

On-Site Child Restraint System Investigation  
Dynamic Science, Inc. (DSI), Case Number DS09007  
2001 Pontiac Sunfire SE  
Washington  
January 2009

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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.

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16. Abstract  This on site investigation focused on a child restraint system (CRS) installed in a 2001 Pontiac Sunfire that was involved in a two-vehicle crash. The subject vehicle was being driven by a restrained 35-year-old male. A 13-month-old female seated in a Cosco/Dorel Regal Ride CRS occupied the second row center seat position. The crash occurred in January 2009 in the state of Washington. The other vehicle was a 1985 GMC K3500 pickup truck that was being driven by a 39-year-old male. The crash site was a two-lane north/south state highway. At the time of the crash the roadway was dry and the light conditions were dark. The Pontiac was traveling northbound and the GMC was traveling southbound. The GMC crossed the center divide line and entered the northbound travel lane. In response to the encroachment of the GMC, the driver of the Pontiac steered into the southbound lane. The GMC then reentered the southbound lane and the front end of the GMC impacted the right side of the Pontiac. The Pontiac came to rest off the west roadway edge. The GMC overturned and came to rest on the west shoulder. The 13-month-old female occupant of the Pontiac sustained fatal injuries and was pronounced deceased at the scene. The driver of the Pontiac sustained incapacitating injuries and was hospitalized. The driver of the GMC sustained non-incapacitating injuries and was transported, treated, and arrested. The police report stated that the driver of the GMC was operating the vehicle while under the influence of alcohol.			
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**Dynamic Science, Inc.**  
**Crash Investigation**  
**Case Number: DS09007**

**TABLE OF CONTENTS**

Background. ....	1
Summary. ....	2
Crash Site.....	2
Pre-Crash. ....	2
Crash. ....	2
Post-Crash. ....	3
Vehicle Data - 2001 Pontiac Sunfire SE .....	4
Vehicle Damage	
Exterior Damage. ....	4
Interior Damage.....	5
Manual Restraints. ....	5
Lower Anchors and Tethers for Children (LATCH).....	6
Supplemental Restraint Systems. ....	6
Child Restraint System. ....	7
Vehicle Data - 1985 GMC K3500 .....	9
Vehicle Damage	
Exterior Damage. ....	9
Rollover Dynamics. ....	10
Occupant Demographics. ....	11
Occupant Kinematics.....	11
Occupant Injuries.....	13
Attachment 1. Scene Diagram. ....	15

## Background

This on site investigation focused on a child restraint system (CRS) installed in a 2001 Pontiac Sunfire SE that was involved in a two-vehicle crash (**Figure 1**). The subject vehicle was being driven by a restrained 35-year-old male. A 13-month-old female seated in a forward-facing Cosco/Dorel Regal Ride CRS occupied the second row center seat position. The crash occurred in January 2009 in the state of Washington. The other vehicle was a 1985 GMC K3500 pickup truck that was being driven by a 39-year-old male. The crash site was a two-lane north/south state highway.



**Figure 1.** Subject vehicle, 2001 Pontiac Sunfire SE

The Pontiac was traveling northbound and the GMC was traveling southbound. The GMC crossed the center divide line and entered the northbound travel lane. In response to the encroachment of the GMC, the driver of the Pontiac steered into the southbound lane. The GMC then reentered the southbound lane and the front end of the GMC impacted the right side of the Pontiac. The Pontiac came to rest off the west roadway edge. The GMC overturned and came to rest on the west shoulder.

The 13-month-old female occupant of the Pontiac sustained fatal injuries and was pronounced deceased at the scene. The driver of the Pontiac sustained incapacitating injuries and was hospitalized. The driver of the GMC sustained non-incapacitating injuries and was transported, treated, and arrested. The police report stated that the driver of the GMC was operating the vehicle while under the influence of alcohol.

This on-site CRS investigation was initiated by a DSI investigator after a review of an internet news article. The article reported that a 1-year-old female, who was properly restrained in a CRS, died as a result of injuries she sustained in a two-vehicle crash. On January 23, 2009, DSI forwarded the news article to the National Highway Traffic Safety Administration (NHTSA). On January 26, 2009, NHTSA assigned the case to DSI. On January 27, 2009, the investigating police agency was contacted and the preliminary police report was obtained. Permission to inspect the vehicles and the CRS was obtained on January 28, 2009. The vehicles and the CRS were inspected on February 19, 2009.

