On Site Child Safety Seat Investigation / Vehicle v. Object
Dynamic Science, Inc. / Case Number: DS03010
1997 Ford Taurus LX four-door
Colorado
March, 2003

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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 the crash severity, the installation and performance of a child safety seat, and the injury mechanisms for the four child passengers of a 1997 Ford Taurus. This single vehicle crash occurred in March, 2003 at approximately 1500 hours. The crash occurred off-road, near a four-lane undivided state highway. The case vehicle was a 1997 Ford Taurus four-door sedan driven by a 62-year-old female. The front right seat was occupied by an improperly restrained 9-year-old male. The rear left seat was occupied by a lap and shoulder belt restrained 4-year-old male. The rear middle seat was occupied by a 2-year-old female who was seated in a forward facing child seat. The rear right seat was occupied by an improperly restrained 8-year-old female. The vehicle was traveling westbound in the second lane from the right at 105 km/h (65 mph). The case vehicle drifted to the left and departed the roadway. The vehicle traveled in a westbound direction before striking a 10 cm (4 in) wooden fence rail with its front left end. The fence rail was pushed out of the ground. The case vehicle continued on for an additional 12 m (41 ft) before striking a metal culvert that was sunk into an embankment. Both front air bags deployed at this time. The case vehicle rotated in a clockwise direction and came to rest facing north. The driver sustained some minor abrasions and contusions. She was able to exit the vehicle on her own. She was transported to a local hospital and then hospitalized overnight. The front right occupant sustained contusions to the frontal lobe, an L3 Chance fracture involving the pedicle and spinous process, fracture of 11th rib on left side, and multiple abrasions. He was transported by air to an area trauma center where he was placed in pediatric intensive care. He was hospitalized for seven days. The rear left occupant was fatally injured. He sustained a fracture/transection of the cervical spine and cord at C7, a laceration/transection of right subclavian vein and right internal jugular vein, subdural hemorrhages, cerebral edema, and various contusions. He was declared dead after hospital arrival. The rear middle occupant child was removed from the vehicle by motorists responding to the crash. She sustained minor injuries, including: a laceration to her forehead, above the right eye and an abrasion to her left shoulder. She was being held by driver when the last group of EMTs arrived. She was transported by ground ambulance to a local hospital. The rear right occupant sustained an aortic tear, retroperitoneal hemorrhage, left radius and ulna fractures, an L3 Chance fracture, and multiple abrasions/contusions. She was air lifted to an area trauma center. She was hospitalized for 15 days.

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Air bag, deployment, injury, child seat, fatality, passenger.	

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Dynamic Science, Inc.
Accident Investigation
Case Number: DS03010

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BACKGROUND:

Description:	This child safety seat case was identified by a National Transportation Safety Board (NTSB) investigator. The investigator contacted the Special Crash Investigation office directly. DSI was assigned the case on April 1, 2003. All field work was completed on April 8, 2003. Attending the inspection of the case vehicle was the NTSB investigator, several local highway patrol investigators, and the responding tow truck operator.
Investigation Type:	On-site
Crash Location:	Colorado
Crash Date:	March, 2003
Notification Date:	April 1, 2003
Field Work Completed:	April 8, 2003

SUMMARY:

Crash Site

This single vehicle crash occurred in March, 2003 at approximately 1500 hours. The crash occurred off-road, near a four-lane undivided state highway. There is a positive 4% grade approaching the area of the crash. There is a negative 30% slope on the left side of the roadway leading into a farm field. The speed limit is 105 km/h (65 mph).

Figure 1. Approach to area of road departure (west)

Pre-Crash

The case vehicle was a 1997 Ford Taurus four-door sedan driven by a 62-year-old female (157 cm/62 in, 59 kg/130 lbs). The vehicle trunk was apparently full of luggage. A cardboard box containing unknown objects was in the right side of the trunk.

The front right seat was occupied by an improperly restrained 9-year-old male (34 kg/75 lbs, height unknown). Per the responding EMT, this occupant had the shoulder belt tucked under his arm.

