CRASH DATA RESEARCH CENTER

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CALSPAN ON-SITE CHILD SAFETY SEAT CRASH INVESTIGATION

CASE NO: CA04-054

VEHICLE: 2003 SATURN ION

LOCATION: NEW YORK

CRASH DATE: NOVEMBER 2004

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

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

TECHNICAL REPORT STANDARD TITLE PAGE

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CALSPAN ON-SITE CHILD SAFETY SEAT CRASH INVESTIGATION
CASE NO.: CA04-054
LOCATION: STATE OF NEW YORK
VEHICLE: 2003 SATURN ION
CRASH DATE: NOVEMBER 2004

BACKGROUND

This on-site investigation focused on the performance of a rear-facing convertible Child Safety Seat (CSS) that was installed in the right rear position of a 2003 Saturn Ion. A booster CSS was present in the rear left position of the Ion, but was unoccupied at the time of the crash. The Saturn Ion **(Figure 1)** was occupied by a 30-year-old female restrained driver and a 9-month-old male rear right passenger, restrained in the rear-facing CSS. The CSS was installed with the Lower Anchors and Tethers for Children (LATCH) system and the CSS tether was attached to the lower aspect of the right rear seat cushion frame. The vehicle's manual 3-point lap and shoulder belt was also routed through the rear-facing belt path and used in addition to the LATCH system to secure the CSS. The Ion was struck on the right side aspect by a 2001 Freightliner straight tanker truck in an intersection at a right angle configuration. The impact resulted in sufficient longitudinal deceleration of the Saturn to command the deployment of the frontal air bag system. The Saturn was deflected laterally across the intersection and sustained moderate right side damage. The driver of the Saturn sustained a police reported head injury, unspecified internal injuries, and an unspecified contusion. She was transported by ambulance to a regional trauma center and admitted for treatment. The 9-month-old child remained in the CSS and did not sustain injury. He was transported by ambulance in the CSS to a regional children's hospital for evaluation and released. The driver of the truck was not injured and the truck was driven from the crash scene.

Figure 1. Damaged 2003 Saturn Ion

The Special Crash Investigations team at Calspan was notified of this crash by a local police department on December 1, 2004. The notification was forwarded to the Crash Investigation Division of the National Highway Traffic Safety Administration (NHTSA) and an on-site investigation was assigned December 2, 2004. Cooperation with the investigating police agency was established and the Saturn and CSS were immediately made available for inspection. The Freightliner truck was under repair and was not inspected.

SUMMARY

Vehicle Data – 2003 Saturn Ion

The 2003 Saturn ION was identified by the Vehicle Identification Number (VIN): 1G8AL52F33Z (production sequence omitted). The vehicle's odometer could not be read, as there was no power to the instrument panel when power was applied to the vehicle. The Saturn was a Level 3 four-door sedan that was equipped with a 2.2 liter, four-cylinder engine, traction control, an automatic five-speed transmission, front disc/rear drum power brakes with ABS,

daytime running lights, power steering, and a tilt-steering wheel. The Ion was configured with Firestone Firehawk GTA P205/55R16 tires. The manufacturer's recommended tire pressure was unknown. The specific tire information is as follows:

Position	Measured Pressure	Measured Tread Depth	Restricted	Damage
LF	Unknown	3 mm (4/32")	No	None
LR	134 kpa (19.5 psi)	5 mm (7/32")	No	None
RF	131 kpa (19.0 psi)	2 mm (3/32")	No	Laceration in sidewall
RR	134 kpa (19.5 psi)	5 mm (7/32")	No	None

The seating in the Saturn Ion was configured with front bucket seats with adjustable head restraints and a rear bench seat with a folding back. The driver's seat was located 9 cm (3.5") rear of the full-forward position and 14 cm (5.5") forward of the full-rear position and the head restraint was adjusted 7 cm (3.0") above the seat back. The front right seat was located at the mid-track position, 11 cm (4.5") rear of full-forward and 11 cm (4.5") forward of full-rear. The front right passenger's head restraint was adjusted 4 cm (1.8") above the seat back.

Vehicle Data – 2001 Freightliner Tanker Truck

The Freightliner truck was identified by the VIN on the police report: 1FVABTBV41DH (production sequence omitted). The vehicle was under repair and was not available for inspection. The truck was a Freightliner FL-70, 4 x 2 chassis that was configured with a conventional cab and a 442 cm (174") wheelbase. The truck was configured with a 7,500 liter (2,000 gallon) storage tank that measured approximately 495 cm (195") in length, and equipped with a rear-mounted pump and hose reel. The truck was carrying windshield washer fluid, classified as a non-polar/water-immiscible flammable liquid. The owner estimated that the storage tank was approximately 75 percent full of fluid at the time of the crash but could not provide the weight of the unloaded truck. The unloaded weight of the truck was estimated to be 5,900 kg (13,000 lb). The weight of the fluid cargo was estimated to be similar to water at 1 kg per liter (8 pounds per gallon), and at 75 percent capacity, weighed approximately 5,400 kg (12,000 lb). The total loaded truck weight was estimated to be approximately 11,400 kg (25,000 lb) at the time of the crash. A photograph of an exemplar tank truck obtained from an Internet website is shown in **Figure 2**.