The Pontiac was equipped with an Event Data Recorder (EDR) that was supported by the Bosch hardware and software. The police attempted to image the EDR through the vehicle's Data Link Connector (DLC) and were unsuccessful due to damage to the vehicle. The EDR was located under the front row right seat cushion but could not be accessed due to damage to the vehicle. The vehicle was being held in evidence and the seat cushion could not be removed, and for that reason, the EDR data was not obtained.

## Summary

### Crash Site

The crash site was a two-lane, north/south undivided state highway (**Figure 2**). The roadway comprised one bituminous lane for each direction of travel and each lane measured 3.7 m (12.2 ft) in width. The travel lanes were separated by a single yellow dashed stripe and were bordered on the edges by white fog lines. Outboard of the travel lanes were paved shoulders followed by descending gravel shoulders. The east paved shoulder measured 1.9 m (6.3 ft) in width and the gravel shoulder measured 3.1 m (10.0 ft) in width. The west paved shoulder measured 2.2 m (7.1 ft) in width and the gravel shoulder measured 3.1 m (10.0 ft) in width. The roadway character was a slight curve left for northbound traffic, a slight curve right for southbound traffic; and the profile was level and the roadway surface was dry. The speed limit at this location was 97 km/h (60 mph).



**Figure 2.** Crash site, northbound approach

### Pre-Crash

The Pontiac was traveling northbound and the GMC was traveling southbound. The GMC crossed the center divide line and entered the northbound travel lane. In response to the encroachment of the GMC, the driver of the Pontiac steered left and traveled into the southbound lane. The driver of the GMC then steered left and reentered the southbound lane, and applied the brakes with lock-up; the vehicle initiated a counterclockwise yaw. The vehicle deposited four skid marks, the longest of which measured 11.9 m (39.0 ft), by the right rear tire. The left rear tire deposited a skid mark that measured 9.9 m (32.5 ft). The front left and front right tires deposited skid marks that measured 8.7 m (28.5 ft) and 4.7 m (15.4 ft), respectively. The rear tire marks began near the roadway centerline, extended across the southbound travel lane, and ended near the west fog line.

### Crash

The front right of the GMC impacted the right side of the Pontiac. The point of impact (POI) was on the near the fog line bordering the west paved shoulder. The location of the GMC at the POI was determined based on a gouge in the southbound lane that measured 12 cm (4.7 in) in diameter that resulted from contact with the vehicle's undercarriage at impact. The gouge was located 0.8 m (2.6 ft) east of the fog line. The Pontiac initiated a post-impact clockwise rotation, was displaced to the left, and traveled off the west edge of the roadway. The vehicle's undercarriage deposited a group of gouge marks to the paved shoulder, possibly while the vehicles were still engaged. The gouges were located in a 0.3 x 0.9 m ( 1.0 x 3.0 ft) area that ended at the edge of the shoulder. As the Pontiac continued its post-impact trajectory, the vehicle rotated clockwise approximately 150 degrees and came to rest off the roadway and facing southeast. The distance the Pontiac traveled from the POI to final rest was 9.8 m (32.2 ft). The at-rest location was indicated by tire furrows in the ground.

The GMC initiated a post-impact clockwise rotation, and its left side tires engaged the roadway with sufficient lateral force to initiate a trip rollover left side leading. The GMC rolled about its longitudinal axis for two quarter turns and came to final rest on its roof. During the rollover the vehicle deposited scrape marks within a 0.9 x 1.2 m (3.0 x 4.0 ft) area in the southbound lane and west shoulder. The final rest location for the GMC was on the paved west shoulder and the descending gravel shoulder, and the vehicle was facing northeast. A fluid spill was present at the west edge of the paved shoulder. The estimated roll distance from the trip point to final rest for the GMC was 6.0 m (19.7 ft).

For the Pontiac, the standard algorithm of the WinSMASH program computed a Total Delta-V of 66.0 km/h (41.0 mph). The longitudinal and lateral components were -42.4 km/h (-26.3 mph) and -50.6 km/h (-31.4 mph), respectively. The WinSMASH results for the Pontiac appear reasonable.

For the GMC, the standard algorithm of the WinSMASH program computed a Total Delta-V of 42 km/h (26.1 mph), based on the vehicle's front end crush profile. The longitudinal and lateral components were -41.4 km/h (-25.7 mph) and 7.3 km/h (4.5 mph), respectively. The WinSMASH results for the GMC appear reasonable.