The rear left seat was occupied by an lap and shoulder belt restrained[1] 4-year-old male (114 cm/45 in, 20 kg/44 lbs). Several of the first responders to this crash indicated that the available lap and shoulder belt had been used in the correct configuration.

The rear middle seat was occupied by a 2-year-old female (14 kg/31 lbs, height unknown) who was seated in a forward facing Century Brevera Classic child seat (Model #4865R CK).

The rear right seat was occupied by an improperly restrained 8-year-old female (height and weight unknown). Per the responding EMT, this occupant had the seat belt behind her back.

Figure 2. Road departure (west)

The vehicle was traveling westbound in the second lane from the right at 105 km/h (65 mph). According to the driver, the cruise control was on. The driver had fallen asleep[2].

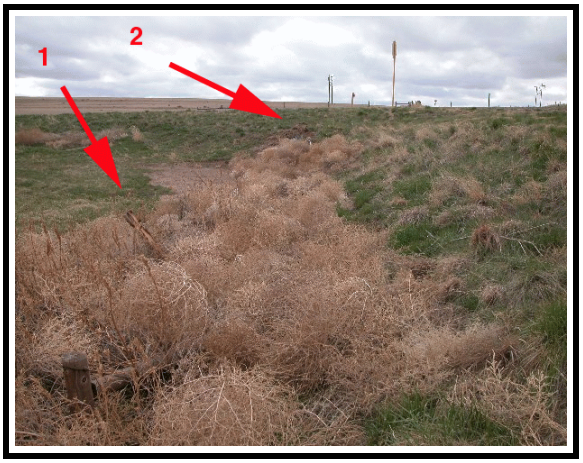

Figure 3. Impact with post, then culvert

Crash

The case vehicle drifted to the left and departed the roadway. The vehicle traveled 48 m (157 ft) in a westbound direction before striking a 10 cm (4 in) wooden fence rail with its front left end (12FLEE3). The fence rail was pushed out of the ground. The ground is muddy and soft at this location. The case vehicle continued on for an additional 12 m (41 ft) before striking a metal culvert that was sunk into an embankment (12FDEW2).

The total velocity change calculated by the Barrier algorithm of the WinSmash collision model was 32 km/h (20 mph). The longitudinal and lateral components were -32 km/h (-20 mph) and 0 km/h (0 mph), respectively.

The case vehicle rotated in a clockwise direction and came to rest facing north.

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[1]Child this age should have been in a booster seat per NHTSA and manufacturer recommendations.

[2]The driver reported that she had fallen asleep at the wheel twice before several years ago. One incident resulted in a crash.

Post-Crash

A number of drivers responded to the crash early on. Three ambulance units responded from three separate locations.

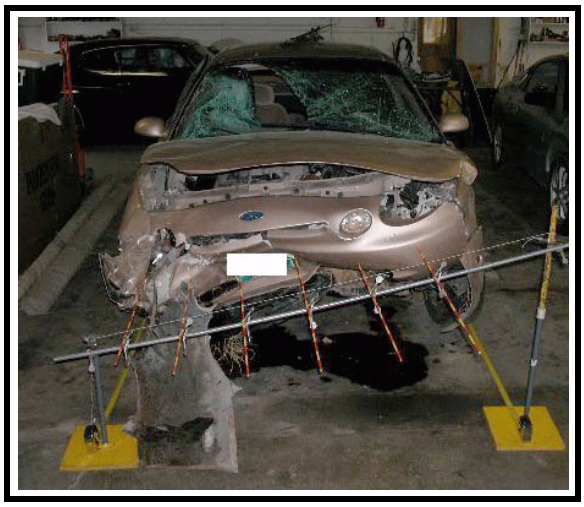

Figure 4. Front, case vehicle

The driver sustained minor abrasions and contusions. She was able to exit the vehicle on her own. She was transported to a local hospital where she was first seen at 1655 hours (1 hour 55 minutes post-crash) and then hospitalized overnight.

