

Remote Child Safety Seat Investigation
Dynamic Science, Inc. / Case Number: DS07028
1998 Buick Century
North Dakota
January 2007

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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 The focus of this remote level case was on the dynamics of a 1998 Buick Century Custom that was involved in a single vehicle crash with a tree, and the injury sources for a 4-year-old male passenger seated in a child safety seat in the second row left position. The vehicle was being driven by a restrained 46-year-old female and was occupied by the 4-year-old child who was restrained within an Evenflo Big Kid booster seat by a manual lap and shoulder belt. The crash took place in the afternoon hours in January 2007 as the vehicle was traveling eastbound on a two-lane roadway. As the Buick was traveling, the driver reportedly heard a loud noise from the back of the vehicle and immediately turned toward the second row to monitor the status of the child. As she did so, the Buick crossed the roadway's centerline, departed the north roadside and began descending down a snow-covered embankment. The frontal plane of the vehicle impacted a medium-sized hardwood tree on the roadside resulting in moderate-to-severe damage. The driver was transported to a local hospital by a family member who arrived on-scene. The 4-year-old male passenger was removed from the booster seat by the driver. He was transported by air ambulance to a local hospital. He arrived at the hospital in a state of cardiac arrest, and with a Glasgow Coma Score (GCS) of 3. He was pronounced dead at 1636 hours, approximately 41 minutes post-crash. The Buick Century was towed from the scene due to damage. The vehicle was declared a total loss by the insurance company and was sold to an auto salvage company.					
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BACKGROUND

The focus of this remote level case was on the dynamics of a 1998 Buick Century Custom that was involved in a single vehicle crash with a tree, and the injury sources for a 4-year-old male passenger seated in a child safety seat in the second row left position. The vehicle was being driven by a restrained 46-year-old female and was occupied by the 4-year-old child who was restrained within an Evenflo Big Kid booster seat by a manual lap and shoulder belt. The crash took place in the afternoon hours in January 2007 as the vehicle was traveling eastbound on a two-lane roadway. As the Buick was traveling, the driver reportedly heard a loud noise from the back of the vehicle and immediately turned toward the second row to monitor the status of the child. As she did so, the Buick crossed the roadway's centerline, departed the north roadside and began descending down a snow-covered embankment. The frontal plane of the vehicle impacted a medium-sized hardwood tree on the roadside resulting in moderate-to-severe damage (**Figure 1**).



Figure 1. 1998 Buick Century at scene

The driver was transported to a local hospital by a family member who arrived on-scene. The 4-year-old male passenger was removed from the booster seat by the driver, and was transported by air ambulance to a local hospital. He arrived at the hospital in a state of cardiac arrest, with a Glasgow Coma Score (GCS) of 3. He was pronounced dead at 1636 hours, approximately 41 minutes post-crash. The Buick Century was towed from the scene due to damage. The vehicle was declared a total loss by the insurance company and was sold to an auto salvage company.

This remote child safety seat investigation was identified by the National Highway Traffic Safety Administration (NHTSA) during a review of police crash reports. DSI received a faxed police report on July 13, 2007, and was assigned the case on July 15, 2007. On-scene photos and medical records were requested at that time. DSI received the medical records on February 12, 2008 and received the on-scene photos of the crash on February 19, 2008.

SUMMARY

Crash Site

This single-vehicle crash occurred on an east/west section of an undivided two-lane rural highway in January 2007. The roadway consisted of one lane in each direction (**Figure 2**). The roadway character was straight and level. The pavement was constructed of asphalt. The center line consisted of a yellow dash and solid stripe pattern which permitted eastbound traffic to pass. Just prior to the area of impact, the center line pattern changed to a single dash stripe. The north and south roadway edges were marked by solid white fog lines. Adjacent to the north roadway edge was a descending

embankment planted intermittently with assorted trees and brush.

The crash occurred at 1555 hours. The weather was clear and the asphalt roadway was dry. There was snow on the ground north of the roadway. The speed limit at this location was 89 km/h (55 mph).