Figure 2. Exemplar tank truck

Crash Site

This two-vehicle crash occurred at a four-leg intersection of two state roadways in November 2004. At the time of the crash, there were no adverse weather conditions and the asphalt roadway surface was dry. The north/south roadway was configured with two lanes in each direction that were separated by a double-yellow painted centerline. The roadway widened at the north and

south legs of the intersection to accommodate center left turn lanes, and painted white arrows identified the left/right turn and through lanes. The east/west roadway was configured with four lanes in each direction that were separated by a raised concrete median. The median narrowed on approach to the intersection to accommodate left turn lanes. Traffic flow through the intersection was controlled by overhead three-phase traffic signals. Each left turn lane (all intersection legs) was also controlled by a separate three-phase left turn signal. The posted speed limit for the north/south roadway was 48 km/h (30 mph) and the posted speed limit for the east/west roadway was 64 km/h (40 mph). The scene schematic is included as **Figure 18** at the end of this narrative report.

Crash Sequence

Pre-Crash

The 2003 Saturn Ion was traveling in the outboard northbound lane through the four-leg intersection. The 30-year-old female driver of the Saturn brought the vehicle to a controlled stop at the intersection as the traffic signal for northbound traffic was in the red phase **(Figure 3)**. She proceeded into the intersection as the traffic signal cycled to the green phase, evidenced by the steady increase in pre-crash vehicle speed, throttle position, and engine speed that was reported in the EDR summary. The 43-year-old male driver of the Freightliner tank truck was operating the vehicle in the inboard westbound lane **(Figure 4)**. The truck's pre-crash speed was unknown. As the Saturn traversed the four eastbound lanes, she may not have seen the approaching truck if traffic was stopped in the westbound left turn lane, or may have seen the truck but anticipated the driver would bring the truck to a controlled stop. For unknown reasons, the driver of the tank truck proceeded into the intersection against the red traffic signal. When the driver of the Saturn detected the approaching truck, she applied the brakes. The EDR-reported speed one second prior to impact was 35 km/h (22 mph). Brake application was based on the EDR pre-crash data, which showed the brake switch circuit status as "on", one second prior to impact. Although police reported that the driver of the tank truck applied the brakes in full-lockup prior to impact, which resulted in approximately 2 m (6') of pre-impact tire marks in the travel lane, there was no evidence present during the SCI scene documentation.

Figure 3. Northbound approach for the 2003 Saturn Ion

Figure 4. Westbound approach for the 2001 Freightliner truck

Crash

The front of the Freightliner truck struck the right side aspect of the Saturn in the passenger area. The impact severity was moderate, and resulted in the deployment of the frontal air bag system in the Saturn. The EDR-reported longitudinal delta-V was -16 km/h (–10.49 mph), 130

milliseconds into the crash. The barrier routine of the WinSMASH program computed a total delta-V of 38 km/h (21.7 mph), based on the Saturn Ion's right side crush profile. The longitudinal and lateral components were –7 km/h (-3.8 mph) and –37 km/h (-21.4 mph), respectively. The Saturn was redirected laterally across the intersection and came to rest approximately 11 m (35') northwest of the point of impact. The final rest of the tank truck was not documented at the time of the crash, and the driver of the truck drove the vehicle out of the intersection after the crash.

Post-Crash

The driver of the Saturn sustained a police-reported head injury and was unconscious at the scene. The 9-month-old child did not sustain visible injury. Rescue personnel removed the left side doors and left B-pillar to remove both occupants of the Saturn. The driver was transported by ambulance to a regional trauma center and admitted for treatment. The 9-month-old child was removed from the vehicle in the CSS, which was used for immobilization. He was transported by ambulance to a regional children's hospital for evaluation and released. The driver of the truck was not injured and did not receive medical treatment. The Saturn Ion was towed from the scene and the truck was driven from the scene.

Vehicle Damage

Exterior Damage – 2003 Saturn Ion

The 2003 Saturn Ion sustained moderate right side damage as a result of the impact with the large truck **(Figure 5)**. The direct damage began 51 cm (21.3") forward of the right rear axle, extended 228 cm (89.8") forward along the right side plane, and terminated 20 cm (8.0") forward of the right front axle. The maximum lateral crush was located 156 cm (61.3") forward of the right rear axle and measured 43 cm (17.0") at the mid-door level. A rubber scuff mark was present 64 cm (25.0") forward of the right rear axle from direct contact with the front left tire of the truck. The composite body panels on the right side doors and right front fender sustained multiple fractures as a result of the impact. Both right side doors were deformed and jammed shut. The direct contact damage extended vertically to the upper aspect of the right side door frames, below the right roof side rail, which was supported by the approximate height of 145 cm (57") of the front hood of the tank truck. The combined direct and induced damage began 18 cm (7.0") forward of the right rear axle, extended 262 cm (103.0") forward, and terminated 20 cm (8.0") forward of the right front axle **(Figure 6)**. The front aspect of the right sill was rotated inward and displaced vertically. The right roof side rail sustained induced lateral crush as a result of the right side door and B-pillar crush.

Figure 5. Right side damage

Figure 6. Lateral view of right side crush profile

The composite trim on the forward aspect of the roof side rail and the right A-pillar was fractured and separated. The windshield header and roof sustained lateral buckling and the windshield was fractured from impact forces. There was no reduction of the right side wheelbase. Six crush measurements were documented at the mid-door level as follows: C1 = 2 cm (0.8”), C2 = 8 cm (3.0”), C3 = 35 cm (13.6”), C4 = 34 cm (13.5”), C5 = 22 cm (8.8”), C6 = 11 cm (4.5”). The Collision Deformation Classification (CDC) for the impact with the truck was 03-RYAW-3.

Figure 7. Left side view showing damaged left front wheel

The left front spindle fractured and separated as a result of the lateral friction from the post-impact travel across the intersection. The suspension components remained intact, but the left front wheel collapsed during the post-impact travel **(Figure 7)**. The inboard edge of the alloy wheel also sustained a gouge.