The front right occupant sustained hemorrhages to the frontal lobe, an L3 Chance[3] fracture involving the pedicle and spinous process, fracture of 11th rib on left side, and multiple abrasions. Responding EMTs indicated that he also cut his lip and chipped a tooth. His seat belt was cut and he was removed by the EMTs. He was transported by air to an area trauma center where he was placed in pediatric intensive care. When he arrived he was intubated and sedated, with a Glasgow Coma Scale (GCS) of 3. He was hospitalized for seven days.

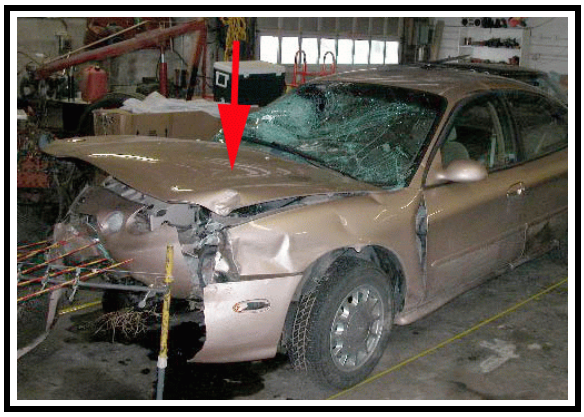

Figure 5. Front left–shows post impact to left corner

The rear left occupant was fatally injured. He sustained a fracture/transection of the cervical spine and cord at C7, a laceration/transection of right subclavian vein and right internal jugular vein, subdural hemorrhages, cerebral edema, and various contusions. He was found in the vehicle slumped over to his right. Civilian responders initially provided CPR on the child while he was still in the vehicle in an upright position. They were in contact with emergency personnel via cell phone during this time. They obtained permission to remove the child from the vehicle. They cut the seat belt off him and placed him flat on the roadway and continued CPR. He was declared dead after hospital arrival. The coroner indicated that the..."cause of death is due to the combined impact of head and neck injuries second to blunt force trauma sustained in the motor vehicle accident."

The rear middle occupant child was removed from the vehicle by motorists responding to the crash. She sustained minor injuries, including: a 10.1 cm (4.0 in) laceration to her forehead,

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[3]A horizontal fracture of a vertebral body, which can be combined with fractures of laminae or spinour processes or with ligamentous tears. Chance fractures often result from seat belt injuries. The injury results from acute flexion, as of the trunk of the body over the seat belt during a vehicular accident. (American Health)

above the right eye and an abrasion to her left shoulder. She was being held by driver when the last group of EMTs arrived. She was transported by ground ambulance to a local hospital.

The rear right occupant sustained an aortic tear, retroperitoneal hemorrhage, left radius and ulna fractures, an L3 Chance fracture, and multiple abrasions/contusions. Her seat belt was cut and she was removed from the vehicle by the EMTs. She was air lifted to an area trauma center. She was hospitalized for 15 days.

VEHICLE DATA - 1997 Ford Taurus

Description:	1997 Ford Taurus LX four-door
VIN:	1FALP53S6VAxxxxxx
Odometer:	Unknown, digital
Engine:	3.0 L V6
Reported Defects:	None related to this crash
Cargo:	Luggage, unknown weight

VEHICLE DAMAGE

Exterior Damage - 1997 Ford Taurus

Damage Description:	Major front end damage. Right side doors slightly jammed. Vehicle declared a total loss by insurance company.	
CDC:	Impact 1: 12FLEE3 Impact 2: 12FDEW2	
Delta V (Impact 2):	Total	32 km/h (20 mph)
	Longitudinal	-32 km/h (-20 mph)
	Latitudinal	0 km/h (0 mph)
	Energy	66,248 joules (48,862 ft-lbs)

The case vehicle sustained 9.0 cm (3.5 in) of direct contact to the left corner from the initial impact with the fence post. For impact 2, the case vehicle sustained 122.0 cm (48.0 in) of direct contact damage across the front end beginning at the left front bumper corner. The residual crush measured along the bumper reinforcement bar was as follows: C1=0 cm (0 in), C2=13.0 cm (5.1 in), C3=29 cm (11.4 in), C4=35 cm (13.8 in), C5=37 cm (14.6 in), C6=32 cm (12.6 in). The maximum crush was located at C5. The principle direction of force (PDOF) was within the 12 o'clock sector and was an estimated 0 degrees. The impact energy was managed by the forward structures of the vehicle. The damaged components for this impact included the bumper fascia and reinforcement bar, upper and lower radiator supports, and hood. The left wheelbase was shortened by 3.0 cm (1.2 in), the right by 18 cm (7.0 in).