### **Post-Crash**

Extrication efforts were required to remove the occupants of the Pontiac from the vehicle. The vehicle's pillars were cut through and the entire roof was removed. The driver's medical record stated that the extrication effort lasted approximately 30 minutes. The driver's safety belt was cut by on-scene responders and he was removed from the vehicle while unconscious through the front left door. He was placed on a stretcher, fitted with a cervical collar, and transported to a local hospital, where he arrived at 2025 hours with a Glasgow Coma Score (GCS) of 4. He was treated in the emergency department for approximately 2 hours then air transported at 2235 hours to a medical center to receive advanced trauma care. The driver was admitted to the medical center for surgery and was hospitalized for eighteen days. At the time of this report he was undergoing therapeutic treatment for his injuries and had not returned to work.

The 13-month-old female occupant was found unresponsive and seated in her CRS that was secured in the second row center position. The occupant was mechanically pinned in the vehicle due to intrusion and extrication was used to remove the occupant and CRS from the vehicle. The roof and second row left side door were removed. On-scene responders cut the vehicle's lap belt that secured the CRS and removed the CRS, with the child restrained in the seat, through the left side door opening. The child sustained fatal injuries and was pronounced deceased at the scene by responding Emergency Medical Services (EMS) personnel. The coroner's report stated that the child's death was immediate and the cause of death was multiple internal injuries due to blunt force impact to the head, chest, and abdomen.

According to the police report, the driver of the GMC sustained non-incapacitating injuries to the head and hand. He was transported to a local hospital, treated, then arrested. The two vehicles were towed due to damage and were impounded by the police. The CRS was also held in evidence by the police.

### Vehicle Data - 2001 Pontiac Sunfire SE

The 2001 Pontiac Sunfire SE 4-door sedan was identified by Vehicle Identification Number (VIN): 1G2JB524517xxxxxx. The vehicle was manufactured in January 2001. The electronic odometer could not be read due the absence of power to the instrument panel. The Pontiac was equipped with a 4-cylinder, 2.2-liter engine, automatic transmission, front wheel drive, 4-wheel anti-lock brakes, daytime lights, and power steering with tilt steering functionality. The vehicle was equipped with front disc brakes and rear drum brakes. The vehicle's fuel system was equipped with a single metallic fuel cell. The vehicle manufacturer's recommended tire size was P195/70R14, and the recommended cold tire pressure was 207 kPa (30 psi). The Pontiac was equipped with Radial ST/2 Snowtrakker P195/65R15 tires. The tires were metal studded snow tires and were designed for #13 (10 mm, 13/32 in) studs. The tire manufacturer's maximum pressure rating was 303 kPa (44 psi); the tires were manufactured in week 31 of 2008. The specific tire data were as follows:

Position	Measured Pressure	Measured Tread Depth	Restricted	Damage
LF	Tire flat	10 mm (12/32 in)	No	Unknown
LR	186 kPa (27 psi)	10 mm (13/32 in)	No	None
RR	179 kPa (26 psi)	10 mm (12/32 in)	No	None
RF	Tire flat	10 mm (12/32 in)	Yes	Sidewall gouged, cut

The Pontiac's passenger compartment was equipped with seating for 5 occupants. The first row seating was configured with fabric-covered bucket seats with adjustable head restraints for the outboard seating positions. The second row seating was configured with a fabric-covered, three position bench seat with a folding back and no head restraints.

### Vehicle Damage - 2001 Pontiac Sunfire SE

#### Exterior Damage

The Pontiac sustained severe exterior damage as a result of the impact with the GMC. The vehicle sustained direct and induced damage to the right, left, front, top and bottom planes. The front axle was displaced and the right wheelbase was shortened by 49 cm (19.3 in). The front bumper fascia was detached and the right side view mirror was broken off. The vehicle also sustained damage as a result of post-impact extrication activities. The roof, left B-pillar, second row left door, windshield, and backlight were all removed. The roof probably sustained crush as a result of the crash, but the damage could not be quantified or separated from the post-crash extrication damage.

The direct damage to the right side began at the front right bumper corner, extended 276 cm (109.7 in) rearward, and ended 83 cm (32.7 in) forward of the rear axle. The vertical extent of direct damage began at the sill, extended 105 cm (41.3 in) upward and ended at the roof side rail. The Field L began at the front right bumper corner, extended 296 cm (116.5 in) rearward, and ended at the trailing edge of the second row door, 63 cm (24.8 in) forward of the rear axle. Six crush



measurements were taken at mid-door level (**Figure 3**) as follows:  $C_1 = 0$  cm,  $C_2 = 37$  cm (14.6 in),  $C_3 = 15$  cm (5.9 in),  $C_4 = 48$  cm (18.9 in),  $C_5 = 0$  cm,  $C_6 = 9$  cm (3.5 in). Maximum crush at the mid-door level was located at  $C_4$ . The height of maximum door crush measured 58 cm (22.8 in), the sill height measured 30 cm (11.8 in), and the Door Sill Differential (DSD) was 20 cm (7.8 in). The Collision Deformation Classification (CDC) for the side impact was 02RYAW3.



