the CDR software. The EDR recorded a deployment event. A non-deployment event was detected but not reported. The Supplemental Inflatable Restraint (SIR) warning lamp was recorded as "off." The driver's and front right passenger's safety belt switch circuits were recorded as "unbuckled" and the front seat tracks were recorded as "Rearward." The pretensioners were commanded to actuate and the IC air bags were commanded to deploy due to the rollover event. The maximum recorded lateral velocity change occurred at 160 msec following the deployment command and was reported as -28.68 km/h (-17.82 mph). The maximum recorded longitudinal velocity change was 1.03 km/h (0.64 mph) occurring at 10 msec following algorithm enable (AE). The pre-crash data was presented in the pre-crash section on page 2 of this report. The EDR report is attached at the end of this report<sup>3</sup>.

#### **AUTOMATIC RESTRAINT SYSTEM**

The GMC was equipped with a Certified Advanced 208-Compliant (CAC) frontal air bag system that consisted of dual stage driver and front right passenger air bags, front retractor mounted pretensioners, and a front right passenger weight sensor. The manufacturer has certified that the vehicle is compliant to the Advanced Air Bag portion of the Federal Motor Vehicle Safety Standard (FMVSS) No. 208. Neither of the frontal air bags deployed in this crash.

The GMC was also equipped with rollover/side impact IC air bags. The side impact sensors were located within the lower front doors. Both IC air bags deployed in this crash.

The IC air bags were located along the roof side rails inside the headliners and extended from the A-pillar to the C-pillar. There were no external vent ports. The deployed left IC was 170 cm (66.9 in) in width and 49 cm (19.3 inches) in height. It was attached at the A-pillar by a 16 cm (6.3 in) nylon tether. The IC extended 15 cm (5.9 in) below the beltline and the gap between the front center of IC and the A-pillar was 9 cm (3.5 in). There was a 5 cm (1.9 in) tether connecting the bottom of the IC to the bottom of the C-pillar. Inspection of the IC revealed no discernable evidence of occupant contact. The IC had two 10-cm (3.9 in) vertical cuts on the outboard side adjacent to the left front window that probably occurred during the rollover. The

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<sup>3</sup> Pages 8-9 of the EDR report have been deleted for confidentiality purposes.

dimensions of the right side IC were similar to the left side. The front portion of the IC was cut away by rescue personnel during the extrication of the driver.

#### **MANUAL RESTRAINT SYSTEM**

The GMC was equipped with integrated lap-and-shoulder safety belts for the driver and front right passenger seating positions. The driver's safety belt consisted of continuous loop belt webbing, a sliding latch plate, and an Emergency Locking Retractor (ELR). The front right safety belt was similar to the driver's but had a switchable ELR/Automatic Locking Retractor (ALR). The second row lap-and-shoulder safety belts consisted of continuous loop belt webbing, sliding latch plates, ELR/ALRs, and fixed upper anchors.

Inspection of the driver's safety belt assembly revealed that the retractor-mounted pretensioner actuated during the crash. The retractor was non-functional and the belt webbing was tightly retracted. This evidence suggested that the driver was not restrained by the lap-and-shoulder safety belt at the time of the crash. The EDR also reported the driver's safety belt switch circuit as "unbuckled."

#### **CASE VEHICLE DRIVER KINEMATICS**

Based on the SCI interview, the unrestrained driver of the GMC [52-year-old male, 185 cm (73 in) and 100 kg (220 lb)] was seated in an upright posture with his back against the seat. He had his left foot on the floor and his right foot on the brake. Both hands were on the steering wheel, bracing for the impending impact. The seat track was adjusted to the rear position and the seat was slightly reclined. The distance from the top of the seat back to the top of the head restraint was 23 cm (9.1 in). The tilt steering column was located in the full-up position and the adjustable foot pedals were located in the full forward position. The driver was not wearing glasses or contact lenses.

