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CALSPAN ON-SITE CHILD RESTRAINT SYSTEM CRASH INVESTIGAITON

SCI CASE NO: CA09023

VEHICLE: 2007 SATURN ION

LOCATION: NEW YORK

CRASH DATE: APRIL 2009

Contract No. DTNH22-07-C-00043

Prepared for:

U.S. Department of Transportation
National Highway Traffic Safety Administration
Washington, D.C. 20590

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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

1. Report No. CA09023	*2. Government Accession No.*	*3. Recipient's Catalog No.*	
4. Title and Subtitle Calspan On-Site Child Restraint System Crash Investigation Vehicle: 2007 Saturn ION Location: New York		*5. Report Date*: January 2011	
		6. Performing Organization Code	
7. Author(s) Crash Data Research Center		*8. Performing Organization Report No.*	
9. Performing Organization Name and Address Calspan Corporation Crash Data Research Center P.O. Box 400 Buffalo, New York 14225		*10. Work Unit No.*	
		11. Contract or Grant No. DTNH22-07-C-00043	
12. Sponsoring Agency Name and Address U.S. Department of Transportation National Highway Traffic Safety Administration Washington, D.C. 20590		*13. Type of Report and Period Covered* Technical Report Crash Date: April 2009	
		14. Sponsoring Agency Code	

15. Supplementary Note

An investigation of the roadside departure rollover crash of a 2007 Saturn ION that resulted in the deaths of two children restrained in Child Restraint Systems.

16. Abstract

This on-site investigation focused on two occupied Child Restraint Systems (CRS's) in a 2007 Saturn ION 4-door sedan that was involved in a roadside departure/end-over-end rollover crash. The vehicle was occupied by a 35-year-old male driver, a 6-year-old female second row left passenger and a 4-year-old male second row right passenger. The Saturn was equipped with Certified Advanced 208-Compliant frontal air bags for the two front row seating positions. It was not equipped with seat-mounted side impact air bags or Inflatable Curtain (IC) air bags. The 6-year-old female passenger was restrained in a backless booster CRS and the 4-year-old male passenger was restrained in a high-back booster CRS. The crash occurred when the eastbound Saturn drifted to the right and departed the south side of an interstate roadway. The Saturn continued forward through a swale and along a grass embankment for approximately 135 m (443 ft). The Saturn then vaulted, off the end of the embankment, into a 15 m (50 ft) deep ravine and began to pitch down, end-over-end. The Saturn's top plane then struck a large concrete culvert wall during this event. The vehicle continued the end-over-end rotation, impacting the ground with its roof. The Saturn then rebounded back onto its wheels, coming to rest east of the struck culvert. The driver's frontal air bag deployed as a result of the crash. The restrained driver sustained police-reported incapacitating injuries and was transported by ground ambulance to a local trauma center. The 6-year-old female passenger and 4-year-old male passenger were both pronounced deceased at the crash scene.

17. Key Words Roadside departure, Rollover, Child Restraint System, Fatal injury		*18. Distribution Statement* General Public	
19. Security Classif. (of this report) Unclassified	*20. Security Classif. (of this page)* Unclassified	*21. No. of Pages* 26	*22. Price*

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BACKGROUND

This on-site investigation focused on two occupied Child Restraint Systems (CRS's) in a 2007 Saturn ION 4-door sedan **(Figure 1)** that was involved in a roadside departure/end-over-end rollover crash. The vehicle was occupied by a 35-year-old male driver, a 6-year-old female second row left passenger and a 4-year-old male second row right passenger. The Saturn was equipped with Certified Advanced 208-Compliant frontal air bags for the two front row seating positions. It was not equipped with seat-mounted side impact air bags or Inflatable Curtain (IC) air bags. The 6-year-old female passenger was restrained in a backless booster CRS and the 4-year-old male passenger was restrained in a high-back booster CRS. The crash occurred when the eastbound Saturn drifted to the right and departed the south side of an interstate roadway. The Saturn continued forward through a swale and along a grass embankment for approximately 135 m (443 ft). The Saturn then vaulted, off the end of the embankment, into a 15 m (50 ft) deep ravine and began to pitch down, end-over-end. The Saturn's top plane then struck a large concrete culvert wall during this event. The vehicle continued the end-over-end rotation, impacting the ground with its roof. The Saturn then rebounded back onto its wheels, coming to rest east of the struck culvert. The driver's frontal air bag deployed as a result of the crash. The restrained driver sustained police-reported incapacitating injuries and was transported by ground ambulance to a local trauma center. The 6-year-old female passenger and 4-year-old male passenger were both pronounced deceased at the crash scene.

Figure 1: Front left oblique view of the 2007 Saturn ION.

This crash was identified by Calspan's Special Crash Investigation (SCI) team on April 7, 2009, during a routine review of media reported crashes. The crash notification was forwarded to the Crash Investigation Division (CID) of the National Highway Traffic Safety Administration (NHTSA) and was selected for an on-site investigation on the day of notification due to the Agency's interest in child passenger safety. The on-site investigation, which included the inspection of the Saturn and the crash site, was conducted on April 9-10, 2009. The Event Data Recorder (EDR) within the Saturn was also imaged at that time.

SUMMARY

Vehicle Data - 2007 Saturn ION

The 2007 Saturn ION (**Figure 2**) was identified by the Vehicle Identification Number (VIN): 1G8AJ55F27Z (production sequence deleted). The placard indicating this vehicle's date of manufacture could not be identified due to the driver's door being jammed shut. The odometer reading was unknown. The powertrain consisted of 2.2-liter, I4 engine linked to a 4-speed automatic transmission with front-wheel drive. The Saturn was equipped with power-assisted front axle disc and rear axle drum brakes. The Saturn was equipped with Goodyear Assurance P195/60R15 tires mounted on OEM steel wheels. The tire size matched the vehicle manufacturer's recommendation. The vehicle manufacturer recommended front and rear cold tire pressure was 207 kPa (30 PSI). The specific tire data at the time of the SCI inspection was as follows:

Figure 2: Left side view of the Saturn.