**Figure 3.** Right side crush measurement using reference line

### Interior Damage

The Pontiac sustained interior damage as a result of passenger compartment intrusion and occupant contacts. The right side doors were jammed shut. The windshield and backlight were removed during post-crash extrication efforts and their post-crash damage was not known. The right side window glazing disintegrated at impact, and the left side window glazing was undamaged. The roof and left rear door were removed during extrication efforts. The instrument panel was fractured and deformed by intrusion of the right side of the vehicle. The first and second row right seats were deformed by intruding door panels. The Pontiac sustained intrusions of the following components: the right A- and B-pillars, first and second row right side door panels, roof, instrument panel, steering assembly, and first and second row seat backs. The right B-pillar and second row door panel's forward upper quadrant intruded into the second row center seat position.

### Manual Restraints

The Pontiac was equipped with 3-point manual lap and shoulder belts for the four outboard seating positions. The front row safety belts were configured with adjustable D-rings and Emergency Locking Retractors (ELR). The second row outboard safety belts were equipped with ELR retractors. The second row center seat was equipped with a lap belt that did not retract and a locking latch plate.

The driver's safety belt webbing had been cut by on-scene responders during extrication efforts and the lower portion was retracted into its housing. The left B-pillar had been removed during extrication efforts and the shoulder belt webbing, latch plate, and upper anchorage assembly was missing. The retractor was damaged and would not unspool. The remaining webbing measured 80 cm (31.5 in) in length. There was no evidence of occupant loading observed and the webbing was unremarkable. The safety belt buckle was undamaged.

The front row right safety belt was intact, but the upper anchorage assembly was fractured. The latch plate was scratched indicating historical usage. The adjustable D-ring was set to full-down.

The second row safety belts were configured with sliding latch plates for the outboard seating positions. The safety belts retracted through slots that were rearward of the top of the seat backs; the retractors were located behind the seat backs. The left safety belt webbing and latch plate showed wear and scratches indicating historical usage and were otherwise unremarkable.

The second row center seat was equipped with a non-retractable lap belt and a locking latch plate (**Figure 4**). The belt was used to secure a Cosco/Dorel Regal Ride CRS. The safety belt webbing measured 45 cm (17.7 in) from the seat cushion to the buckle with 51 cm (20.1in) of excess webbing extending past the buckle. A measurement of the CRS indicated that the latch plate was adjusted to the approximate length needed to install the CRS in the vehicle. The latch plate was scratched and the webbing had conformed to the shape of the cinching mechanism indicating historical usage.



**Figure 4.** Second row center safety belt used to secure CRS

The safety belt webbing revealed a scuff to the inner side that began 10 cm (3.9 in) from the seat cushion and measured 7 cm ( 2.8 in) in length and 3 cm (1.2 in) in width. The location and nature of the scuff correlated to load marks on the belt path slot on the left side of the CRS shell. The scuff was evidence of occupant loading of the belt during the crash. A section of webbing contained three dried fluid deposits that began 20 cm (7.8 in) from the seat cushion and measured 10 cm (3.9 in) in length and 4 cm (1.6 in) in width. The affected area was routed within the CRS shell at the time of the crash and the source of the deposits was not identified.

The second row right position safety belt was partially retracted in the stowed position. The safety belt would neither unspool nor retract due to impact damage. The latch plate was scratched indicating historical usage. The belt webbing exhibited a hole that measured 2 x 3 cm (0.8 x 1.2 in) and was located 54 cm (21.3 in) above the stop button and 83 cm (32.7 in) above the lower anchor. The source of the damage was not known. The plastic casing of the latch plate showed abrasions that resulted from contact with the intruded door panel.

### **Lower Anchors and Tethers for Children (LATCH)**

The Pontiac was equipped with tether hardware for the three second row seat positions. The vehicle was not equipped with lower anchors. The CSS used in this crash was equipped with LATCH hardware. However, the CRS was secured by the vehicle's manual lap belt in the second row center position and the tether was not used.