Interior Damage – 2003 Saturn Ion

The 2003 Saturn Ion sustained moderate interior damage as a result of passenger compartment intrusion. The right side doors, B-pillar, and roof side rail sustained lateral intrusion. As a result of the lateral intrusion, the front right seat cushion and seat back were compressed 6 cm (2.5”) laterally. The rear right seat cushion and seat back sustained minimal deformation, as the intrusion was primarily forward of the rear seat.

Figure 8. View of damaged instrument panel

The driver’s knee bolster exhibited faint scuff marks on the left aspect, although it could not be confirmed if they were related to occupant contact. The center instrument panel trim was separated and the rear view mirror deflected counterclockwise (CCW) against the windshield. The right and center aspects of the instrument panel were fractured, deformed, and deflected left due to the intrusion of the left front door **(Figure 8)**. The right interior door panel was fractured and partially separated.

The specific passenger compartment intrusions were documented as follows:

Position	Intruded Component	Magnitude of Intrusion	Direction
FR	Right front door interior	32 cm (12.8”)	Lateral
FR	Right front armrest	24 cm (9.5”)	Lateral
FR	Right A-pillar	7 cm (3.0”)	Lateral
FR	Right B-pillar	22 cm (8.5”)	Lateral
FR	Roof side rail	20 cm (8.0”)	Lateral

Position	Intruded Component	Magnitude of Intrusion	Direction
RR	Right B-pillar	22 cm (8.5”)	Lateral
RR	Right rear door interior (forward aspect at beltline)	24 cm (9.3”)	Lateral
RR	Right rear door interior panel (at CSS seatback, below beltline)	13 cm (5.0”)	Lateral
RR	Right C-pillar	3 cm (1.0”)	Lateral
RR	Right roof side rail	8 cm (3.0”)	Lateral

The right rear door interior sustained minor damage as a result of the engagement against the right aspect of the rear-facing CSS due to the lateral intrusion **(Figure 9)**. A vertically oriented scuffmark with impression that measured 15 cm (6.0”) in height and 3 cm (1.0”) in width, began 3 cm (1.0”) above the armrest and 5 cm (2.0”) rear of the forward aspect of the armrest. A 4 cm (1.5”) vertical scuffmark from engagement with the CSS was present 5 cm (2.5”) below the top aspect of the interior door panel and 15 cm (5.8”) rear of the forward aspect of the door. A 8 cm (3.0”) semi-circular black transfer was present on the apex of the top door panel (at the beltline) and located 42 cm (16.5”) rear of the forward edge of the door. Based on the rear-facing orientation of the CSS, it was not likely a result of contact with the CSS.

Figure 9. View of damaged right rear door and intrusion

Manual Restraints – 2003 Saturn Ion

The 2003 Saturn Ion was configured with manual 3-point lap and shoulder belts for each seating position. Both front seat safety belts were equipped with retractor pretensioners and adjustable D-rings that were in the full-down positions. The driver’s safety belt was configured with a sliding latch plate and an Emergency Locking Retractor (ELR). At the time of the vehicle inspection, the driver’s retractor was restricted in the used position as a result of pretensioner actuation. Rescue personnel had cut the webbing. The cut section of webbing measured 169 cm (66.5”) in length from the lower anchor **(Figure 10)**. A linear plastic transfer from the plastic-covered latch plate was located 85 cm (33.5”) above the lower anchor and extended across the entire width of the webbing. The residual length of webbing that extended from the locked retractor measured 43 cm (17.0”). Although the driver’s D-ring did not exhibit abrasions, the bottom aspect sustained two areas that were “polished” from probable engagement with the shoulder belt webbing. The driver’s plastic-covered latch plate sustained abrasions from the loading of the driver.

Figure 10. View of cut driver's safety belt

The remaining safety belts were configured with sliding latch plates and switchable ELR/Automatic Locking Retractors (ALR). Labels were present on each of the safety belts identifying the switchable ELR/ALR retractors. The front right safety belt was restricted in the stowed position at the time of the inspection due to probable pretensioner actuation and intrusion.

The rear left safety belt was used to secure an unoccupied forward-facing booster CSS. The safety belt was found in the stowed position with a locking clip installed adjacent to the latch plate at the time of the vehicle inspection. The booster CSS was not with the vehicle. Lateral creases in the webbing from engagement with the booster CSS belt path were located at the following positions from the lower anchor: 16 cm (6.5”), 22 cm (8.5”), 50 cm (19.5”), 52 cm (20.5”). The locking clip was positioned 55 cm (21.5”) above the lower anchor. A faint body fluid (blood) transfer that measured 1 cm (0.4”) in diameter was present on the safety belt webbing 95 cm (37.3”) above the lower anchor. The source of the transfer was not known. The location of the transfer supported the fact that the safety belt was extended to install the unoccupied booster seat at the time of the crash.

Figure 11. Rear left safety belt

The rear right safety belt was found extended at the time of the vehicle inspection **(Figure 12)**. Based on the inspection of the belt, it appears that it was used in addition to the LATCH system to restrain the rear-facing convertible CSS. A lateral crease in the webbing was located 34 cm (13.5”) from the lower anchor from the sliding latch plate. Based on the position of the latch plate, the lap belt webbing measured 34 cm (13.5”) in length from the lower anchor, and the shoulder belt measured 104 cm (43.8”) between the latch plate and the belt exit on the rear package shelf.