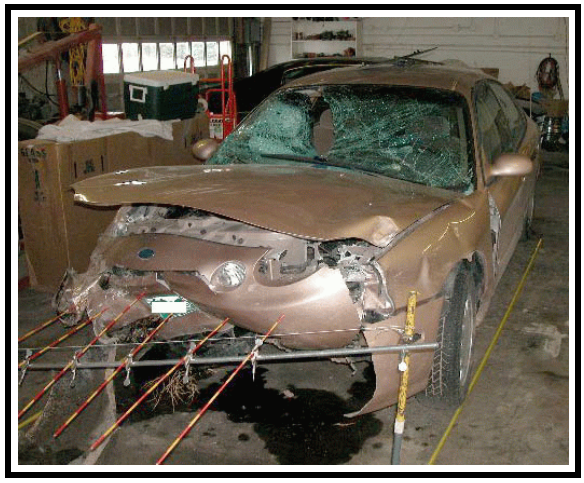


Figure 6. Front left, case vehicle

Figure 7. Close up of damage from initial impact

Interior Damage - 1997 Ford Taurus

Interior damage to the Taurus included windshield damage from the impact, left side toe pan intrusion, and occupant contacts to the rear of the driver's seat back.

The right half of the rear bench seat back failed. The bottom left of this seat was held in place by a metal pin that is inserted into a hole in the left bottom of the seat back–forming a hinge. In normal operation, the seat rotates about the left and right hinges as this seat is folded down to allow access to the trunk area. According to the tow truck operator, the trunk contained a large heavy cardboard box. At impact, the box struck the base of the back of the seat. The bottom of the seat back was forced forward. The pin connecting the seat back remained in place, but did come out of the seat side hole. Post impact, the box was found resting on the back of the failed back seat after the crash. The contents of the box are not known, but it seems likely that the failure was load related. The locking mechanism was struck by an unknown object and was damaged.

Figure 8. Rear seat back failure

Figure 9. Bottom hinge failure

MANUAL RESTRAINT SYSTEMS - 1997 Ford Taurus

The Taurus was configured with manual 3-point lap and shoulder belts for both front positions and the rear outboard seat positions. The middle rear seat position was equipped with a manual lap belt. The front seat restraints were configured with adjustable shoulder belt upper anchorages. The driver's anchorage was adjusted to the mid position, the front right anchorage was adjusted to the full down position. The driver's seat belt was equipped with an emergency locking retractor. The front right and rear outboard seat belts were equipped with switchable retractors (retractors that can be changed from an emergency locking retractor to an automatic locking retractor to assist in securing child seats). All the lap and shoulder seat belts were equipped with sliding latch plates.

Figure 10. Contact to back seat locking mechanism

The front right passenger's seat belt and all three rear seat belts were equipped with switchable retractors (retractors that can be changed from an emergency locking retractor to an automatic locking retractor to assist in securing child seats).

AIR BAG SYSTEM - 1997 Ford Taurus

The driver and front right passenger air bags deployed during the second impact. The driver's air bag module was an "H" design and located in the center hub of the steering wheel rim. The top flap measured 15 cm (6 in) x 8 cm (3 in) high. The bottom flap measured 15 cm (6 in) wide x 5 cm (2 in) high. There was no contact evidence on the cover flaps. The diameter of the air bag measured 60 cm (24 in) in its deflated state. There was a single tether and the air bag was internally vented. There were blood smears to the entire bottom of the air bag face.