### **Supplemental Restraint Systems**

The Pontiac was equipped with first row frontal air bags for the left and right seating positions. The frontal air bags were second-generation meaning they were engineered to deploy with less speed and force as compared with first-generation air bags. Both frontal air bags deployed in the crash as a result of impact deceleration (**Figure 5**). The vehicle was not equipped with a suppression switch for the passenger air bag. The driver's air bag was located in the steering wheel hub and deployed through H-configured cover flaps. The flaps opened at their tear points and were not damaged. The air bag was oval in shape and its front panel measured 55 cm (21.7 in) in height and 45 cm (17.7 in) in width. It was configured with two vent ports and no tethers.

The air bag revealed evidence of occupant loading and contact damage. A blood deposit measuring 1 x 2 cm (0.4 x 0.8) in size and was located in the upper left quadrant, 15 cm ( 5.9 in) left of center. Within the same quadrant was a transfer of skin oil that measured 5 x 9 cm (2.0 x 3.2 in) and was located 15 cm ( 5.9 in) above center.



**Figure 5.** Frontal air bags deployed

The air bag revealed a 4 cm (1.6 in) tear and two small scuffs that were located in the upper right quadrant of the back panel. The damage probably was a result of contact with the windshield glazing. A 1 cm (0.4 in) tear on the upper aspect of the back panel resulted from contact with a corner of the right cover flap. The air bag's front panel revealed vinyl striations that were deposited by the cover flaps at deployment.

The front row right passenger air bag was square in shape and its front panel measured 40 x 40 cm (15.8 x 15.8 in). The bag deployed from a single rectangular cover flap in the vehicle's top instrument panel. The air bag was configured with two tethers and no vent ports. The back panel's upper aspect revealed two holes that measured 7 cm (2.8 in) and 4 cm (1.6 in) in length, respectively, and they were located 15 cm (5.9 in) apart. After eliminating occupant loading and intrusion as probable damage sources, the holes were determined to be the result of post-crash extrication activities. The back panel revealed multiple abrasions that were probably the result of flying glass or windshield glazing contact. The damaged area also showed vinyl striations that were deposited by the cover flap during deployment.

The air bag revealed a large deposit of dried blood that was transferred by the driver, based on his kinematics during the crash and IP movement due to intrusion. The blood deposit measured 35 x 10 cm (13.8 x 3.9 in) in size and was located on the upper aspect of the back panel. Within the deposit was a black colored transfer that measured 3 x 6 cm (1.2 x 2.4 in) that had the appearance of grease. The source of the grease is not known.

### **Child Restraint System (CRS)**

The 13-month-old female second row center position occupant was seated in a forward-facing Cosco/Dorel Regal Ride CRS and restrained by the seat's 5-point harness system (**Figure 6**). The CRS's model number was 22-110-BRS and the date of manufacture was 12/28/2004. The convertible CRS was designed to be used either forward or rear facing. The 5-point harness system was configured with a 2-part retainer clip and a lower buckle that received latches from the two leg straps. The shoulder harness straps were routed through the middle set of slots. The Regal Ride was configured with LATCH straps and hardware, although they were not used to install the CRS.

The driver of the Pontiac was the father of the child and he installed the CRS in the vehicle. The child's mother stated during the interview that the father routinely checked the tension of the vehicle's lap belt and the CRS for lateral movement. The CRS was oriented forward-facing on the bench seat cushion and secured with the vehicle's manual lap safety belt that was routed through the

forward facing slots. The CRS was designed to be installed in a forward-facing orientation either using a lap belt, lap and shoulder belt, or LATCH. The safety belt was not equipped with a retractor and the latch plate was a locking type.

A warning label on the CRS stated it was to be used in a forward facing orientation by children who met the following criteria:

- 73 - 102 cm (29 - 40 in) in height
- 9 - 18 kg (20 - 40 lb) in weight
- greater than one year in age
- the mid-point of the child's head is not above the back of the CRS back

Based on the above criteria, the 13-month-old child was an appropriate height, weight, and age for the CRS.



**Figure 6.** Cosco/Dorel Regal Ride CRS

The CRS was damaged by a combination of occupant loading and vehicle intrusion contact. The safety belt routing slots on the left and right sides revealed scuff marks where the child and CRS loaded the safety belt. The right side of the shell revealed damage in the form of fractures, holes, gouges and discoloration. An irregularly shaped fracture on the right side began on the outboard edge and extended 9 cm (3.5 in) inboard. The plastic shell was deformed at the inboard aspect of the fracture and a 2 x 3 cm (0.8 x 1.2 in) hole was present. A crack that measured 4 cm (1.6 in) was located 12 cm (4.7 in) above the aforementioned fracture. A 1 cm (0.4 in) gouge mark was located 4 cm (1.6 in) above the crack.