Figure 12. Rear right safety belt as found during the vehicle inspection

Supplemental Restraint System – 2003 Saturn Ion

The 2003 Saturn Ion was equipped with dual-stage frontal air bags and safety belt retractor pretensioners for the driver and front right passenger positions. The frontal air bags and safety belt pretensioners deployed as a result of the longitudinal deceleration of the Saturn during the impact with the truck. The EDR summary indicated that a single stage deployment for both frontal air bags was commanded 32.5 milliseconds after algorithm enable. Although the EDR summary did not provide pretensioner information, based on the restricted nature of both frontal retractors, it was probable that both retractor pretensioners fired in conjunction with the frontal deployment.

The driver's air bag deployed from the center of the steering wheel hub through symmetrical H-configuration module cover flaps. Each flap measured 13 cm (5.3") in height and 9 cm (3.5") in width. The deployed driver's air bag **(Figure 13)** measured 53 cm (21.0") in diameter in its deflated state. The air bag was tethered by two internal straps that measured 13 cm (5.0") in width and were located at the 12 and 6 o'clock aspects of the air bag. The tethers were attached to a 17 cm (6.5") diameter circular stitch in the center of the air bag face. Two circular vent ports that measured 3 cm (1.0") in diameter were located at the 11 and 1 o'clock aspects on the rear of the air bag. A light circular body fluid (blood) transfer that measured 4 cm (1.5") was present on the air bag face. The transfer was located 5 cm (2.0") above the horizontal centerline and 8 cm (3.3") right of the vertical centerline.

Figure 13. Deployed driver's air bag

The front right passenger's air bag deployed from a top-mount module with a rectangular cover flap that was hinged at the forward aspect. The module cover flap measured 22 cm (8.8") in width and 14 cm (5.5") in height. The deployed front right passenger's air bag **(Figure 14)** measured 43 cm (17.0") in width and 38 cm (15.0") in height. The air bag was tethered by two internal straps that measured 13 cm (5.0") in width. The tether straps were fixed at the 3 and 9 o'clock aspects to a circular stitch pattern on the center aspect of the air bag that measured 13 cm (5.0") in diameter. Two circular vent ports that measured 5 cm (2.0") in diameter were located at the 3 and 9 o'clock aspects of each side panel of the air bag.

Figure 14. Deployed front right passenger's air bag

The driver and front right safety belt retractors were configured with ball-in-tube type pretensioners that fired as a result of the longitudinal deceleration of the Saturn during the crash.

Event Date Recorder – 2003 Saturn Ion

The Saturn Ion's EDR was downloaded by the SCI investigator and the EDR summary report is attached as **Attachment A** at the end of this narrative report. The system recorded a Deployment Event as a result of the longitudinal deceleration of the vehicle as it was impacted by the truck. The EDR reported the driver's belt switch circuit status as 'buckled', which was supported by the vehicle inspection.

Child Safety Seat

Graco Comfort Sport

A convertible Graco Comfort Sport CSS **(Figure 15)** was positioned in the rear right seat of the Saturn Ion. The model number was 8432 BLK and the date of manufacture was July 29, 2003. The convertible CSS was configured with a five-point harness system and a two-piece, locking harness retainer clip. The outboard side panels of the CSS extended 14 cm (5.5") forward of the CSS seat back, which provided lateral protection to the child. The CSS was also equipped with a leather pillow that was attached to the top aspect of the CSS seat back by a leather strip that closed with Velcro. The leather strap measured 3 cm (1.0") in width and 13 cm (5.0") in length. The pillow measured 15 cm (6.0") in height, 28 cm (11.0") in width, and 4 cm (1.5") in thickness. The CSS was rated for children who weighed between 2 and 18 kg (5 – 40 lb) and are between 48 and 102 cm (19 – 40") in height. The child's height was 71 cm (28") and his weight was 10 kg (22 lb), which was within the manufacturer's recommended height and weight guidelines. A label on the CSS outlined the recommended use of the CSS as follows:

Figure 15. Graco Comfort Sport Convertible CSS

Rear-facing 5-30 lbs (2 – 14 kg)

- Infants who weigh less than 20 lbs (9 kg) MUST be rear facing.

Forward facing 20 – 40 lbs (9-18 kg)

- Toddlers who weigh between 20 and 30 lbs (9 - 14 kg) and are at least one year old may be forward facing.
- Toddlers who weigh between 30 and 40 lbs (14 – 18 kg) and up to 40 in. (102 cm) tall MUST be forward facing.

At the time of the CSS inspection, the harness straps were routed through the second set of harness slots, consistent with rear-facing use. The harness retainer clip was positioned 9 cm (3.5") below the harness slots, which resulted in a remaining shoulder harness length of 17 cm (6.5") between the retainer clip and the CSS latch plates.

LATCH System

The Saturn Ion was equipped with LATCH anchors for each rear seating position. The anchors consisted of 3 mm (1/8") thick steel stock and were spaced 28 cm (11.0") apart at each seat position. Three tether anchors were present on the rear package shelf behind each seat position under plastic covers.

The CSS was configured with a LATCH lower attachment and a rear tether strap. The lower LATCH attachment measured 4 cm (1.5") in width and measured 106 cm (41.8") in total adjustment length. At the time of the vehicle inspection, the lower LATCH attachment was found adjusted to a length of 59 cm (23.3") between the outboard anchor and the locking

adjustment slide. Rescue personnel had cut the LATCH attachment webbing 5 cm (2.0”) above the adjustment slide. Multiple creases were present in the LATCH belt webbing from engagement against the outboard aspects of the CSS’s rear-facing belt path.