Tire	Measured Pressure	Tread Depth	Restricted	Damage
LF	Flat Tire	5 mm (6/32 in)	No	None
LR	221 kPa (32 PSI)	5 mm (6/32 in)	No	None
RF	221 kPa (32 PSI)	7 mm (9/32 in)	No	None
RR	221 kPa (32 PSI)	6 mm (8/32 in)	No	None

The interior of the Saturn was configured for five-passenger seating consisting of two front bucket seats and a second row 60/40 split bench seat. The front seats were equipped with adjustable head restraints. The second row seat was equipped with integral head restraints in the outboard positions. The manual restraint systems consisted of 3-point lap and shoulder safety belts in all five positions. The front safety belts were equipped with retractor pretensioners. The Saturn was equipped with CAC frontal air bags. The vehicle manufacturer had certified that the frontal air bags in this Saturn were compliant with the advanced air bag requirements of Federal Motor Vehicle Safety Standard No. 208.

Crash Site

This crash occurred during the afternoon daylight hours of April 2009, on an east/west divided two-lane interstate roadway with a posted speed limit of 105 km/h (65 mph). At the time of the crash, the local area visibility was cloudy and the level, bituminous road surface was dry. The

roadway alignment was curved to the left for eastbound traffic. The eastbound travel lanes (**Figure 3**) measured 3.7 m (12.1 ft) in width and were bordered by asphalt shoulders, each of which contained a rumble strip. The south shoulder measured 3.5 m (11.5 ft) in width while the north shoulder was 0.9 m (3.0 ft) wide. The opposing westbound travel lanes were separated by a grassy median populated with trees.

Figure 3: Eastbound travel lanes depicting the Saturn's pre-crash path of travel.

Outboard the south shoulder was a grass embankment that formed a swale. The swale was oriented parallel to the interstate and had a negative slope in the easterly direction. The centerline of the swale was located 6.5 m (21.3 ft) south of the road edge. The Saturn's off-road path of travel was evidenced by tracking/rotating tire marks that initially crossed through swale and then arced back to the left along the embankment (**Figure 4**) toward the centerline of the swale. The swale terminated 135 m (443 ft) from the road departure in a growth of brush and small trees. To the east beyond the end of the swale was a ravine that was approximately 15 m (50 ft) deep. **Figure 5** is a look back view across the ravine toward the end of the swale and the vehicle's off-road trajectory. At the bottom of the ravine was a drainage culvert that passed under the interstate (**Figure 6**). The culvert was protected on three sides by a 1.8 m (6 ft) tall concrete headwall. The center of the culvert was located 150 m (492 ft) east of the road departure point. The terrain east of the culvert, in the area of the vehicle's final rest, had an estimated negative 5 percent grade to the south and contained dispersed patches of small trees and brush. Schematics of the crash site are included as **Figures 21 and 22** of this report.

Figure 4: Off-road trajectory of the Saturn crossing through the swale and along the embankment.

Figure 5: Look back view from the base of the ravine toward the end of the swale and the Saturn's trajectory.

Figure 6: Northward view of the culvert and its headwalls.

Crash Sequence

Pre-Crash

The Saturn ION was eastbound, in the right lane, driven by the 35-year-old restrained male at an EDR-reported speed of 114 km/h (71 mph). The Saturn drifted to the right, as it traveled through the left curve, and departed the road at a shallow angle. The tracking tire impressions in the roadside evidenced the vehicle's path of travel (**Figure 7**). The right and left tire impression departed the pavement 32.6 m (107.0 ft) and 13.3 m (43.6 ft) prior to the beginning of a guardrail that protected the road edge, respectively. The Saturn travelled through the swale 48 m (157.4) after departing the pavement and then travelled as additional 67 m (219.8 ft) along the embankment with a left arcing trajectory. At the end of the tire impressions, the Saturn's eastward trajectory was oriented back toward the end of the swale and the ravine.

Figure 7: View of the Saturn's off-road impression's from the point of road departure.

Crash

Based on the physical scene evidence, the Saturn's forward undercarriage contacted the earth embankment at the end of the swale (Event 1). Additionally, the vehicle's front plane impacted a 10 cm (4 in) diameter tree stump (Event 2). Immediately beyond the stump impact, the Saturn vaulted at the end of the swale and entered the ravine (Event 3). The estimated vertical drop from the swale to the culvert below was 15 m (50 ft). This vertical distance was high enough for the Saturn to pitch end-over-end, beyond a vertical orientation, exposing its top plane to the culvert wall and ground below. The Saturn's hood, windshield and A-pillar area impacted the

east concrete headwall of the culvert (Event 4) in a non-horizontal impact. **Figure 8** is a view of the culvert wall impacted by the Saturn. At the location of impact, the height of the angled wall measured 122 cm (48 in). The thickness of the wall measured 30 cm (12 in). The impact force resulted in the (probable) actuation of both front-row safety belt pretensioners and the deployment of the driver's air bag. The Saturn's front right passenger air bag was suppressed due to the unoccupied front right seat.

Figure 8: View of the concrete culvert wall impacted by the top plane of the Saturn.

The wall impact interrupted the end-over-end roll of the vehicle. At impact the Saturn's center of gravity was above the edge of the wall. This resulted in the vehicle continuing its end-over-end rotation about the edge of the culvert wall. The vehicle's roof and trunk area impacted a cluster of sapling trees and the ground immediately beyond the culvert. The vehicle then rebounded and completed an additional 2-quarter turns, end-over-end, coming to rest on its wheels facing an easterly direction. The Saturn came to final rest an estimated 14 m (45 ft) east of the culvert impact along the secondary embankment.

Post-Crash

A cellular call was placed to the emergency response system by an eastbound traveler indicating that he observed a vehicle depart the interstate and disappear from his view. Reportedly, the State Police responded to the call, but did not detect any evidence of the roadside departure or the Saturn in the area identified by the witness. The Saturn was located approximately three hours after the first harmful event took place. It was not until the Saturn's driver regained consciousness, located his cell phone and called the emergency response system that police and emergency medical services were able to locate and identify the crash scene. The driver of the Saturn sustained incapacitating injuries and was transported by ground ambulance to a local trauma center where he was hospitalized. The 6-year-old female passenger and 4-year-old male passenger were both located within the vehicle at final rest. They were both pronounced deceased during their initial, on-scene medical evaluation. The Saturn sustained disabling damage and was towed from the crash scene. The vehicle was under police impound at a local tow facility at the time of the SCI inspection.

2007 Saturn ION

Exterior Damage

The exterior of the Saturn sustained severe damage as a result of the multiple event crash sequence. A distributed portion of the front third of the undercarriage directly contacted the

embankment at the end of the swale (Event 1). This impact damage was described with a Collision Deformation Classification (CDC) of 00UFDW1.