The right side of the CRS shell also revealed evidence of stress in the form of discoloration of the plastic that was lighter in appearance than the undamaged areas. The stressed areas were intermittent beginning at the bottom edge and extending up the right side for approximately 30 cm (11.8 in). The noted fracture, crack, and gouge mark fell within that area as well. The damage to the right side of the CRS shell was due to the intrusion of the right B-pillar and second row door panel.

The CRS's seat cushion exhibited evidence of occupant contact on its right aspect. An impression in the fabric cover measured 3 x 1 cm (1.2 x 0.4 in) and was located on the forward aspect of the inboard side panel. Based on the child's kinematics and injuries, her right leg possibly contacted the CRS shell at impact. Two small deposits of dried blood were noted on the upper right aspect of the cover, as well as one drop of dried blood on the upper left aspect. The fabric had separated from the buckle adjustment at the front of the seat cushion, probably resulting from occupant contact.

During the interview, the mother of the child indicated that the child was restrained in the CRS by the 5-point harness system and that it was adjusted to a snug fit and the retainer clip was near armpit level. The harness system revealed evidence of historical usage and occupant loading. The plastic grommets were displaced from the middle set of slots through which the shoulder straps were routed,

and the left upper and lower flanges were missing. Both shoulder straps showed dried deposits that were white in color and were probably body fluids such as perspiration or saliva, and the manufacturer name plate was displaced from the retainer clip. The left shoulder webbing revealed a 4 cm (1.6 in) stretch mark and crease near the lower buckle. The lower buckle showed a 3 cm (1.2 in) area of scuff marks on the plastic cover. The functionality of the CRS harness system was not compromised by the damage caused by occupant loading.

### Vehicle Data - 1985 GMC K3500

The 1985 GMC K3500 Classic Sierra 2-door pickup truck was identified by the VIN: 1GTHK34M9FJxxxxxx. The GMC was equipped with an 8-cylinder, 5.7-liter engine, automatic transmission, and 4-wheel drive. The vehicle's fuel system was equipped with two nonmetallic fuel cells. The vehicle manufacturer's recommended tire size was LT235/85R16 and the recommended cold tire pressure was 552 kPa (80 psi). The GMC was equipped with a Cooper Discover ATR LT285/75R16 tire for the left front and Dayton Timberline A/T LT285/75R16 tires for the left rear, right front and right rear. The tires' maximum pressure rating was 448 kPa (65 psi). The specific tire data was as follows:

Position	Measured Pressure	Measured Tread Depth	Restricted	Damage
LF	303 kPa (44 psi)	7 mm (9/32 in)	No	Sidewall gouged, scuffed
LR	303 kPa (44 psi)	6 mm (8/32 in)	No	Sidewall scuffed
RR	310 kPa (45 psi)	7 mm (9/32 in)	No	Sidewall scuffed
RF	Tire flat	7 mm (9/32 in)	Yes	Sidewall gouged, scuffed

### Vehicle Damage - 1985 GMC K3500

#### Exterior Damage

The GMC sustained moderate front end damage from the impact with the Pontiac (**Figure 7**). Measurement of direct damage to the frontal plane began at the front left bumper corner, extended 150 cm (59.1 in) along the damaged profile, and ended at the front right bumper corner. The Field L for the frontal damage measured 130 cm (51.2 in) from bumper corner to bumper corner. Six crush measurements were taken at bumper level as follows:  $C_1 = 14$  cm (5.5 in),  $C_2 = 15$  cm (5.9 in),  $C_3 = 58$  cm (22.8 in),  $C_4 = 67$  cm (26.4 in),  $C_5 = 64$  cm (25.2 in),  $C_6 = 91$  cm (35.8 in). Maximum crush at bumper level was located at  $C_6$  at the front right bumper corner. The CDC for the side impact was 12FDEW4.

The GMC sustained moderate exterior damage during the rollover event. The vehicle rolled about its horizontal axis for two quarter turns and sustained direct damage to the left side and top planes.

Maximum lateral crush was located at the right B-pillar and measured 15 cm (5.9 in). Maximum vertical crush to the vehicle's top was located at the back light header at 35 cm (13.8 in) inboard of the left roof side rail and measured 30 cm (11.8 in). The CDC for the rollover was 00TDDO3.