The CSS tether was permanently fixed to the rear aspect of the CSS. The tether was adjusted to a length of 41 cm (16.0”) between the top of the CSS seat back and the lower anchor hook. The tether was anchored to the bottom aspect of the rear seat cushion frame, which constituted a misuse, as the tether was not secured to a certified tether anchor in the vehicle.

CSS Installation

The CSS was installed in a rear-facing orientation, **(Figure 16)**, restrained by the vehicle’s lap and shoulder belt and LATCH attachment system, which was provided with the CSS. At the time of the vehicle inspection, the cut LATCH belt was still engaged with the anchors. The outboard aspect of the LATCH attachment was secured with the hook facing upward and the inboard aspect secured with the hook facing downward. In this orientation, the LATCH webbing exhibited one-half twist between the outboard aspect of the CSS and the outboard anchor. The Saturn’s manual 3-point lap and shoulder belt was utilized in addition to the LATCH system through the rear-facing belt path to restrain the CSS. It was unknown if the switchable retractor was engaged. The CSS was taken back to the subject vehicle in an attempt to replicate the CSS placement. These replication attempts using the LATCH installation resulted in an approximate 8 cm (3”) gap between the cut ends of the LATCH belt when pulled taut. Although not designed for rear-facing use, the CSS tether strap was attached to the bottom aspect of the rear right seat cushion frame. Based on the post-crash position of the CSS, it appeared that the tether strap may have been used to achieve the recommended 45 degree angle. Post-crash, the seat back angle measured approximately 65 degrees from horizontal when placed unrestrained on the rear right seat. Attempts to replicate the tether adjustment resulted in a 15 cm (6”) gap between the cut ends when they were pulled taut **(Figure 17)**.

Figure 16. Post-crash position of the CSS during vehicle inspection

Figure 17. Post-crash gap between tether cuts

CSS Damage

The CSS sustained minor damage as a result of the crash. The left side plastic circular tray shield housing integrated into the plastic shell (this CSS model not equipped with a tray shield) sustained minor deformation from engagement against the right rear door interior **(Figure 18)**. The damaged plastic was located 5 cm (2.0") forward of the rear aspect of the CSS and 19 cm (7.5") below the top of the CSS seat back. Two very small and faint stress marks were present on the outboard aspect of the left side of the CSS under the fabric cover. The forward aspects (in relation to the CSS) of the inboard and outboard rear-facing belt path sustained minor deformation of the plastic from loading against the LATCH webbing. The harness straps did not exhibit any deformation from the crash, although historical wear was evident.

Figure 18. Left side damage to CSS

Occupant Demographics

Driver

Age/Sex:	30-year-old/Female
Height:	Not available
Weight:	Not available
Seat Track Position:	Mid-track, 9 cm (3.5") rear of full-forward and 14 cm (5.5") forward of full-rear
Manual Restraint Use:	Manual 3-point lap and shoulder belt
Usage Source:	Vehicle inspection, EDR summary
Eyewear:	Unknown
Type of Medical Treatment:	Transported by ambulance to a regional trauma center and admitted for treatment

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
Closed head injury, LOC NFS	Moderate (160406,2,0)	B-pillar
Contusion, NFS	Minor (990400.1,9)	Unknown

Source: Police report.

Driver Kinematics

The 30-year-old female driver was seated in an upright posture and restrained by the 3-point manual lap and shoulder belt. The seat track was positioned 5 cm (1.0") forward of the mid-track position and the head restraint was positioned 8 cm (3.0") above the driver's seat back. At impact, the frontal air bags deployed and the safety belt pretensioners fired. The female driver initiated a lateral and slightly forward trajectory to the right. She loaded the safety belt and probably flexed over the low center console between the front seat cushions. She rebounded to

the left and may have struck the left interior B-pillar with her head. She came to rest unconscious and was removed from the vehicle by rescue personnel. Police reported that the driver sustained a head injury, unspecified internal injuries, and an unspecified contusion. She was transported by ambulance to a regional trauma center and admitted for treatment.

Rear Right Child Passenger

Age/Sex:	9-month-old/Male
Height:	71 cm (28”)
Weight:	10 kg (22 lb)
Seat Track Position:	Fixed
Manual Restraint Use:	Rear-facing convertible CSS with five-point harness, installed with lower LATCH attachment, vehicle safety belt, and tethered to the rear seat cushion
Usage Source:	Vehicle inspection, CSS inspection
Eyewear:	None
Type of Medical Treatment:	Transported by ambulance to a regional children’s hospital for evaluation and released

Rear Right Child Kinematics

The 9-month-old male child was restrained in the rear-facing convertible CSS by the five-point harness. The CSS was installed in rear right position of the Saturn Ion with the lower LATCH attachment and supplemented with the vehicle’s 3-point safety belt. At impact, the child and the CSS initiated lateral and slightly forward trajectories to the right (with respect to the vehicle). The CSS loaded the LATCH webbing and the vehicle safety belt and the child loaded the seat back and harness system of the CSS. Intrusion of the right B-pillar and right front door caused lateral and rearward deflection of the front right seat back, which resulted in contact with the CSS seat back, and arrested the forward movement of the CSS. The intruded right rear door contacted the outboard aspect of the CSS, evidenced by scuff marks on the door interior and damage to the CSS. Lateral CSS movement was supported by scuff marks on the front right head restraint from sustained contact with the dark padding over the top of the CSS shell. The child’s head probably contacted the padded inboard aspect of the left side panel of the CSS shell (with respect to the CSS), which extended 14 cm (5.5”) forward from the CSS seat back. The plastic side panel mitigated direct contact between the child’s head and the intruded right rear door panel, intruded right B-pillar, and front aspect of the striking truck, and prevented significant lateral flexion of the child’s neck. The child rebounded rearward and loaded the harness straps. Given that the top tether attachment was anchored to the vehicle’s rear seat cushion, it was not known how much energy was absorbed by the CSS during the rebound. The child came to rest in the CSS, and remained in the CSS as a form of preventative stabilization. Rescue personnel removed the child in the CSS by unbuckling the vehicle safety belt and cutting the LATCH webbing and tether strap. The child was transported in the CSS to a regional children’s hospital for evaluation and released.