The initial impact to the GMC's left plane by the Saturn probably displaced the driver forward opposite the 12 o'clock direction of force. As the vehicle traveled into the ditch and rolled over, right side leading, the driver was redirected toward the roof. He was displaced out of his seat and contacted the roof, which caused a neck strain. He sustained a contusion just below his left knee from contact with the center console as he was displaced into the front right seating area. He also contacted the right instrument panel, which abraded his left flank and left elbow. He came to rest in the front right seating area of the vehicle. Rescue personnel mechanically opened the right front door and extricated him from the vehicle.

#### **CASE VEHICLE DRIVER INJURIES**

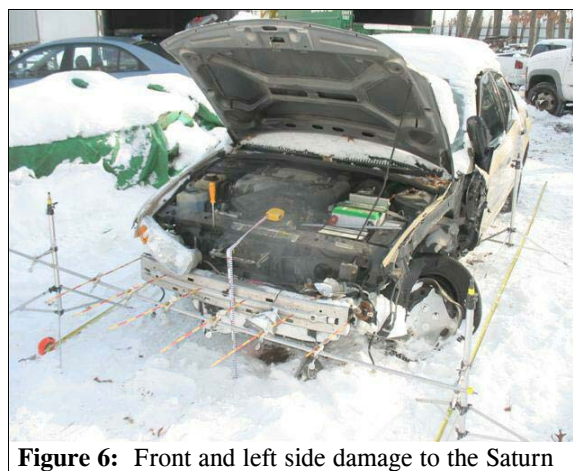
The driver was transported by ambulance to a hospital where he was treated in the emergency room and released. He missed one day of work due to the crash. The following table presents the driver's injuries and injury sources.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 2005	Injury Source	Source Confidence	Source of Injury Data
1	Strain, neck with	minor 640278.1,6	Roof (Indirect injury)	Probable	Interviewee (same person)
	cervical neural foraminal and central stenosis C <sub>4</sub> -C <sub>5</sub> and C <sub>5</sub> -C <sub>6</sub> and straightening of C-spine				Emergency room records
2	Abrasion left flank, not further specified	minor 510202.1,2	Right instrument panel	Probable	Emergency room records
3	Abrasion left elbow—no active bleeding, not further specified	minor 710202.1,2	Right instrument panel	Probable	Emergency room records
4	Contusion, 15.2-20.3 cm (6-8 in), left knee, not further specified	minor 810402.1,2	Interior, center console first row	Probable	Interviewee (same person)

**OTHER VEHICLE**

The 2000 Saturn SL-1 was a front wheel drive, 5-passenger, 4-door sedan (VIN: 1G8ZH5280YZ-----), equipped with a 1.9-liter, L-4 engine and a 4-speed automatic transmission. The Saturn was equipped with redesigned frontal air bags, which deployed during the crash.

**Exterior Damage Event 1:** The Saturn sustained damage on the front and left planes during the impact with the left plane of the GMC. The Saturn’s front bumper, left fender, hood, left front wheel, and left front door were directly damaged. The direct damage began at the front left bumper corner and extended 2 cm (0.8 in) along the bumper (**Figure 6**). Crush measurements were taken on the bumper and the residual maximum crush was 1 cm (0.4 in) occurring at C<sub>1</sub>. This impact was a narrow end engagement and the damage extended down the left side onto the left front wheel and left front door. The left wheelbase was reduced 12 cm (4.7 in) and the right wheelbase was extended 2 cm (0.8 in).



**Figure 6:** Front and left side damage to the Saturn

**Damage Classification Event 1:** The CDC for the Saturn’s impact with the GMC was 12FLES6 (10 degrees). The WinSMASH program could not be used to calculate Delta V on this impact since sideswipe type impacts are out of scope for the program. The severity of the damage was minor.

The vehicle manufacturer’s recommended tire size was P185/65R14. The Saturn was equipped with tires of the recommended size. The vehicle’s tire data are shown in the table below.

The tire pressure for the right rear tire could not be determined since the valve stem was frozen.