### Rollover Discussion - 1985 GMC K3500

Prior to the impact with the Pontiac, the GMC applied the brakes with lockup of all four wheels. Based on scene evidence that included skid marks leading to the point of impact, the vehicle initiated a slight counterclockwise yaw and was not tracking. The front end of the GMC impacted the right side of the Pontiac, and then initiated a post-impact clockwise rotation. The GMC's left side tires engaged the asphalt roadway and tripped in response to the opposing lateral forces. The vehicle rolled two quarter-turns and continued to rotate clockwise until it came to final rest. The vehicle came to final rest on its roof in a northeast heading. It was partially on the west paved shoulder and partially on the gravel shoulder. The estimated roll distance was 6.0 m (19.7 ft) from the trip point to final rest.



**Figure 7.** Front end crush profile measurement, 1985 GMC K3500

The Static Stability Factor (SSF) for the GMC was not known. The SSF of a vehicle is an at-rest calculation of its rollover resistance, which is based on its track width and center of gravity. The vehicle was not equipped with anti-lock brakes, traction control or electronic stability control systems. Between the first impact and the rollover, there was insufficient time and travel distance to allow for driver steering input or other avoidance measures.

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Based on the inspection of the vehicle's left side tires, their engagement with the roadway as the vehicle rotated laterally to its path of travel resulted in the trip and rollover. The left front tire revealed gouges and scuffs that were oriented radially, suggesting they were induced as the vehicle traveled laterally. The left rear tire was scuffed similarly but less severe. The right front tire was scuffed, gouged and restricted, and the rim was fractured due to vehicle-to-vehicle contact. The right rear tire sidewall and rim were scuffed by vehicle-to-vehicle contact as well.

**Occupant Demographics - 2001 Pontiac Sunfire SE**

	<b>Driver</b>	<b>Occupant 2</b>
Age/Sex:	35/Male	13 Months/Female
Height:	180 cm (71 in)	74 cm (29 in)
Weight:	77.3 kg (170 lb)	10 kg (23 lb)
Seat Type:	Bucket	Bench with folding back
Seat Track Position:	Middle-track	Not adjustable
Manual Restraint Usage:	Lap and shoulder belt	Lap belt with a CRS
Restraint Usage Source:	Vehicle inspection	Vehicle inspection
Air Bag:	Steering wheel mounted deployed	None available
Eyewear:	None	None
Alcohol/Drug Involvement:	None	N/A
Type of Medical Treatment	Hospitalization	None; declared deceased at scene

**Occupant Kinematics - 2001 Pontiac Sunfire SE****Driver**

The 35-year-old male driver was seated in an unknown posture and was restrained by the vehicle's 3-point manual lap and shoulder belt. The safety belt was snug across the driver's hips and collarbone and the belt was equipped with an ELR retractor. The driver's right foot was on the accelerator, his left foot was on the floor, and he was steering the vehicle. His seat was adjusted to mid-track and his seat-back was slightly reclined. His attention was focused on the roadway and there were no distractions within the vehicle.

At impact with the GMC, the driver's frontal air bag deployed, and the driver was displaced forward and right in response to the 2 o'clock direction of force. The steering assembly intruded longitudinally 14 cm (5.5 in) and the driver's face and head loaded the deployed frontal air bag, as evidenced by a skin oil transfer in the air bags upper left quadrant. The driver's head contacted the steering wheel rim resulting in moderate facial fractures. The roof intruded into the occupant compartment and the driver's head contacted the roof resulting in contusions of the cerebrum and scalp. Additionally, the driver sustained a contusion to the right lung when his chest loaded first the safety belt restraint and then the steering wheel. A scuff was documented on the upper right quadrant of the steering wheel rim resulting from a combination of contact from the driver and the frontal air bag. The scuff measured approximately 12 cm (4.7 in) in length and was located on the

inside and outside aspects of the rim. The driver's left knee contacted the lower steering column causing an abrasion. A correlative scuff was deposited measuring 10 x 12 cm (3.9 x 4.7 in). His right hip contacted the safety belt buckle resulting in an abrasion.

The Pontiac initiated a post-impact clockwise rotation and was displaced to the left. The driver continued to be displaced to the right in response to the vehicle's rotation and path of travel. The driver was rendered unconscious due to his injuries and remained in his seated position until he was removed by on-scene responders. He sustained a loss of consciousness for an unknown length of time and was amnesic following the incident.

### **Second Row Center Occupant**

The 13-month-old female child was seated in a Cosco/Dorel Regal Ride CRS and restrained by the seat's 5-point harness system. The CRS was placed in a forward facing orientation on the center position of the bench seat and was secured by the vehicle's manual lap belt. The CRS harness was adjusted snugly to the child's body and the retainer clip was buckled and positioned at armpit level. At impact, the occupant and CRS were displaced forward and right in response to the 2 o'clock direction of force. The occupant loaded the CRS harness, which resulted in abrasions to the anterior neck.