A small fracture of the front bumper fascia was located along the centerline of the vehicle. Immediately behind the fracture, the front bumper reinforcement bar sustained an isolated region of buckling (Event 2). The buckling was located 16 cm (6.3 in) left of center and was deformed to an 8 cm (3.1 in) depth. This damage was related to the impact with the tree stump at the end of the swale and was the likely cause of the Non-Deployment event recorded by the vehicle's EDR. The CDC of this impact damage was 12FCLN1.

The vehicle vaulted and pitched end-over-end (Event 3) to a near-vertical attitude which exposed the vehicle's top plane to the culvert wall. The CDC of the rollover was 00TDDO99. The 99 code represents an unknown extent zone due to overlapping damage and the extrication efforts that altered the residual crush of the roof.

The Saturn's hood, windshield, and A-pillar area then impacted the wall (Event 4) which resulted in vertical crush to the pillars, windshield header and roof. **Figure 9** is a left side view of the damaged Saturn. The non-horizontal impact forces, from this event, produced a maximum residual vertical crush of 35 cm (13.8) to the top left A-pillar area of the roof (**Figure 10**). The maximum residual lateral crush to this same component measured 12 cm (4.7 in). The CDC of the culvert impact was 00TYDW5.

Figure 9: Left side view of the crush to the Saturn's roof area.

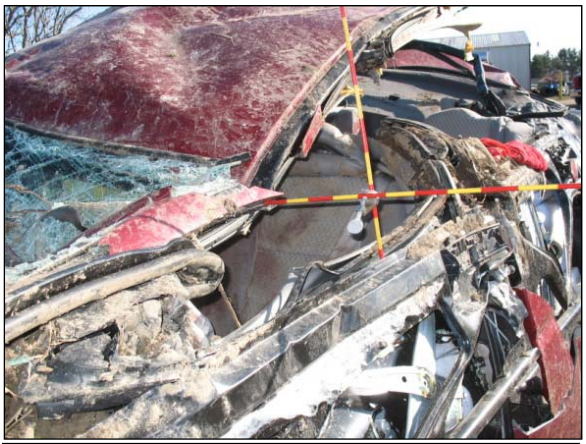


Figure 10: View of the maximum vertical and lateral crush at the Saturn's left A-pillar.

The roof and trunk lid impacted the sapling trees/ground as the vehicle pivoted (end-over-end) about the culvert wall. The aft aspect of the roof crushed down. The left C-pillar crushed inboard and was in contact with the package shelf behind the second row. The roof probably crushed down to the level of the beltline. It should be noted that both B-pillars and C-pillars were cut and the roof was deflected forward during the extrication of the passengers.

The composite body panels of the left plane completely fractured and separated from the space frame. The left front, left rear and right front doors were jammed shut. The right rear door remained closed during the crash and was operational post-crash. The fixed right rear door glazing was intact. All other glazing panels were fractured or disintegrated from impact forces. The SCI vehicle inspection confirmed that there was no damage to the Saturn's fuel system and no leakage of the gasoline fuel it contained.

Interior Damage

The interior damage to the Saturn consisted of deployment of the driver's frontal air bag, the actuation of the front row pretensioners, multiple vertical intrusions of the greenhouse components and occupant contact points. The occupant contacts (**Figure 11**) consisted of compression type blood transfers and scuff marks to the front row headliner, the second row left roof side rail and the second row right headliner. The contact to the second row left roof side rail also contained embedded hair strands.

Figure 11: Interior view of the Saturn's headliner and the occupant contacts.

Figure 12 is a view of the front interior. The driver seat was located in the mid-to-forward track position and the seatback was reclined 30 degrees aft of vertical with the head restraint located in the full-down position. The head restraint was deformed 10 cm (4 in) from vertical intrusion of the roof. The 4-spoke tilt steering wheel was located in the full-down position. There was no deformation of the steering wheel rim and no displacement of the shear capsules. The driver's head contacted the roof headliner as evidenced by a 5 cm (2.8 in) diameter blood transfer mark and deformation of this component. No contact evidence was identified on the driver's deployed frontal air bag due to the magnitude of dripped blood from the driver's injuries.

Figure 12: View of the Saturn's interior front row.

The left and center second row seatbacks were deformed and compressed 13 cm (5.1 in) downward from vertical and lateral passenger compartment intrusions of the interior roof components (**Figure 13**). The second row left occupant's head contacted the left roof side rail as evidenced by a 12 cm (4.7 in) diameter blood transfer mark and deformation of this component which contained embedded hair. The upper aspect of the second row right CRS and the head of the occupant contacted the right roof area, as evidenced by a 10 cm (3.9 in) diameter deformation of this component, and contained a 24 cm (9.4 in) scuff mark. Refer to the CRS section below for additional detail regarding the damage to the CRS.

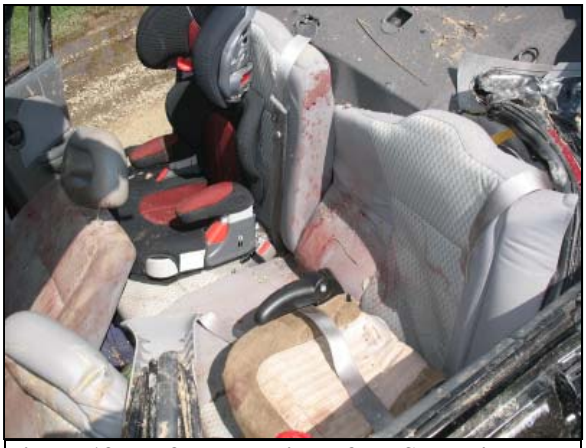


Figure 13: Left lateral view of the Saturn's second row.

A number of intrusions could not be determined due to on-scene extrication damage. Descriptions of the Saturn's measured intrusions are listed in the following table:

Location	Component	Intrusion	Direction
Front row, left third	Left A-pillar	29 cm (11.4 in)	Vertical
	Roof side rail	32 cm (12.6 in)	Vertical
	Roof top	26 cm (10.2 in)	Vertical
Front row, center third	Windshield header	32 cm (12.6 in)	Vertical
	Roof top	19 cm (12.6 in)	Vertical
Front row, right third	Right A-pillar	9 cm (7.5 in)	Vertical
	Roof side rail	13 cm (5.1 in)	Vertical
	Windshield header	32 cm (12.6 in)	Vertical
Second row, left third	Left B- pillar	31 cm (12.2 in)	Vertical
	Left C-pillar	11 cm (4.3 in)	Vertical
Second row, right third	Right B- pillar	15 cm (5.9 in)	Vertical
	Right C- pillar	13 cm (5.1 in)	Vertical

Manual Restraint Systems

The driver's manual restraint was a 3-point lap and shoulder safety belt that consisted of continuous loop webbing, a sliding latch plate, an adjustable D-ring and an Emergency Locking Retractor (ELR). The position of the D-ring could not be determined due to on-scene extrication damage of the Saturn's pillars. Both front row retractor mounted pretensioners actuated as a result of the crash. At initial examination, the retractor was locked with the belt webbing extended from a worn position. The latch plate revealed historical evidence of use and the friction surface exhibited abrading to its full width as a result of the webbing being loaded by its occupant. The total length of exposed belt webbing measured 168 cm (66.1 in) from the lower anchor to the D-ring.