Pre-Crash

The 1998 Buick Century was traveling eastbound at a driver estimated speed of 89 km/h (55 mph). The 46-year-old driver was restrained by a 3-point manual lap and shoulder belt. The 4-year-old male occupied the second row left position. He was seated in an Evenflo high-back belt positioning booster seat and restrained by the 3-point manual lap and shoulder belt. The driver stated she heard a loud noise toward the rear of the vehicle, and turned to check on the child in the back seat. The Buick crossed the roadway's centerline, and traveled off the left side of the roadway, and down the descending embankment (**Figure 3**).

Crash

The Buick's front end contacted a medium-sized tree. The vehicle rebounded rearward a short distance from the tree and came to rest approximately 1.0 m (3.0 ft) from the tree (**Figure 4**). The impact with the tree resulted in moderate-to-severe damage to the Buick's front end. The damage algorithm of the WinSmash program computed a total delta V of 36.0 km/h (22.4 mph)¹.

Post-Crash

The driver stated that following the crash, the 4-year-old child was crying due to a combination of his injuries and his inability to undo the restraint system. The driver unhooked his belt and assisted



Figure 2. Area of roadside departure



Figure 3. Approach to impact area



Figure 4. Buick at final rest

¹Calculated using estimated crush measurements.

him from the vehicle. After a short time, the child reportedly became unresponsive. He was transported by air ambulance to a local medical facility in the state of cardiac arrest, with a Glasgow Coma Score (GCS) of 3. It was learned that the child sustained a ruptured aortic versus leading to exsanguination, defined as a loss of blood. In addition, the child sustained internal trauma to his abdominal region, contusions to his abdomen and pelvis, and contusions to his left shoulder. He was pronounced dead at 1636 hours, 41 minutes following the crash.

The driver was transported to the hospital by a private vehicle belonging to a relative who arrived at the scene some time after the crash. During the crash, she sustained lacerations to the forehead and right knee, abrasions to her left head (temple area), and contusions to her left shoulder, right elbow, and left forearm.

VEHICLE DATA -1998 Buick Century

The Buick Century was identified by the Vehicle Identification Number (VIN): 2G4WS52M7W1xxxxxx. The Buick was a four-door, six passenger sedan that was equipped with a 3.1 liter, 6 cylinder engine, an automatic transmission, 4-wheel anti-lock brakes, and front-wheel drive. The vehicle manufacturer's recommended tire size was P205/70SR15; the recommended pressure is not known. The specific tire information was as follows:

Position	Measured Pressure	Measured Tread Depth	Restricted	Damage
LF	Unknown	Unknown	No	None
LR	Unknown	Unknown	No	None
RR	Unknown	Unknown	No	None
RF	Unknown	Unknown	No	None

The front row seating in the Buick was configured with fabric-covered bucket seats with folding backs and adjustable head restraints. The second row seating was configured with a fabric-covered bench seat with integral head restraints.

Vehicle Damage

Exterior Damage -1998 Buick Century

The Buick sustained moderate-to-severe damage to the front end due to the impact with the tree (**Figure 5**). The center aspect of bumper fascia was missing. The hood was buckled and displaced rearward. The bumper backing bar, radiator and engine were displaced rearward. The driver reported that the front left door was jammed shut. The direct damage was located laterally near the center and left of the front end, and vertically from the frame to the beltline. The estimated location for the direct damage began 37 cm (14.6 in) from the left front bumper corner and measured 25 cm (9.8 in) to the right laterally across the bumper. The combined estimated direct and induced damage began at the left front bumper corner and measured 155 cm (61.0 in) laterally across the entire front end. The estimated Collision Deformation Classification (CDC) for the tree impact was 12FYEN3.



Figure 5. Front end damage

Six crush measurements were estimated at bumper level as follows: C1 = 0 cm, C2 = 35 cm (13.8 in), C3 = 48 cm (18.9 in), C4 = 33 cm (13.0 in), C5 = 16 cm (6.3 in), C6 = 0 cm. The estimated maximum crush measurement was 50 cm (19.7 in) and was located between C2 and C3.

The barrier algorithm of the WinSmash program computed a total delta V of 36.0 km/h (22.4 mph) for the tree impact. The longitudinal and lateral components were -36.0 km/h (-22.4 mph) and 0 km/h respectively.