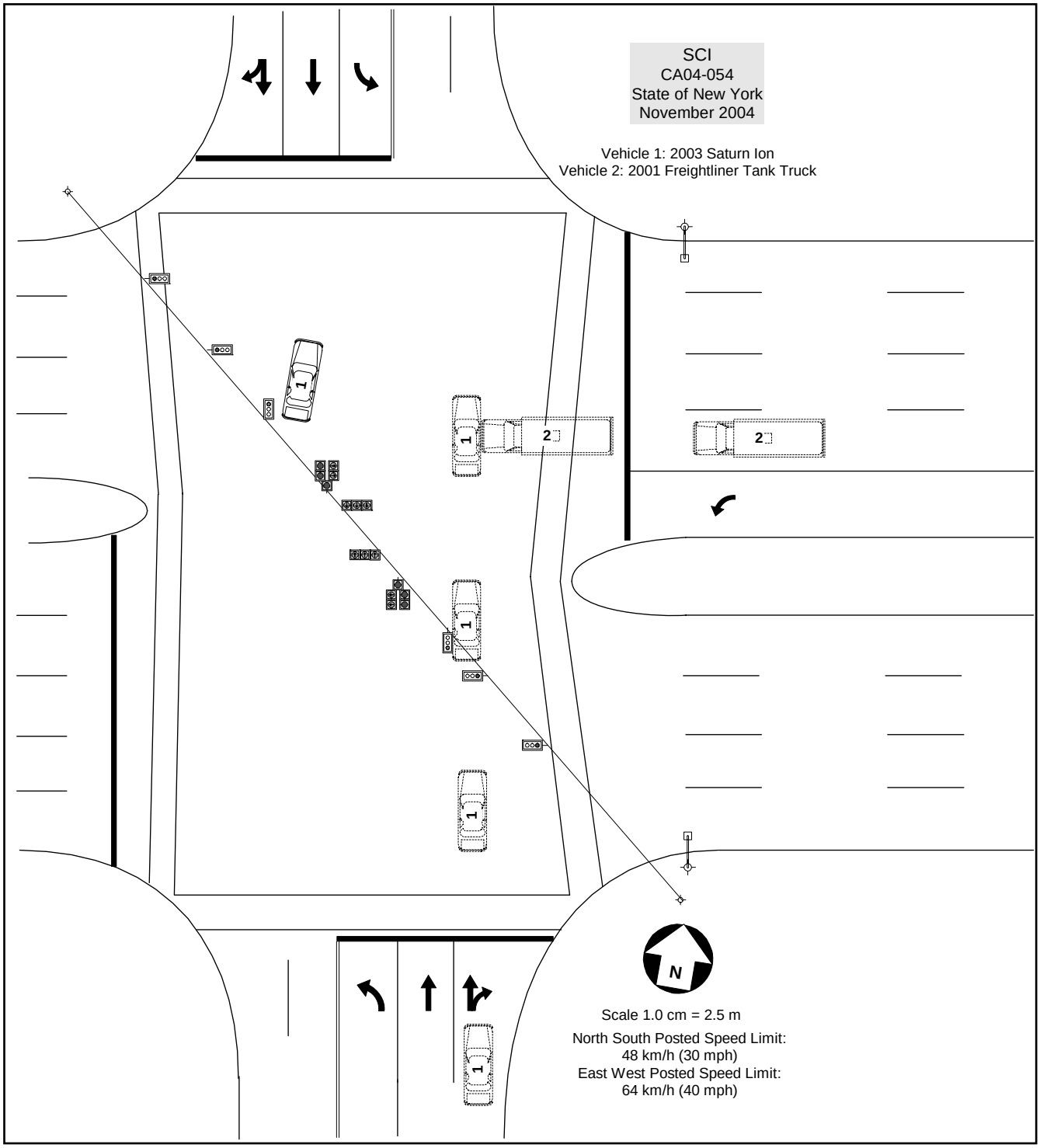


Figure 18. Scene schematic

APPENDIX A: EDR SUMMARY 2003 SATURN ION

CDR File Information

Vehicle Identification Number	1G8A352F33Zxxxxxx
Investigator	
Case Number	
Investigation Date	
Crash Date	
Filename	CA04-054 NOSEQ.CDR
Saved on	Thursday, December 2 2004 at 02:40:17 PM
Data check information	69AA0DAF
Collected with CDR version	Crash Data Retrieval Tool 2.61
Collecting program verification number	CB788FCD
Reported with CDR version	Crash Data Retrieval Tool 2.50
Reporting program verification number	30CAB595
Interface used to collected data	Block number: 00 Interface version: 41 Date: 11-04-04 Checksum: 9E00
Event(s) recovered	Deployment