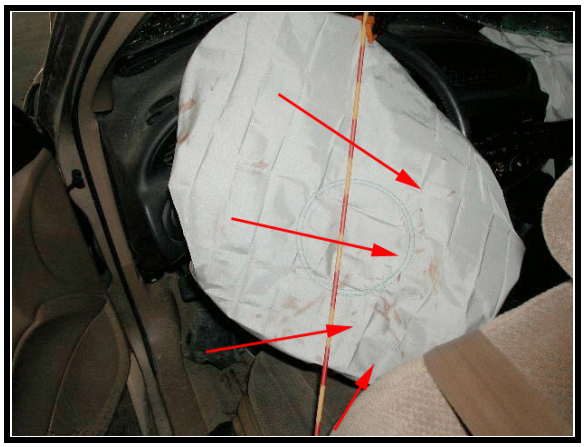


Figure 11. Driver's air bag. Arrows show blood smears.

The front right passenger air bag was a top mount design located in the right aspect of the instrument panel. There was a single module cover that was vaguely rectangular in shape. It measured 44 cm (17 in) wide x 27 cm (11 in) high. The deflated air bag measured 56 cm (22 in) wide x 54 cm (21 in) high. The bag had a maximum excursion of 54 cm (21 in). The air bag was not equipped with vent ports or tethers. There were blood drops on the right bottom of the air bag face.

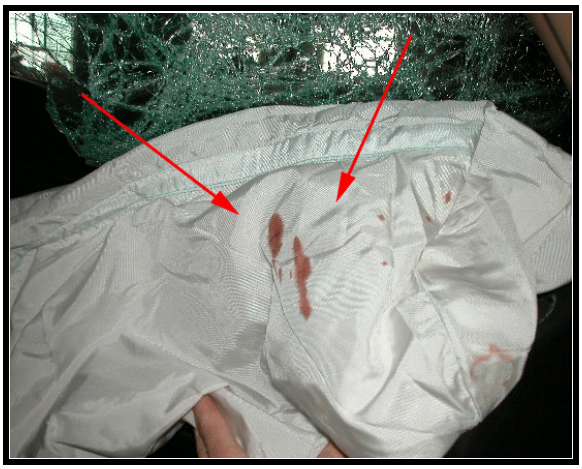


Figure 12. Front right passenger air bag. Blood drops marked by arrows.

CHILD SAFETY SEAT - 1997 Ford Taurus

The rear middle seat was occupied by a 2-year-old female who was seated in a forward facing Century Breverra Classic child seat (Model #4865 RCK) with a 5-point harness. It is unclear if the seat was manufactured in 1998 or 1996 (the label is illegible). There is a comfort clip warning for Century Breverra models, but no recalls. The manufacturer recommends usage with children who weigh between 14-18 kg (30-40 lbs) and whose height is between 89-109 cm (35-43 in). The weight of this occupant was estimated to be 14 kg (31 lbs), putting her at the lower end of the range. It is not known if she met the height requirement.

It appears that the child seat was anchored to the vehicle using the available lap belt. There were loading marks to the lap belt. It also appears that the child seat was not tightly anchored to the vehicle seat. The responding EMT indicated that the seat was found tipped over and leaning to the right with the base 15-20 cm (6-8 in) off the seat bottom.

Figure 13. Front, child safety seat

Figure 14. Position of child seat at time of inspection

At the time of the inspection the 5-point harness was found to have been partially unthreaded. Both shoulder straps were no longer in their respective slots in the back of the child seat. There are loading marks to both the seat and harness that indicate that the harness was being used. However, it does not appear that the shoulder straps were secured properly. In normal usage the straps are passed from the front to rear through either the upper or lower horizontal slots in the seat back–dependent on the height of child. The straps are then threaded through the metal adjuster bar above the slots on the back of the seat (see Attachment 1). However, loading evidence found on the back of the child seat between the upper and lower slots would indicate that the straps had been routed from one slot to another in some fashion, and not correctly secured with the metal adjuster bar. The most likely configuration would have been the straps initially being routed through the bottom slot from the front, up to the top slot and back out to the front, and then back through the bottom slot before being incorrectly secured by the adjuster bar.