Interior Damage - 1998 Buick Century

The Buick sustained moderate interior damage as a result of passenger compartment intrusion and occupant contacts (**Figure 6**). The windshield was cracked. The rear view mirror was displaced from the windshield, the right instrument panel was intruded, and the second row seat back was deformed and intruded by shifting cargo from the trunk. Based on a review of the interior images, the following specific intrusions were observed:



Figure 6. First row interior damage

Position	Intruded Component	Magnitude of Intrusion	Direction
First row right	Instrument panel	> 3 cm to < 8 cm	Longitudinal
Second row left	Second seat back	> 8 cm to < 15 cm	Longitudinal

Manual Restraints - 1998 Buick Century

The Buick Century was configured with a front row split bench seat and separate back cushions. The outboard seats were equipped with 3-point manual lap and shoulder belts with sliding latch plates; the center seat was equipped with a lap belt. The first row shoulder belts were configured with adjustable D-ring anchorages. The driver seat belt anchorage was in the full down position. The front row outboard seats were configured with adjustable head restraints.



Figure 7. Second row interior belt restraints

The second row bench seat was configured with manual 3-point lap and shoulder belts for the outboard seat positions (**Figure 7**). The belts were equipped with sliding latch plates. A safety belt buckle was present for the middle seat position. The belt webbing was not visible in the interior images; this seat was probably equipped with a lap belt. The seat back was configured without head restraints.

The front row left lap and shoulder belt was used by the driver. After the crash, there was significant slack in the belt webbing, which indicated usage. The shoulder belt webbing was twisted, which prevented retraction of the webbing. The lap belt webbing was observed on the seat cushion. The driver sustained contusions to her shoulder and clavicle areas which were consistent with safety belt loading.

The second row left lap and shoulder belt was used by the 4-year-old male passenger. Interior images showed the shoulder belt routed through the upper left belt positioning slot. The belt webbing showed stretch marks in this area, which indicated loading by the booster seat. The belt webbing was spooled out and laid in the booster seat. The latch plate's position on the belt was consistent with having been used. The child sustained contusions and internal trauma consistent with loading of the belt. A review of the injuries indicated the shoulder belt had been worn under the child's arm rather than over the shoulder.

Child Safety Seat - Second Row Left

The 4-year-old male child occupied the second row left seat. The child was seated in an Evenflo Big Kid high-back belt positioning booster seat at the time of the crash (**Figures 8-9**). The model number and manufacture date are not known. The vehicle's 3-point manual lap and shoulder belt was used to restrain the child. The child seat was designed to be used only with a lap and shoulder belt. A review of on-scene images revealed that the shoulder belt was routed through the left side belt guide.

The Evenflo booster was designed to be used with or without the detachable back support. The manufacturer recommended that children weighing between 13.6 - 45.3 kg (30.0 - 100.0 lbs) and whose height is between 96.0 - 145.0 cm (38.0 - 57.0 in) use the booster seat with the back support. Children weighing between 18.0 - 45.3 kg (40.0 - 100.0 lbs) and whose height is between 101.0 - 145.0 cm (40.0 - 57.0 in), and whose ears are below the vehicle's head restraint may use the booster seat without the back support.

The child in this crash met the weight guidelines (18 kg/40 lbs); his height is not known.



Figure 8. Evenflo Big Kid booster seat



Figure 9. Evenflo booster seat, on-scene

Supplemental Restraint Systems - 1998 Buick Century

The Buick Century was equipped with frontal air bags for the front row driver and passenger positions. Both air bags deployed as a result of the impact with the tree. The driver air bag deployed from the steering wheel hub (**Figure 10**). The passenger air bag deployed from the top right instrument panel.