The second row left manual restraint was a 3-point lap and shoulder safety belt that consisted of continuous loop webbing, a sliding latch plate, a nonadjustable D-ring and a switchable ELR/ALR. A backless booster CRS was also located within this seating position. At initial examination, the retractor was locked with the belt webbing extended in a used position. The retractor was locked due to deformation of the C-pillar. The webbing was cut 102 cm (40.2 in) above the lower. The total length of the exposed webbing measured 145 cm (57.1 in). The latch plate was still engaged within the buckle. Further examination of this component revealed historical evidence of use. The friction surface of the latch plate exhibited abrading to its full width as a result of the webbing being loaded by its occupant.

The second row right manual restraint was a 3-point lap and shoulder safety belt that consisted of continuous loop webbing, a sliding latch plate, a nonadjustable D-ring and a switchable ELR/ALR locking retractor in Emergency Locking Retractor (ELR) mode. A high back booster CRS was located within this seating position. At initial examination, the retractor was operational and the belt webbing was routed through the outboard belt guides of the CRS. Examination of the latch plate revealed indicators of historical use. The latch plate's friction surface contained no evidence of occupant loading. The position of the restraint was reconstructed during the SCI inspection. The upper portion of the webbing measured 73 cm (28.7 in) from the D-ring to the latch plate. The webbing's lower portion measured 62 cm (24.4) from the latch plate to the lower anchor. The total length of exposed belt webbing measured 135 cm (53.1 in). The lower outboard aspect of the webbing was blood soaked.

Air Bag System

The Saturn was equipped with the CAC frontal air bag system. The driver's air bag was located in the center of the steering wheel behind symmetrical I-configuration cover flaps, each measuring 10 cm x 12 cm (3.9 in x 4.7 in), width x height. The driver's air bag deployed as a result of the crash. The deployed air bag measured 45 cm (17.7 in) in diameter in its deflated state. This air bag contained two tethers located in the 3/9 o'clock sectors and one vent port located in the 12 o'clock sector. The face of the air bag was soaked with blood. There were no

other discernable contact points. The front right passenger air bag was a top-mount design located in the right aspect of the instrument panel. The deployment of this air bag was suppressed due to the unoccupied condition of the front right seat.

Event Data Recorder

The air bag system in the Saturn was controlled by an Air bag Control Module (ACM) that was located in the first row, under the rear aspect of the center console. The ACM controlled the diagnostic, sensing and deployment command functions of the air bag systems and had EDR capabilities. The EDR was imaged via the diagnostic link connector with Bosch's Crash Data Retrieval scan tool and software version 3.1. The imaged data has been reanalyzed and reported with the Crash Data Retrieval Tool software version 3.5.1.

The Saturn's EDR recorded one Non-Deployment event and one Deployment event pertaining to the impact dynamics of this crash. These events occurred on ignition cycle 4156 and the data was imaged on ignition cycle 4157. The image data indicated that the driver safety belt was buckled with a forward seat position at the time of the recorded events. The SIR warning lamp status was in the "Off" position. Based on the CDR data limitation definitions, it was determined that the Non-Deployment recorded event occurred first. It was theorized that the Non-Deployment event was related to the frontal impact with the tree stump and the Deployment event was related to the impact with the culvert wall. A field within the Deployment data indicated that the time between the events was 0.6 seconds. The data is attached to the end of this technical report as Attachment A.

Child Restraint Systems

Two child restraint systems were in use at the time of the crash and were still located within the second row of the Saturn at the time of the SCI inspection. **Figure 14** is a right lateral interior view of the vehicle's second row interior. The first CRS was identified as an Eddie Bauer, Auto Booster ™ backless booster seat with a labeled model number of "22828 SON". The 6-year-old female passenger, seated within the second row left seat position, occupied this CRS at the time of the crash. The second CRS was identified as a Graco, TurboBooster ™ high-back booster seat with a labeled model number of "8693 GLY". The 4-year-old male passenger, seated within the second row right seat position, occupied this CRS at the time of the crash. Both CRS's were removed from the Saturn for further SCI inspection.

Figure 14: Right lateral interior view of the Saturn depicting the position of the CRS's.

The Eddie Bower backless CRS (**Figure 15**) was manufactured on June 21, 2007 and consisted of a single black plastic shell base with adjustable plastic armrests. The CRS was labeled for use by children over 1 year of age with a height of 109 to 145 cm (43 to 57 in) and weight of 18 to 45 kg (40 to 100 lb) and were to utilize the vehicle's 3-point lap and shoulder belt. The base was covered with a quilted brown and tan fabric cover, which was held in place with two posterior mounted bilateral elastic bands. The seat cover contained dirt and blood stains to its forward aspect. The left plastic armrest was also soiled with dirt and exhibited scuff marks. The CRS appeared to be structurally intact while maintaining its symmetrical shape; however, once the seat cover was removed the left armrest was found to be slightly deformed and separated from the plastic base (**Figure 16**), which indicated that the occupant loaded the CRS during the crash sequence.

Figure 15: Front view of the Eddie Bauer backless CRS used by the 6-year-old female in the second row left position.

Figure 16: Overhead view of the CRS depicting the loading evidence to the left arm rest.

The Graco high-back CRS (**Figure 17**) was manufactured on November 8, 2006. This CRS was designed with a detachable back support and could be used in the high-back or backless mode. The CRS was labeled for use by children from 3 to 10 years of age with the high-back in use and from 4 to 10 years of age without the back support. The child utilized the vehicle's 3-point lap and shoulder belt for restraint. With the high-back in use, the CRS was rated for a child with a height of 97 to 145 cm (38 to 57 in) and a weight of 14 to 45 kg (30 to 100 lb).