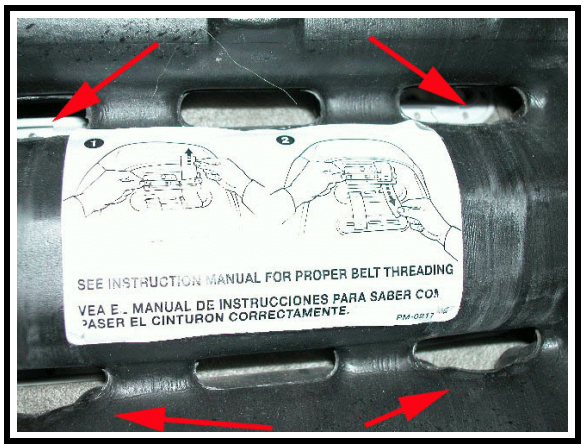


Figure 15. Loading marks to back of child seat

Figure 16. Load marks to lap belt

OCCUPANT DEMOGRAPHICS - 1997 Ford Taurus

Case vehicle	Occupant 1	Occupant 2
Age/Sex:	62/Female	9/Male
Seated Position:	Front left	Front right
Seat Type:	Fabric covered split bench with folding back, seat adjusted to forward most track position. Seat back was slightly reclined.	Fabric covered split bench with folding back, seat adjusted to between forward most and middle track position. Seat back was slightly reclined.
Height:	157 cm (62 in)	Unknown
Weight:	59 kg (130 lbs)	34 kg (75 lbs)
Occupation:	Bank employee	NA
Pre-existing Medical Condition:	None indicated	None
Alcohol/Drug Involvement:	None	NA
Driving Experience:	Presumed to be > 20 years	NA
Body Posture:	Driver asleep. Likely held in an generally upright position by the lap and shoulder belt.	Unknown
Hand Position:	Unknown	Unknown
Foot Position:	Both feet on floorboard. Cruise control on.	Unknown
Restraint Usage:	Lap and shoulder belt available, used correctly.	Lap and shoulder belt available, used incorrectly. Shoulder belt tucked under arm.
Air bag:	Steering wheel mounted air bag available, deployed.	Top instrument panel mounted air bag, deployed.

	Occupant 3	Occupant 4
Age/Sex:	4/Male	2/Female
Seated Position:	Rear left	Rear middle
Seat Type:	Fabric covered bench seat with folding back.	Fabric covered bench seat with folding back.
Height:	113 cm (45 in)	Unknown
Weight:	20 kg (44 lbs)	14 kg (31 lbs)
Occupation:	NA	NA
Pre-existing Medical Condition:	None	None
Alcohol/Drug Involvement:	NA	NA
Driving Experience:	NA	NA
Body Posture:	Upright right. Lap belt at level of umbilicus.	Upright, facing forward.
Hand Position:	Unknown	Unknown
Foot Position:	Given child size, feet likely not touching floorboard.	Unknown
Restraint Usage:	Lap and shoulder belt used.	Manual belt used with child safety seat. Child seat not tightly anchored to vehicle seat.

	Occupant 5
Age/Sex:	8/Female
Seated Position:	Rear right
Seat Type:	Fabric covered bench seat
Height:	Unknown
Weight:	Unknown
Occupation:	NA
Pre-existing Medical Condition:	None
Alcohol/Drug Involvement:	NA
Driving Experience:	NA
Body Posture:	Upright.
Hand Position:	Unknown
Foot Position:	Unknown
Restraint Usage:	Lap and shoulder belt available, used incorrectly. Shoulder belt behind back.

OCCUPANT INJURIES - 1997 Ford Taurus

Driver: Injuries obtained from discharge summary, radiology report, emergency room record and history/physical report.