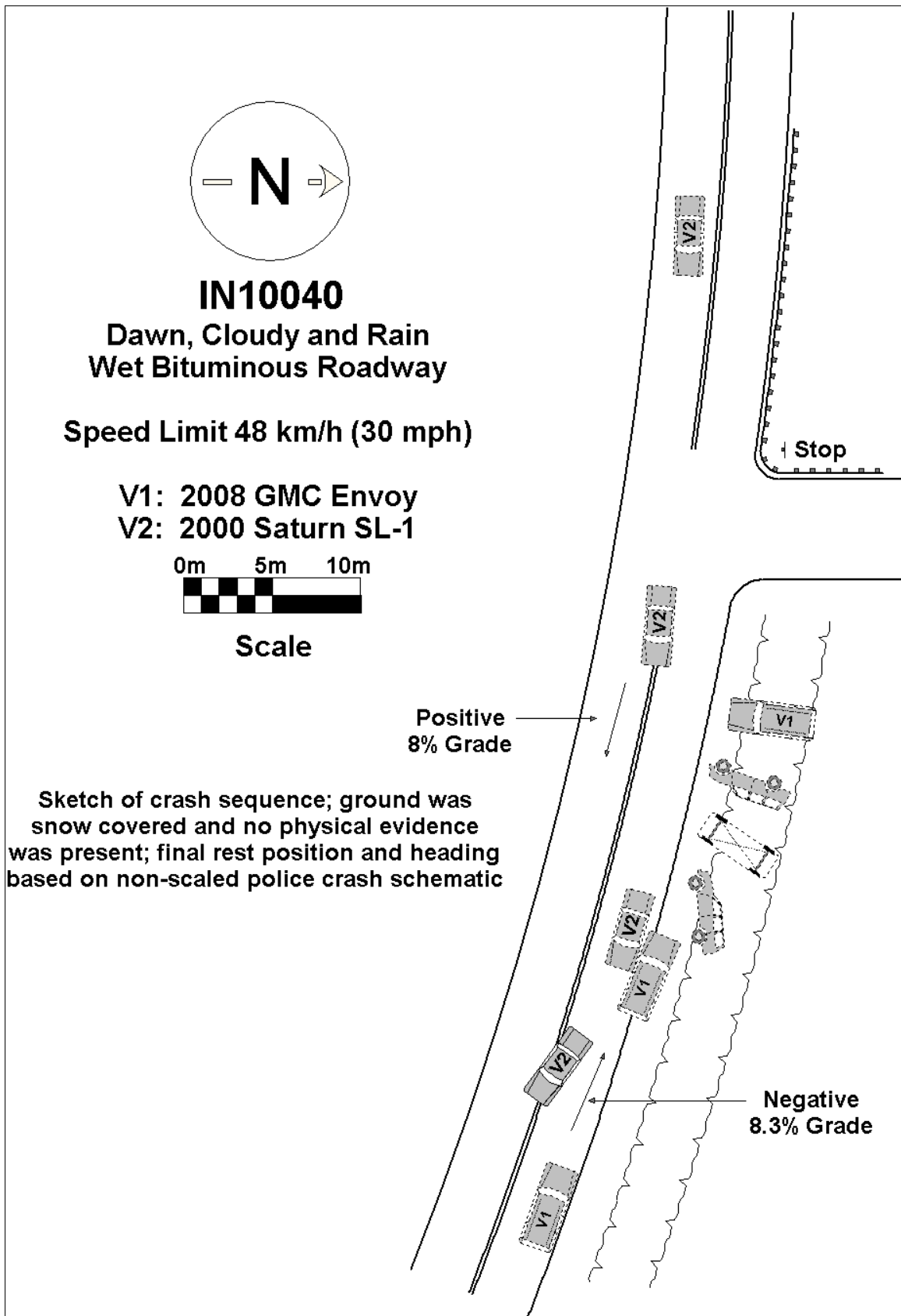
Tire	Measured Pressure		Vehicle Manufacturer's Recommended Cold Tire Pressure		Tread Depth		Damage	Restricted	Deflated
	kPa	psi	kPa	psi	milli-meters	32 <sup>nd</sup> of an inch			
LF	Flat	Flat	207	30	4	5	Sidewall cut, de-beaded	Yes	Yes
LR	179	26	179	26	5	6	None	No	No
RR	unk	unk	179	26	5	6	None	No	No
RF	165	24	207	30	4	5	None	No	No