The CRS appeared to be structurally undamaged at initial inspection. The seat cover and padded armrests of the CRS contained dirt and blood stains. However, once the fabric coverings were removed the styro-foam insert in the upper aspect of the high-back exhibited bilateral vertical cracks (**Figure 18**), which separated this component into three separate pieces. Additionally, light discolorations in the upper plastic shell were observed, which indicated that the plastic material had been subjected to loading. Further, it was determined that the hinge system connecting the back support to the base was deformed and disjointed from the same impact

forces. A scuff mark to the fabric covering at the outboard wing of the back support was also identified. The damage to the CRS was directly associated to the vertical intrusion of the roof and right side rail during the crash.

Figure 17: Front view of the Graco high-back CRS used by the 4-year-old male in the second row right position.

Figure 18: View of the damaged styro-foam insert within the upper back of the Graco CRS.

Driver Demographics

Age/Sex:	35-year-old/Male
Height:	Unknown
Weight:	Unknown
Seat Track Position:	Mid-to-forward track position.
Safety Belt Usage:	3-point safety belt
Usage Source:	SCI vehicle inspection, EDR image
Egress from Vehicle:	Exited under own power
Type of Medical Treatment:	Transported to trauma center; hospitalized 4 days

Driver Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
Unknown head injury	Unknown (115099.7,0)	Front header

Injury Source: Police report. The medical records were not available.

Driver Kinematics

The 35-year-old male driver of the Saturn was seated in a mid-to-forward track position and was restrained with the available 3-point safety belt system. For unknown reasons, the driver allowed the vehicle to depart the right side of the road precipitating the crash sequence.

As the Saturn vaulted, its front end pitched down as it rotated about its lateral axis. The safety belt system's ELR locked belt webbing. The driver responded to the vehicle's inverted condition by loading the locked 3-point safety belt system with his left shoulder, chest and pelvis. While the Saturn was airborne, with an attitude past vertical, the hood, windshield and A-pillar area contacted the concrete culvert wall. The force of this impact buckled the pillars and deformed the roof structure vertical down. The driver responded with a vertical trajectory (with respect to the vehicle) and impacted the intruding roof. During the SCI vehicle inspection, contact points consisting of compression-type transfer marks and scuff marks were identified to the left front headliner. These contacts, in conjunction with the post-crash position of the Saturn's intruded roof structure, indicated that the driver probably sustained a combination of blunt force head injuries. The driver was rendered unconscious by the impact.

After maximum engagement with the concrete culvert wall and surrounding terrain, the Saturn rotated back onto its wheels and rolled to final rest as the driver rebounded into his original seating position.

An unknown length of time after the crash, the injured driver regained consciousness, exited the vehicle and searched for his cellular phone. He called the emergency response system and the police and medical services responded to the crash site. Following their arrival, the driver was then transported to a local trauma center where he was hospitalized 4 days.

Second Row, Left Passenger Demographics

Age/Sex:	6-year-old/Female
Height:	117 cm (46 in)
Weight:	21 kg (47 lbs)
Seat Track Position:	Not adjustable
Safety Belt Usage:	3-point safety belt
Usage Source:	SCI vehicle inspection
Egress from Vehicle:	Removed by EMS
Type of Medical Treatment:	None, fatal at scene

Second Row, Left Passenger Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
Brain avulsion from a 13 cm laceration on the right temporal scalp	Severe (140688.4, 1)	Left roof side rail
15 cm open skull fracture along the right frontal and right temporal bones	Severe (150406.4, 1)	Left roof side rail
4 cm abrasion on the mid forehead	Minor (290202.1, 7)	Left roof side rail
5 cm abrasion on the left cheek	Minor (290202.1, 2)	Left rear window sill
3 linear abrasions (3 mm) on the mid upper lip	Minor (290202.1, 8)	Left rear window sill
Laceration on the upper frenulum with hemorrhage about the gums	Minor (243204.1, 8)	Left rear window sill
1 cm abrasion on the upper to mid left shoulder (above the clavicle)	Minor (790402.1, 2)	Safety belt webbing
6 mm abrasion on the ventro-medial aspect of the right knee	Minor (890402.1, 1)	Posterior aspect of the driver seatback

Source –External Autopsy Records

Second Row, Left Passenger Kinematics

The 6-year-old female was seated in a backless booster CRS, located in the left position of the second row split bench seat. The CRS was an appropriate seat considering the age, height and weight of the child. This passenger was restrained with the vehicle's available 3-point safety belt system which was routed around the CRS.

The Saturn vaulted and pitched down (end-over-end) as it rotated about its lateral axis. The non-horizontal orientation of the vehicle caused the retractor to lock the safety belt. This occupant responded to the vehicle's inverted condition by loading the locked belt system.

The Saturn impacted the culvert wall with its hood, windshield and A-pillars. This impact crushed the forward aspect of the roof down. The vehicle then continued to pitch (end-over-end) about the edge of the culvert wall. The Saturn's roof and trunk then impacted the ground. The roof crushed down approximately to the level of the beltline. As the roof crushed, the passenger's head was partially ejected through the left rear door window opening. It was impacted by the left roof side rail resulting in multiple head, brain and facial injuries from contact with the left roof side rail and left rear window sill. She sustained an open skull fracture along the right frontal and right temporal bones. The impact forces which produced this injury

also facilitated a brain avulsion from a laceration on the right temporal scalp which was located directly over the skull fracture.

During the SCI vehicle inspection, a compression type transfer mark consisting of blood and underlining scuffs were identified to the left rear headliner, which covered the metal and rubber gasket portion of the left roof side rail. A semi-circle deformation of the metal roof side rail was located directly above the blood transfer mark (**Figure 19**). Multiple long hair strands were found to be embedded in the second row left roof side rail. Additional long hair strands were discovered on the left C-pillar and left side of the backlight shelf.

Figure 19: Depicts the headliner and roof side rail contact points associated with the second row left side occupant

The child sustained abrasions to her mid forehead, left cheek, and mid-upper lip attributed to contact with the window sill. The mid left shoulder abrasion was attributed to safety belt loading. An abrasion to ventro-medial aspect of her right knee was attributed to the driver seat back. A self-inflicted oral injury consisting of a laceration on the upper frenulum with hemorrhage about the gums was also reported.

After maximum engagement with the surrounding terrain, the Saturn rotated back onto its wheels and rolled to final rest as this occupant rebounded into her original seating position. This occupant was removed from the Saturn in an expired condition following the crash. Based on the external-only autopsy conducted by the Medical Examiner (ME), the cause of death was attributed to blunt force head trauma sustained during the crash.