The vehicle's right B-pillar and second row door panel intruded into the second row center passenger compartment. As the occupant was displaced forward and right toward the direction of force, the right B-pillar intruded laterally and longitudinally. The child's head contacted the right upper B-pillar and she sustained severe injuries of the skull, brain, face, spinal cord and vertebra. The injuries to the skull, brain and face were a result of direct contact with the B-pillar.

The child's chest and torso contacted the B-pillar resulting in injuries to the thoracic aorta, lungs and liver, and abrasions and contusions to the abdomen. Her lower extremities contacted the right B-pillar resulting in a fracture of the right tibia and abrasions and contusion to both knees and legs.

The injuries to the spinal cord and vertebra resulted from hyperextension/flexion movement of the head. When the B-pillar contacted the child's head, sufficient force was transferred from the head to the spinal cord and vertebra to result in spinal cord transection and a vertebral fracture. Hyperextension/flexion mechanism injuries are typically associated with rear impacts since the head is displaced rearward; however, in this case the occupant's biomechanics were acted upon by a combination of restraints, rigid components, and impact forces.

The Pontiac initiated a post impact clockwise rotation and was displaced to the left. The child continued to be displaced to the right in response to the vehicle's clockwise rotation and path of travel. According to the autopsy, the cause of death was determined to be multiple internal injuries due to blunt impact to the head, chest and abdomen; the child's death was immediate.

Based on the vehicle and CRS inspections, occupant kinematics, contacts, and injuries, and the interview, it was determined the occupant was properly restrained in the CRS. The CRS and the vehicle's lap belt revealed no evidence of malfunction or damage that was not attributable to the intrusion of rigid components and high Delta-V impact forces.



**Occupant Injuries - 2001 Pontiac Sunfire SE****Driver**

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Unconscious on Admission or Initial Observation at Scene, Length of Unconsciousness NFS, with neurological deficit	160804.4,0	Roof	Probable
Fracture, zygoma/malar, right	251800.2,1	Steering wheel rim	Probable
Fracture, LeFort II	250806.2,4	Steering wheel rim	Probable
Contusion, parietal scalp, right	190402.1,1	Roof	Probable
Contusion, orbit, right	297402.1,1	Steering wheel rim	Probable
Abrasion, hip, right	590202.1,1	Safety belt buckle	Probable
Contusion, cerebrum, parietal lobe, right	140602.3,1	Roof	Probable
Abrasion, knee, left	890202.1,2	Left IP	Probable
Contusion NFS, lung, right	441402.3,1	Steering wheel hub	Probable

**Second Row Center Occupant**

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Multiple basilar skull fractures, complex (hinge) involving right and left posterior fosse, right middle fosse and frontal bones	150206.4,8	Right B-pillar	Certain
Subdural hemorrhage, small, cerebrum, bilateral	140654.5,3	Right B-pillar	Probable
Subarachnoid hemorrhage, cerebrum, temporal lobe, right	140684.3,1	Right B-pillar	Probable
Contusion (hemorrhage), temporal scalp, right	190402.1,1	Right B-pillar	Probable
Spinal cord laceration NFS (transection) with dislocation	640240.5,6	Right B-pillar	Probable

Fracture NFS, C7	650216.2,6	Right B-pillar	Probable
Laceration, major (complete transection), thoracic aorta	420210.5,4	Right B-pillar	Probable
Contusions with hemothorax, lungs, bilateral	441410.4,3	Right B-pillar	Probable
Laceration NFS, liver, right	541820.2,1	Right B-pillar	Probable
Lacerations, minor, and abrasions, face, bilateral	290602.1,1 290202.1,1 290202.1,2	Flying glass	Probable
Abrasions, neck, anterior	390202.1,5	CRS harness	Probable
Contusions, neck, posterior	390402.1,6	CRS shell	Possible
Abrasion, abdomen, right	590202.1,1	Right B-pillar	Probable
Abrasion, wrist, left anterior	790202.1,2	Unknown	Unknown
Abrasions, thigh, anterior right	890202.1,1	Right B-pillar	Probable
Abrasions, knees, bilateral	890202.1,3	Right B-pillar	Possible
Fracture, tibia shaft, right	853420.2,1	Right B-pillar	Possible
Abrasions, lower legs, bilateral	890202.1,3	Right B-pillar	Possible

Attachment 1. Scene Diagram