**Event Data Recorder:** The Saturn's EDR was imaged using version 3.5.1 of the Bosch Crash Data Retrieval (CDR) software via direct connection to the air bag control module (ACM). The imaged data was read and reported with version 3.8 of the CDR software. The EDR recorded a deployment and a non-deployment event. The Supplemental Inflatable Restraint (SIR) warning lamp was reported as "off." The driver's and front right passenger's safety belt switch circuits were recorded as "unbuckled." The deployment criteria was met at approximately 50 ms after AE. The maximum longitudinal velocity change occurred at 80 ms following AE and was reported as 15.9 km/h (9.88 mph). The maximum longitudinal velocity change for the non-deployment event was reported as -0.06 km/h (-0.04 mph). The EDR report is attached at the end of this report<sup>4</sup>.

**Other Vehicle Driver:** Based on EDR data, the driver of the Saturn (56-year-old male) was not restrained by his lap-and-shoulder safety belt. The driver did not sustain any injury and was not transported for medical treatment.

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<sup>4</sup> Page 6 of the EDR report has been deleted for confidentiality purposes.



## Event Data Recorder Report, 2008 GMC Envoy

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	1GKDS13S082*****
User	
Case Number	
EDR Data Imaging Date	12/28/2010
Crash Date	
Filename	ENVOY_IN10040.CDRX
Saved on	Tuesday, December 28 2010 at 09:23:01
Collected with CDR version	Crash Data Retrieval Tool 3.5.1
Reported with CDR version	Crash Data Retrieval Tool 3.8
EDR Device Type	airbag control module
Event(s) recovered	Deployment

## Comments

No comments entered.

## Data Limitations

### Recorded Crash Events:

There are two types of recorded crash events. The first is the Non-Deployment Event. A Non-Deployment Event records data but does not deploy the air bag(s). 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 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.
- 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.
- 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 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.

01010\_SDMDC\_r002

### Multiple Event Data

Associated Events Not Recorded	1
An Event(s) Preceded the Recorded Event(s)	No
An Event(s) was in Between the Recorded Event(s)	Yes
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)	Yes