Second Row, Right Passenger Demographics

Age/Sex:	4-year-old/Male
Height:	107 cm (42 in)
Weight:	19 kg (42 lbs)
Seat Track Position:	Not adjustable
Safety Belt Usage:	3-point safety belt routed through CRS
Usage Source:	SCI vehicle inspection
Egress from Vehicle:	Removed by EMS
Type of Medical Treatment:	None, Fatal at scene

Second Row, Right Passenger Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
Open radius fracture of the left forearm	Serious (752804.3, 2)	Right side roof area
Open ulna fracture of the left forearm	Serious (753204.3, 2)	Right side roof area
Skull fracture of the frontal bone, NFS	Moderate (150400.2, 5)	Right side roof area
2 lacerations (6 mm) on the frontal scalp	Minor (190602.1, 5)	Right side roof area
3 cm contusion on the upper lateral left chest wall	Minor (490402.1, 2)	3-point safety belt system

Source –External Autopsy Records

Second Row, Right Passenger Kinematics

The 4-year-old male was seated in a high-back booster CRS, located in the right position of the non-adjustable second row split bench seat. Based on the child's age height and weight, the CRS was an appropriate selection for use. This occupant was restrained with the vehicle's available 3-point safety belt system, which was routed through the CRS belt positioning channels and around the occupant. The vault and subsequent pitch over (end-over-end) of the Saturn caused the safety belt retractor to lock the belt system. This occupant responded to the vehicle's inverted condition by loading the 3-point safety belt system.

The Saturn impacted the culvert wall with its hood, windshield and A-pillars. This impact crushed the forward aspect of the roof down. The vehicle then continued to rotate (end-over-end) about the edge of the culvert wall and the Saturn's roof and trunk impacted the ground. The roof crushed down approximately to the level of the beltline and impacted the top right aspect of the CRS. The foam insert of the CRS was fractured and the back support was loaded. The child responded with a vertical trajectory and also impacted the roof. His contact to the roof resulted in the skull fracture and scalp lacerations.

During the SCI vehicle inspection, multiple scuff marks were identified to the right rear headliner (**Figure 20**). CRS damage consisting plastic stress marks and fractures in the styro-foam insert were attributed to a combination of vertical loading of the CRS by the intruding roof in conjunction with loading contact from this occupant. It was also concluded that the open radius and ulna fractures of the left forearm were most likely attributed to the intruding roof structure. As the roof intruded into the greenhouse area, this occupant may have raised his hands in a bracing motion. The downward force of the intrusion may have loaded this occupant's left

palm or hand area, which caused the left radius and ulna to fracture in a manner that produced an open laceration above the break.

After maximum engagement with the surrounding terrain, the Saturn rotated (end-over-end) back onto its wheels and rolled to final rest as this occupant rebounded into his original seating position. This occupant was also fatally injured prior to being removed from the Saturn. Based on the ME's external autopsy, the cause of death was attributed to blunt force head injuries sustained in the crash.

Figure 20: Depicts the headliner contact points associated with the second row right side occupant

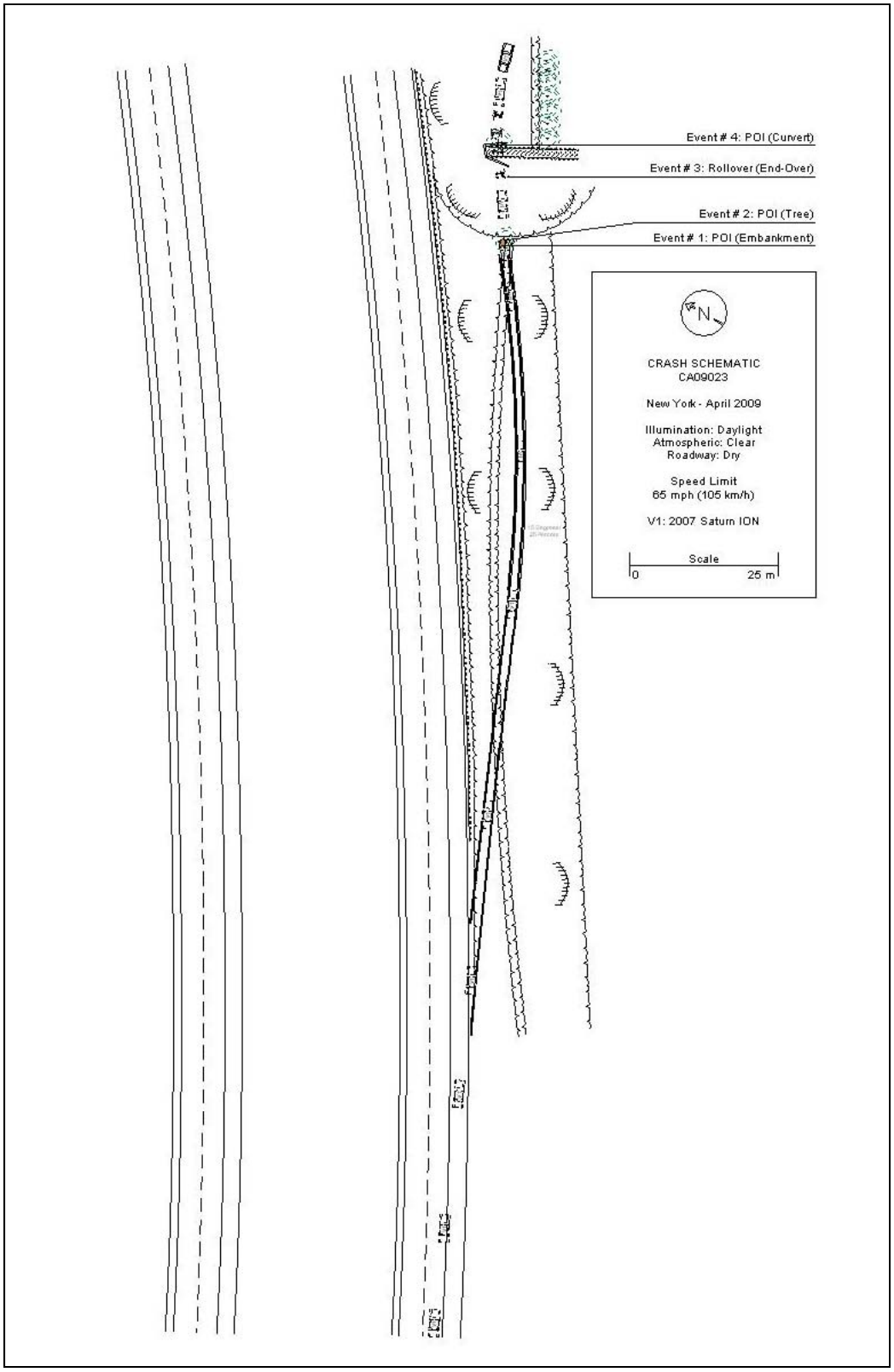


Figure 21: Crash schematic.