SDM Data Limitations

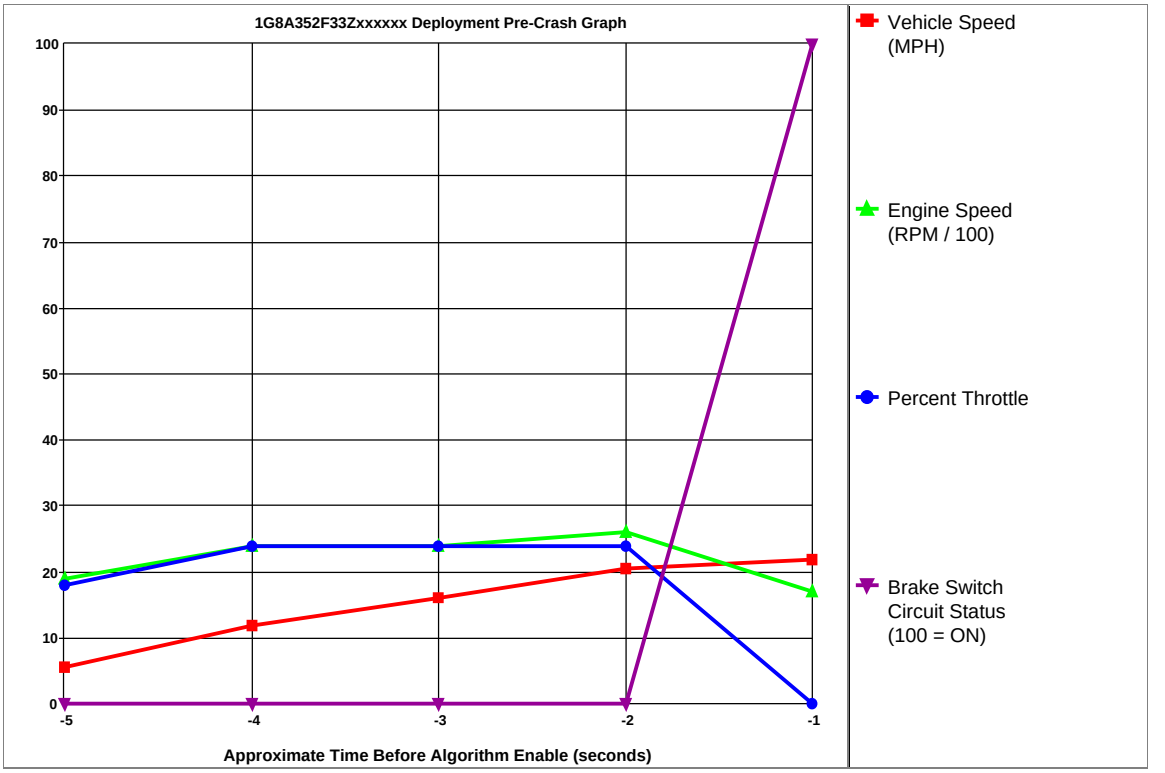
SDM Recorded Crash Events:
There are two types of SDM recorded crash events. The first is the Non-Deployment Event. A Non-Deployment Event is an event severe enough to "wake up" the sensing algorithm but not severe enough to deploy the air bag(s). It contains Pre-Crash and Crash data. The SDM can store up to one Non-Deployment Event. This event can be overwritten by an event that has a greater SDM recorded forward velocity change. This event will be cleared by the SDM after the ignition has been cycled 250 times.
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. Deployment events cannot be overwritten or cleared from the SDM. Once the SDM has deployed the air bag, the SDM must be replaced.
The data in the non-deployment file will be locked after a deployment, if the non-deployment occurred within 5 seconds before the deployment or a deployment level event occurs within 5 seconds after the deployment.

SDM Data Limitations:
-SDM Recorded Vehicle Forward Velocity Change reflects the change in forward velocity that the sensing system experienced during the recorded portion of the event. SDM Recorded Vehicle Forward 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. This data should be examined in conjunction with other available physical evidence from the vehicle and scene when assessing occupant or vehicle forward velocity change. For deployments and deployment level 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-deployments, the SDM will record the first 150 milliseconds of data after algorithm enable.
-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 if the vehicle has had the tire size or the final drive axle ratio changed from the factory build specifications.
-Brake Switch Circuit Status indicates the status of the brake switch circuit.
-Pre-Crash Electronic Data Validity Check Status indicates "Data Invalid" if the SDM does not receive a valid message.
-Driver's Belt Switch Circuit Status indicates the status of the driver's seat belt switch circuit.
-The Time between Non-Deployment and 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.