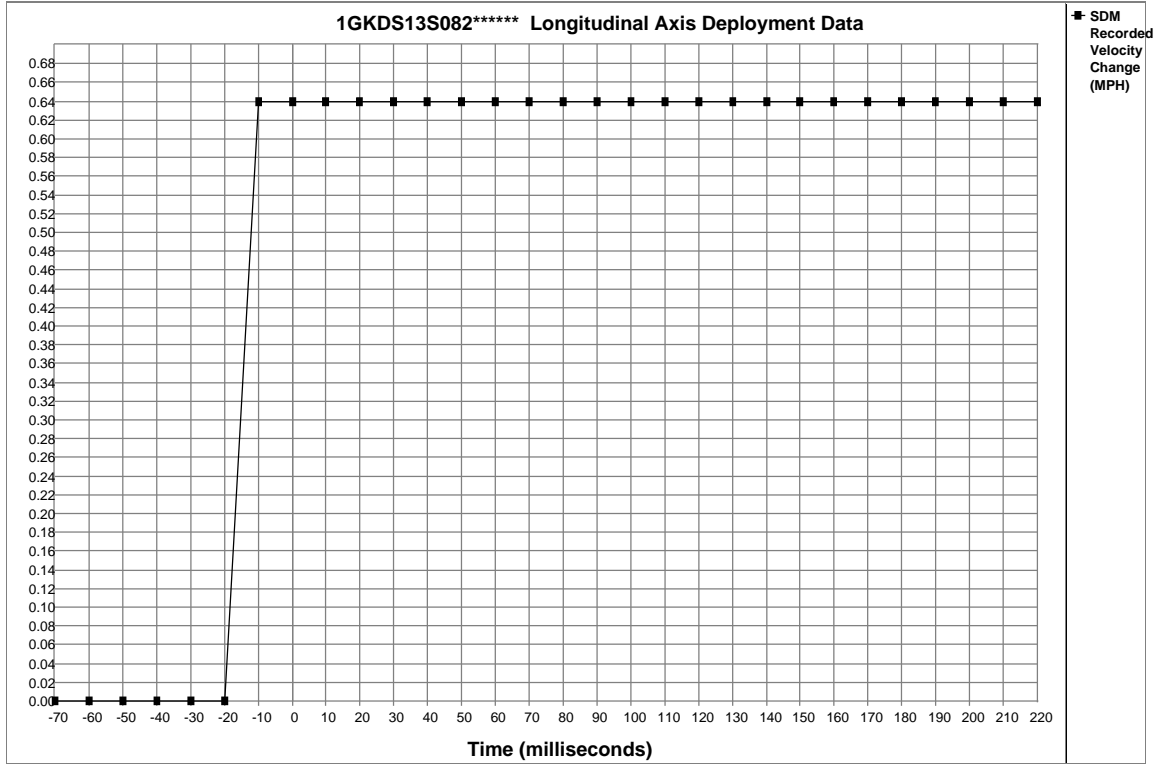
### Pre-Crash Data

Parameter	-2.5 sec	-2.0 sec	-1.5 sec	-1.0 sec	-0.5 sec
Vehicle Speed (MPH)	36	36	36	35	31
Engine Speed (RPM)	896	896	896	896	832
Percent Throttle	0	0	0	0	0
Brake Switch Circuit State	ON	OFF	OFF	ON	ON