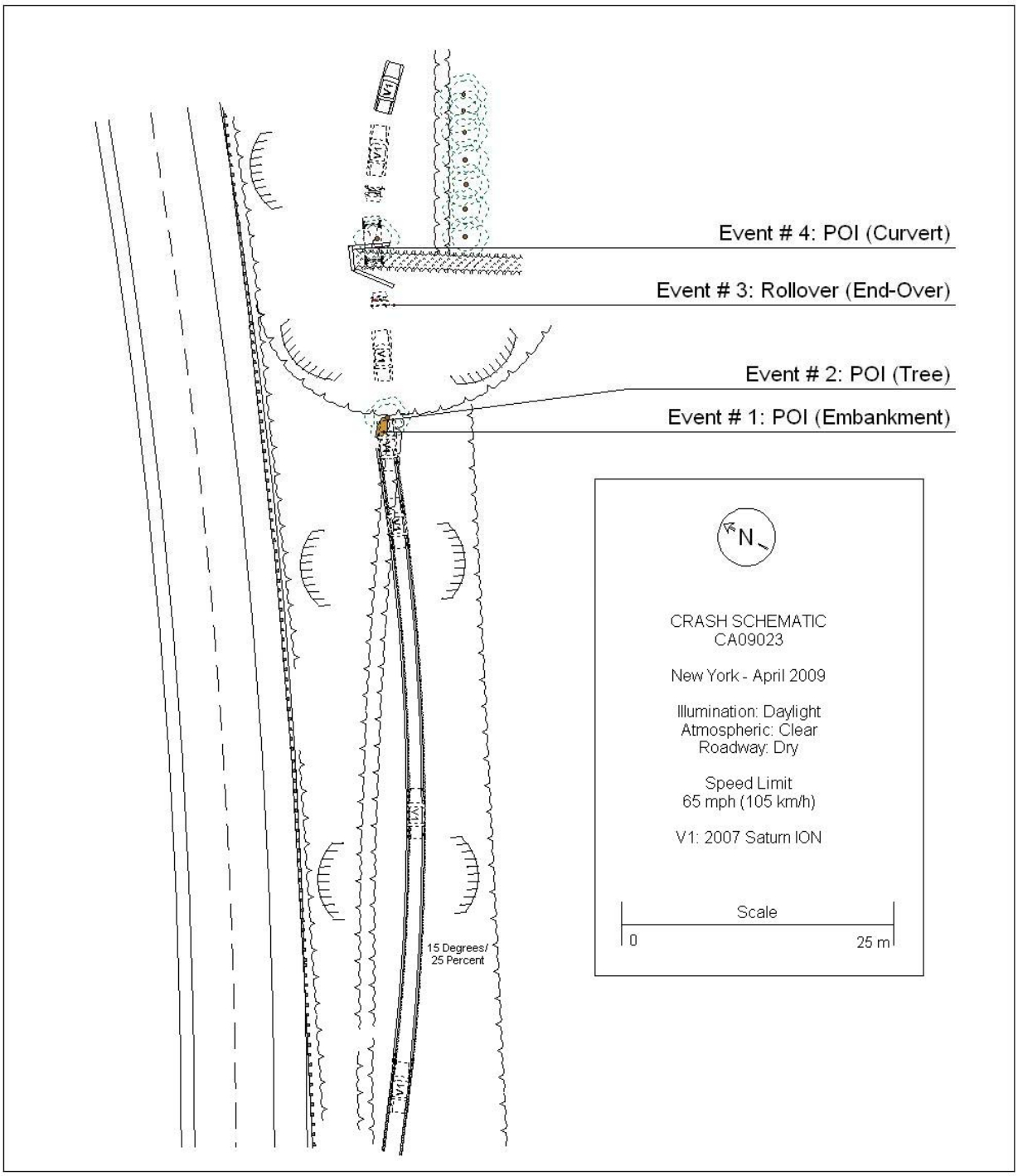


Figure 22: Enlarged view of the Crash Schematic.

ATTACHMENT A:

2007 Saturn ION 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	1G8AJ55F27Z******
User	
Case Number	
EDR Data Imaging Date	
Crash Date	
Filename	
Saved on	
Collected with CDR version	Crash Data Retrieval Tool 3.1
Reported with CDR version	Crash Data Retrieval Tool 3.5.1
EDR Device Type	airbag control module
Event(s) recovered	Deployment Non-Deployment

Comments

Through DLC

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 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 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.

-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. Depending on vehicle option content, the Brake Switch Circuit Status data may not be available.
-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.