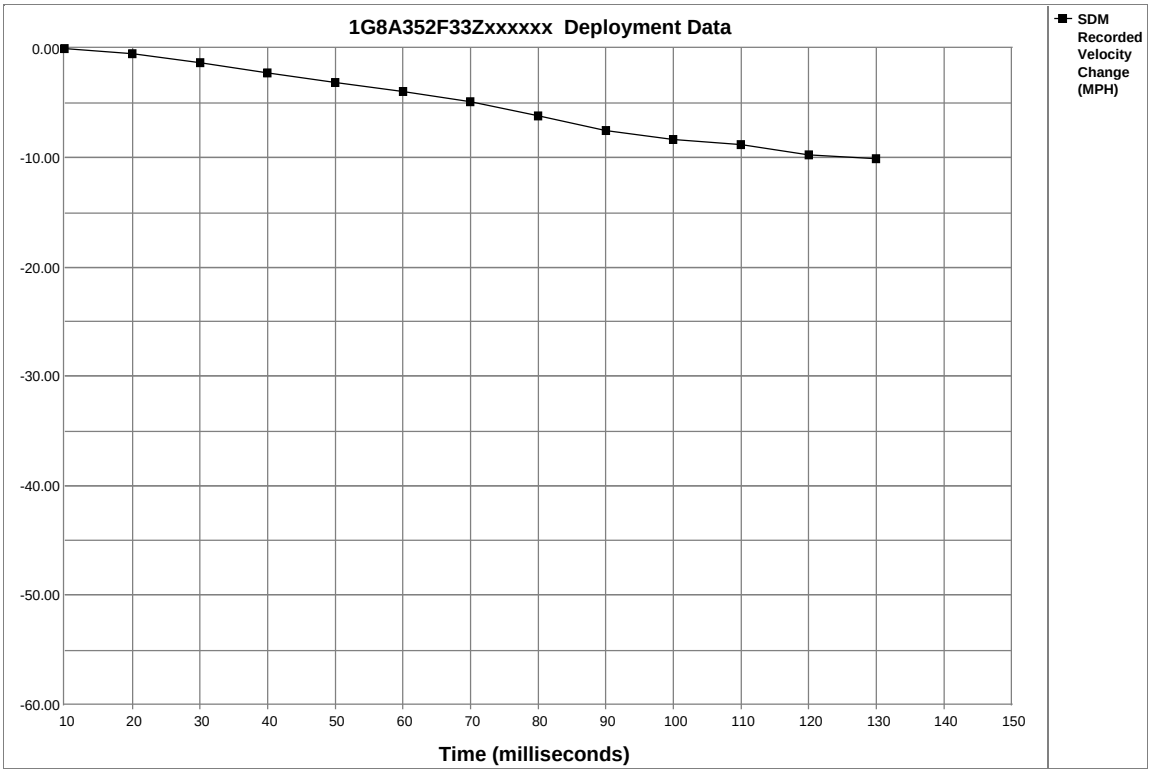
SDM Data Source:
All SDM recorded data is measured, calculated, and stored internally, except for the following:
-Vehicle Speed, Engine Speed, and Percent Throttle data are transmitted once a second by the Powertrain Control Module (PCM), via the Class 2 data link, to the SDM.
-Brake Switch Circuit Status data is transmitted once a second by either the ABS module or the PCM, via the Class 2 data link, to the SDM. Depending on vehicle option content, the Brake Switch Circuit Status data may not be available.
-In most vehicles, the Driver's Belt Switch Circuit is wired directly to the SDM. In some vehicles, the Driver's Belt Switch Circuit Status data is transmitted from the Body Control Module (BCM), via the Class 2 data link, to the SDM.

System Status At Deployment

SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	BUCKLED
Ignition Cycles At Deployment	4023
Ignition Cycles At Investigation	4025
Maximum SDM Recorded Velocity Change (MPH)	-10.49
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	127.5
Driver First Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	32.5
Driver Second Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	N/A
Passenger First Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	32.5
Passenger Second Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	N/A
Event Recording Complete	Yes



Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status
-5	6	1856	18	OFF
-4	12	2432	24	OFF
-3	16	2432	24	OFF
-2	21	2560	24	OFF
-1	22	1664	0	ON



Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
SDM Recorded Velocity Change	0.00	-0.44	-1.32	-2.19	-3.07	-3.95	-4.83	-6.14	-7.46	-8.34	-8.78	-9.65	-10.09	N/A	N/A

Hexadecimal Data

This page displays all the data retrieved from the air bag module.
It contains data that is not converted by this program.

```
$01  A0 1B 00 00 00 00
$02  A8 5F 00 00 00 00
$03  41 53 32 31 34 30
$04  4B 30 32 54 48 31
$05  02 41 00 00 00 00
$06  22 70 52 83 00 00
$10  FE 08 FE 00 00 00
$11  97 00 00 00 00 80
$12  00 00 00 00 00 00
$13  02 00 00 00 00 00
$14  F3 04 ED 00 50 00
$18  80 80 80 19 FF 00
$1C  38 32 41 FA FA FA
$1D  FA 38 32 41 FA FA
$1E  FA FA 00 00 00 00
$1F  FF 02 00 00 00 00
$20  FF FF FF FF FF 00
$21  FF FF FF FF FF FF
$22  FF FF FF FF 00 00
$23  FF FF FF FF FF FF
$24  FF FF FF FF FF FF
$25  FF FF FF FF 00 00
$26  FF FF FF FF FF FF
$27  FF FF FF FF FF 00
$28  FF FF FF FF FF FF
$29  FF FF FF FF FF 00
$2A  FF FF FF FF 00 00
$2B  FF FF FF FF FF FF
$2C  FF FF FF FF FF FF
$2D  FF FF FF FF 00 00
$2E  FF FF FF 00 00 00
$30  40 00 00 7D 80 00
$31  FF FF FF FF FF FF
$32  FF FF FF FF 00 00
$33  12 12 00 00 03 03
$34  00 00 00 01 03 05
$35  07 09 0B 0E 11 13
$36  14 16 17 FF FF 0D
$37  23 21 1A 13 09 83
$38  00 3D 3D 3D 2D 00
$39  1A 28 26 26 1D 00
$3A  FE 09 80 00 00 00
$3B  31 31 00 00 00 00
$3C  54 02 FE 00 00 AA
$3D  00 00 00 00 00 00
$3E  00 00 00 00 00 00
$40  FF FF FF FF FF 00
$41  FF FF FF FF FF FF
$42  FF FF FF FF 00 00
$43  FF FF FF 00 00 00
$44  FF 00 00 00 00 00
$50  FF FF FF FF FF FF
$51  FF FF 00 00 00 00
$60  0D 0D 00 00 54 33
$61  33 00 00 00 00 00
```