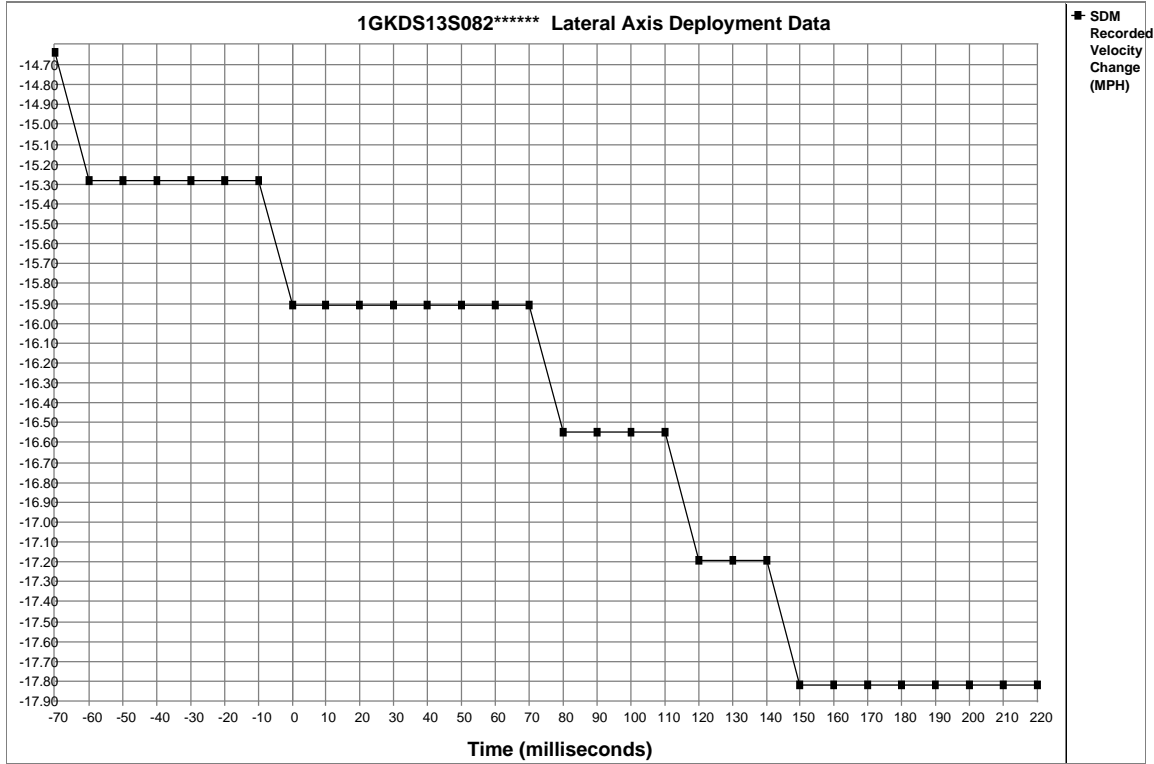
## System Status At Deployment

SIR Warning Lamp Status	OFF
SIR Warning Lamp ON/OFF Time Continuously (seconds)	655350
Number of Ignition Cycles SIR Warning Lamp was ON/OFF Continuously	6331
Ignition Cycles At Investigation	6338
Ignition Cycles At Event	6331
Ignition Cycles Since DTCs Were Last Cleared	255
Driver's Belt Switch Circuit Status	UNBUCKLED
Passenger's Belt Switch Circuit Status	UNBUCKLED
Driver Seat Position Switch Circuit Status	Rearward
Passenger Seat Position Switch Circuit Status	Rearward
Automatic Passenger SIR Suppression System Status at AE	Air Bag Suppressed
Rollover Sensor Status	Rollover Event
Number of Consecutive Error Free Messages Received From Rollover Sensor	Last 8 Consecutive Messages Were Error Free
SDM Synchronization Counter	8253
Side Air Bag(s) Were First Commanded to Deploy Due to Side Impact Event	No
Side Air Bag(s) Were First Commanded to Deploy Due to Rollover Event	Yes
Time Between Events (sec)	N/A
Driver 1st Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	N/A
Driver 2nd Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	N/A
Passenger 1st Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	N/A
Passenger 2nd Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	N/A
Driver 1st Stage Time From Arming Signal to Deployment Command Signal	N/A
Driver 2nd Stage Time From Arming Signal to Deployment Command Signal	N/A
Passenger 1st Stage Time From Arming Signal to Deployment Command Signal	N/A
Passenger 2nd Stage Time From Arming Signal to Deployment Command Signal	N/A
Driver 1st Stage Field Effect Transistor (FET) on time	N/A
Driver 2nd Stage Field Effect Transistor (FET) on time	N/A
Passenger 1st Stage Field Effect Transistor (FET) on time	N/A
Passenger 2nd Stage Field Effect Transistor (FET) on time	N/A
Driver 1st Stage Deployment Loop Commanded	No
Driver 2nd Stage Deployment Loop Commanded	No
Driver Side Deployment Loop Commanded	No
Driver Pretensioner Deployment Loop Commanded	Yes
Driver Roof Rail/Head Curtain Loop Commanded (If Equipped)	Yes
Supplemental Deployment Loop #1 Commanded (If Equipped)	No
Passenger 1st Stage Deployment Loop Commanded	No
Passenger 2nd Stage Deployment Loop Commanded	No
Passenger Side Deployment Loop Commanded	No
Passenger Pretensioner Deployment Loop Commanded	Yes
Passenger Roof Rail/Head Curtain Loop Commanded (If Equipped)	Yes
Supplemental Deployment Loop #2 Commanded (If Equipped)	No
Second Row Left Side Deployment Loop Commanded	No
Second Row Left Pretensioner Deployment Loop Commanded (If Equipped)	No
Supplemental Deployment Loop #3 Commanded (If Equipped)	No
Second Row Right Side Deployment Loop Commanded (If Equipped)	No
Second Row Right Pretensioner Deployment Loop Commanded	No
Supplemental Deployment Loop #4 Commanded (If Equipped)	No
Supplemental Deployment Loop #4 Suppressed (If Equipped)	No
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
Diagnostic Trouble Codes at Event, fault number: 7	N/A
Diagnostic Trouble Codes at Event, fault number: 8	N/A
Diagnostic Trouble Codes at Event, fault number: 9	N/A
Crash Record Locked	Yes
Vehicle Event Data (Pre-Crash) Associated With This Event	Yes

Driver 1st Stage Deployment Algorithm Mode (Unbelted)	No Trigger Mode
Driver 1st Stage Deployment Algorithm Mode (Belted)	No Trigger Mode
Passenger 1st Stage Deployment Algorithm Mode (Unbelted)	No Trigger Mode
Passenger 1st Stage Deployment Algorithm Mode (Belted)	No Trigger Mode
Event Recording Complete	Yes



Time (milliseconds)	-70	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70
SDM Longitudinal Axis Recorded Velocity Change (MPH)	0.00	0.00	0.00	0.00	0.00	0.00	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64
Time (milliseconds)	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220
SDM Longitudinal Axis Recorded Velocity Change (MPH)	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64