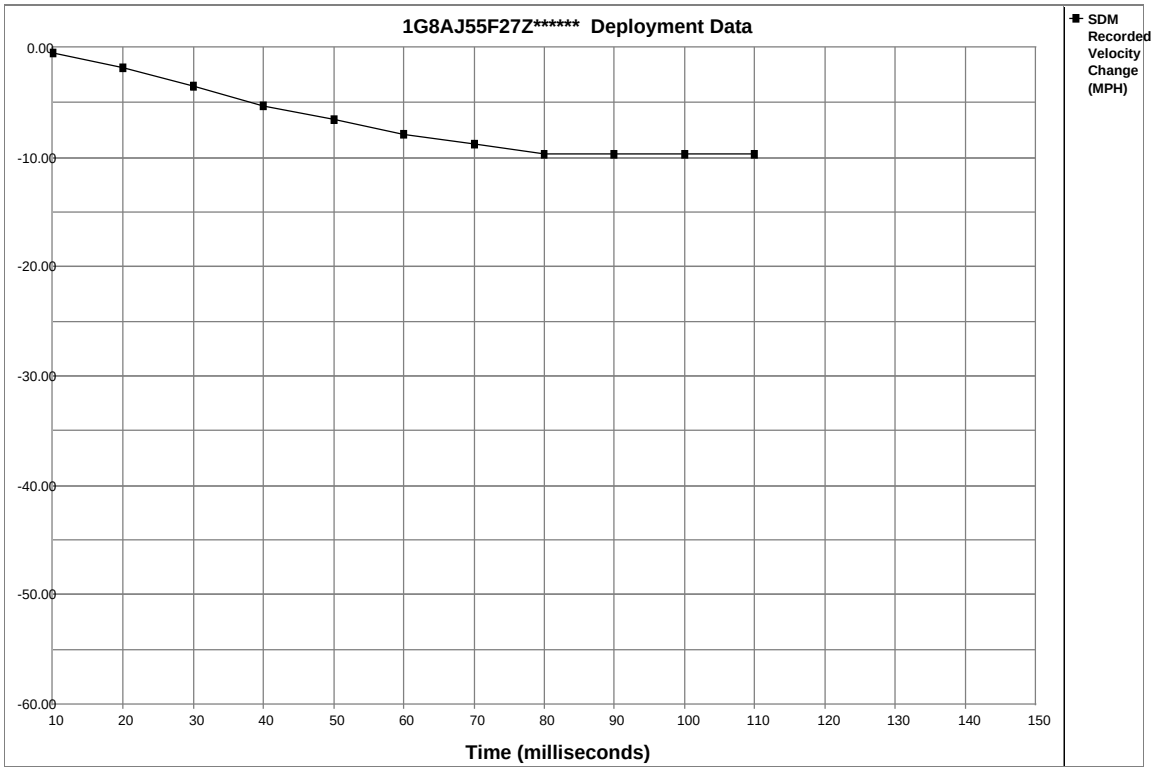
01014_SDMDW_r002

System Status At Deployment

SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	BUCKLED
Passenger Belt Switch Circuit Status (If Equipped)	UNBUCKLED
Driver Seat Position Status (If Equipped)	Forward
Passenger Seat Position Status (If Equipped)	Forward
Passenger SIR Suppression Switch Circuit Status (if equipped)	Air Bag Not Suppressed
Ignition Cycles At Deployment	4156
Ignition Cycles At Investigation	4157
Maximum SDM Recorded Velocity Change (MPH)	-9.78
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	107.5
Driver 1st Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	12.5
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)	12.5
Passenger 2nd Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	N/A
Time Between Non-Deployment And Deployment Events (sec)	.6
Event Recording Complete	Yes

Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle
-5	71	2496	0
-4	71	2496	0
-3	68	3072	0
-2	65	3200	0
-1	65	5056	0

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



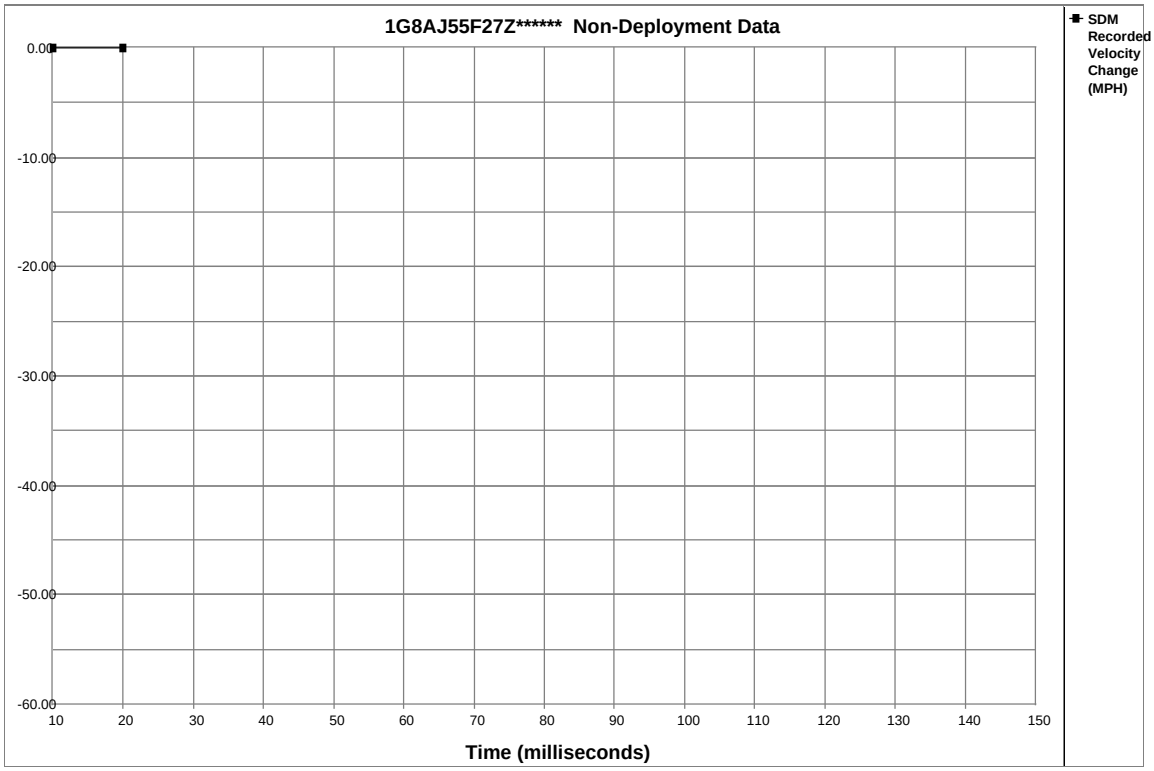
Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
SDM Recorded Velocity Change	-0.44	-1.76	-3.51	-5.27	-6.58	-7.90	-8.78	-9.65	-9.65	-9.65	-9.65	N/A	N/A	N/A	N/A

System Status At Non-Deployment

SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	BUCKLED
Passenger Belt Switch Circuit Status (If Equipped)	UNBUCKLED
Driver Seat Position Status (If Equipped)	Forward
Passenger Seat Position Status (If Equipped)	Forward
Passenger SIR Suppression Switch Circuit Status (if equipped)	Air Bag Not Suppressed
Ignition Cycles At Non-Deployment	4156
Ignition Cycles At Investigation	4157
Maximum SDM Recorded Velocity Change (MPH)	-0.01
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	45
A Deployment was Commanded Prior to this Event	No
Event Recording Complete	No

Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle
-5	71	2496	0
-4	71	2496	0
-3	71	2496	0
-2	71	2496	0
-1	71	2496	0

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



Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
SDM Recorded Velocity Change	0.00	0.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A