Figure 10. Driver's air bag

OCCUPANT DEMOGRAPHICS -1998 Buick Century

	Driver	Occupant 2
Age/Sex:	47/Female	4/Male
Seated Position:	Front left	Second row left
Seat Type:	Split bench	Bench seat
Height:	Unknown	Unknown
Weight:	Unknown	18 kg (40 lbs), per medical record
Alcohol/Drug Involvement:	None	N/A
Body Posture:	Unknown	Seated on booster seat
Hand Position:	Unknown	Unknown
Foot Position:	Unknown.	Unknown
Restraint Usage:	Lap and shoulder belt available, used	Lap and shoulder belt available, used with booster seat
Air bag:	Steering wheel mounted air bag, deployed	None

OCCUPANT KINEMATICS

Driver Kinematics

The 46-year-old female driver was seated in an unknown posture and was reportedly restrained by the vehicle's lap and shoulder belt. According to the investigating agency, the driver heard a loud noise emanating from the rear of the vehicle and immediately turned to monitor the status of the rear seated child. The driver allowed the vehicle to track to the left and depart the roadside. The vehicle descended a snow-covered embankment and struck a medium-sized tree with its frontal plane. The vehicle's frontal air bags deployed and the driver initiated a forward trajectory in response to the 12 o'clock direction of force. The driver loaded the lap and shoulder belt webbing, and it is probable she also loaded the air bag, causing an abrasion to the left side of her head. She sustained a contusion to her left shoulder and it is likely the safety belt webbing was the source for this injury. The driver also suffered a laceration to her forehead; the rearview mirror became separated from the windshield during the crash and it is possible that this component caused that injury. The driver also sustained contusions to her right elbow and left forearm and a laceration to her right knee. The review of images for this remote case did not reveal the specific sources for these injuries.

The driver exited the vehicle under her own power and then assisted the second row left child passenger from the vehicle. She was transported by a family member to a local hospital where she was treated and released.

Second Row Left Occupant Kinematics

The 4-year-old male seated within the Evenflo Big Kid booster seat was improperly restrained by the lap and shoulder belt. His belt usage status was supported by the on-scene images provided by the investigating agency and the injury patterns identified within the images. They revealed an injury pattern consistent with wearing the shoulder belt under his arm as opposed to over his left shoulder. The contusions along his chest deviated from the near 45-degree diagonal contusion pattern typically seen when the shoulder belt is used properly. The contusions were linear in form at an angle of approximately 30 degrees above horizontal. The bruising began at the lower aspect of his left chest, extended under his left arm, and terminated near his left shoulder blade.

At impact with the tree, the child responded to the frontal crash by initiating a forward trajectory and loading the safety belt webbing. The belt positioned as it was allowed for the torso to override the rigid webbing resulting in a ruptured aorta and the bruising patterns described above. The child also sustained horizontal contusions along his abdominal region, bilateral hip contusions and internal trauma to his abdominal region. The abdominal injuries were exacerbated by the lack of support to his upper torso from the out-of-position shoulder belt.

Following the crash, the driver reported that the child began to cry and complain that he could not remove the restraint system. The driver exited the vehicle and removed the child. Shortly after exiting the vehicle, the child lost consciousness. He was transported by air ambulance to a regional medical facility and expired 41 minutes after the crash.

OCCUPANT INJURIES - 1998 Buick Century

Driver: Injuries obtained from discharge summary.

<u>Injury</u>	<u>AIS Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Laceration, forehead	290600.1,7	Rearview mirror	Possible
Abrasion, left temple	290202.1,2	Driver air bag	Probable
Contusion, left shoulder/clavicle area	790402.1,2	Seat belt webbing	Probable
Contusion, right elbow	790402.1,1	Unknown	N/A
Contusion, left forearm	790402.1,2	Unknown	N/A
Laceration, right knee	890600.1,1	Unknown	N/A

Second row left occupant: Injuries obtained from history and physical report, and discharge summary. No autopsy was conducted.

<u>Injury</u>	<u>AIS Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Ruptured aorta	420210.5,4	Shoulder belt webbing	Certain
Contusions, left chest	490402.1,2	Shoulder belt webbing	Certain
Contusions, left back	690402.1,2	Shoulder belt webbing	Certain
Contusions, abdomen	590402.1,4	Lap belt webbing	Certain
Bilateral hip contusions	890402.1,3	Lap belt webbing	Certain
Blunt trauma to abdomen	515099.7,0	Lap belt webbing	Certain

Attachment 1. Scene Diagram