Time (milliseconds)	-70	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70
SDM Lateral Axis Recorded Velocity Change (MPH)	-14.64	-15.28	-15.28	-15.28	-15.28	-15.28	-15.28	-15.91	-15.91	-15.91	-15.91	-15.91	-15.91	-15.91	-15.91
Time (milliseconds)	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220
SDM Lateral Axis Recorded Velocity Change (MPH)	-16.55	-16.55	-16.55	-16.55	-17.19	-17.19	-17.19	-17.82	-17.82	-17.82	-17.82	-17.82	-17.82	-17.82	-17.82

## Event Data Recorder Report, 2000 Saturn SL1

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	1G8ZH5280YZ*****
User	
Case Number	
EDR Data Imaging Date	12/29/2010
Crash Date	
Filename	SATURN IN10040.CDRX
Saved on	Wednesday, December 29 2010 at 10:45:54
Collected with CDR version	Crash Data Retrieval Tool 3.5.1
Reported with CDR version	Crash Data Retrieval Tool 3.8
EDR Device Type	airbag control module
Event(s) recovered	Deployment 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 may be overwritten by another Non-Deployment Event. This event will be cleared by the SDM, after approximately 250 ignition cycle. 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 a Deployment Level Event occurs within five seconds after the Deployment Event, the Deployment Level Event 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 Adjusted Algorithm Longitudinal Velocity Change:

Once the crash data is downloaded, the CDR tool mathematically adjusts the recorded algorithm longitudinal velocity data to generate an adjusted algorithm longitudinal velocity change that may more closely approximate the longitudinal velocity change the sensing system experienced during the recorded portion of the event. The adjustment takes place within the downloading tool and does not affect the crash data stored in the SDM, which is displayed in hexadecimal format. The SDM Adjusted Algorithm Longitudinal Velocity Change may not closely approximate what the sensing system experienced in all types of events. For example, if a crash is preceded by other common events, such as rough road, struck objects, or off-road travel, the SDM Adjusted Algorithm Longitudinal Velocity Change may be less than and some times significantly less than the actual longitudinal velocity change the sensing system experienced. 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. Velocity Change data is displayed in SAE sign convention.

-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.

-Some of the Pre-Crash data may be recorded after Algorithm Enable (AE). If this occurs, it may affect the reported pre-crash data values, but does not affect other data such as SDM Adjusted Algorithm Longitudinal Velocity Change.

-Pre-Crash Electronic Data Validity Check Status indicates "Data Invalid" if:

- the SDM receives a message with an "invalid" flag from the module sending the pre-crash data
- no data is received from the module sending the pre-crash data
- no module present to send the pre-crash data



-Engine Speed is reported at two times the actual value in the following vehicles, if the vehicle is equipped with a 6.6L Duramax diesel engine (RPO LB7, LBZ, LLY, or LMM):

- 2001-2006 Chevrolet Silverado
- 2007 Chevrolet Silverado Classic
- 2001-2006 GMC Sierra
- 2007 GMC Sierra Classic
- 2006-2007 Chevrolet Express
- 2006-2007 GMC Savana
- 2003-2009 Chevrolet Kodiak
- 2003-2009 GMC Topkick

-Driver's 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.

-Passenger Front Air Bag Suppression Switch Circuit Status indicates the status of the suppression switch circuit.

-The Time Between 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 power to the SDM is lost during a crash event, all or part of the crash record may not be recorded.

-If the vehicle is a 2000 - 2002 Chevrolet Cavalier Z24 or a Pontiac Sunfire GT, with a manual transmission (RPO MM5) and a 2.4L engine (RPO LD9), the Brake Switch Circuit Status data will be reported in the opposite state than what actually occurred, e.g. an actual brake switch status of "ON" will be reported as "OFF".

-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 SDM may obtain Belt Switch Circuit Status data a number of different ways, depending on the vehicle architecture.

Some switches are wired directly to the SDM, while others may obtain the data from various vehicle control modules, via the vehicle's communication network.

-The Passenger Front Air Bag Suppression Switch Circuit is wired directly to the SDM.

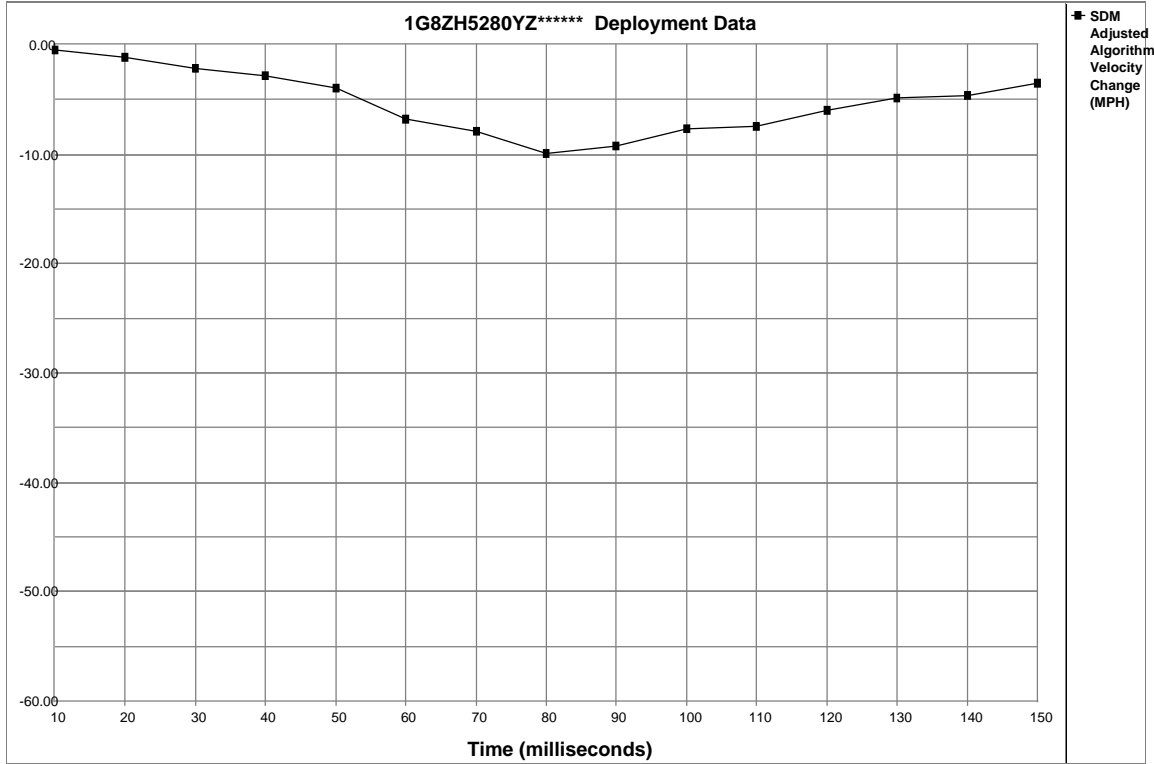
01023\_SDMG-99JXZ01-07\_r002

### System Status At Deployment

SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	UNBUCKLED
Passenger SIR Suppression Switch Circuit Status (if equipped)	Air Bag Not Suppressed
Ignition Cycles At Deployment	19690
Time Between Non-Deployment And Deployment Events (sec)	N/A

Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle
-5	58	1984	0
-4	47	1472	0
-3	13	960	0
-2	0	704	0
-1	0	512	0

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



Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Adjusted Algorithm Velocity Change	-0.44	-1.10	-2.20	-2.86	-3.95	-6.81	-7.90	-9.88	-9.22	-7.69	-7.47	-5.93	-4.84	-4.62	-3.52

### System Status At Non-Deployment

SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	UNBUCKLED
Passenger SIR Suppression Switch Circuit Status (if equipped)	Air Bag Not Suppressed
Ignition Cycles At Non-Deployment	19690
Maximum SDM Algorithm Longitudinal Velocity Change (MPH)	-0.04

Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle
-5	60	2112	5
-4	59	2112	5
-3	58	2048	5
-2	57	1984	5
-1	53	1728	5

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