INJURY	OIC CODE	ICD-9	SOURCE
Slight contusion, lateral right clavicle	490402.1,1	922.1	Unknown
Abrasion, center chest	490202.1,4	911.0	Shoulder belt
Abrasion, center abdomen	590202.1,4	911.0	Lap belt
Contusion, left elbow	790402.1,2	913.0	Left door panel
Abrasion, above left eyebrow	290202.1,7	910.0	Air bag
Abrasion, below left eye	290202.1,2	910.0	Air bag
Contusion, between eyebrows	290402.1,2	920.0	Air bag
Contusions, below lip	290402.1,8	920.0	Air bag
Abrasion, left knee	890202.1,2	916.0	Lower instrument panel
CT scan revealed L1/L2 fracture but indicated that it was most likely an old injury.			

Front right occupant (02): Injuries obtained from discharge summary and radiology report.

INJURY	OIC CODE	ICD-9	SOURCE
Contusions, frontal lobe	140620.3,3	851.4	Air bag
L3 Chance fracture involving the pedicle and spinous process	650626.3,8	805.4	Lap belt (flexion injury)

Fracture, 11th rib on left side	450212.1,7	807.01	Lap belt (flexion injury)
Abrasion, left abdomen	590202.1,2	911.0	Lap belt
Abrasion, right elbow	790202.1,1	913.0	Right door panel
Chipped tooth (per interviewee)	251499.1,8	873.63	Unknown
Lip laceration (per interviewee)	290600.1,8	873.43	Air bag

Rear left occupant (03): Injuries obtained from autopsy report.

INJURY	OIC CODE	ICD-9	SOURCE
Fracture/transection cervical spine and cord at C7	640268.5,6	806.06	Shoulder belt (flexion injury)
Laceration/transection of right subclavian vein and right internal jugular vein at union forming right innominate vein[4]	421606.4,1 (subclavian vein) 320806.3,1 (internal jugular)	901.03 900.1	Shoulder belt
Laceration/transection intercostal arteries, adjacent to aorta	422008.3,2	901.81	Shoulder belt
Infratentorial (just below the cerebellum) subdural hemorrhage (45 cc)	140446.5,6	852.2	Rear seat back (rebound injury)
Subarachnoid hemorrhage, right cerebral hemisphere with swelling	140466.3,6	852.0	Rear seat back (rebound injury)

[4]Formed by the junction of the right internal jugular vein and right subclavian vein. Approximately 2.5 cm in length it lies behind the sternal end of the right clavicle and anterolateral to the brachiocephalic artery. Joins the left brachiocephalic vein to form the superior vena cava.

Abrasion, rectangular shape 30.4 cm (12.0 in) in length and varying in width from 1.3 x 1.9 cm (0.5-0.75 in). At the level of the umbilicus with an upward orientation in the midline.	590202.1,0	911.0	Lap belt
Abrasion, right flank, continued from abdomen. Rectangular shape, 7.6 cm (3.0 in) in length, 1.3 cm (0.5 cm) wide	590202.1,1	911.0	Lap belt
Contusion, midline of upper back, 2.5 cm (1.0 in)	690402.1,4	922.3	Seat back (rebound injury)
Abrasion, left forearm. Longitudinally oriented measuring 2.5 cm (1.0 in) long by 1.0 cm (0.4 in) wide	790202.1,2	913.0	Left door panel
Contusion, anterior surface of right ankle	890402.1,1	924.21	Driver's seat
Contusion, dorsal surface of left foot.	890402.1,3	924.20	Driver's seat
Soft tissue injury, chest wall, upper left anterior surface	490099.1,2	Unk	Shoulder belt
Contusion, anterior surface of right forehead	290402.1,7	920.0	Unknown

Rear middle occupant (04): Injuries obtained from history and physical report and radiology report.

INJURY	OIC CODE	ICD-9	SOURCE
Closed head injury was ruled out	NA	NA	NA
10.1 cm (4.0 in) laceration on forehead, above right eye	290602.1,7	873.42	Unknown
Right eye swollen			Unknown
Abrasion, left shoulder, angled to the right	790202.1,2	912.0	Child seat straps

Rear right occupant (05): Injuries obtained from emergency room records, discharge summary, radiology report, and surgical report.

INJURY	OIC CODE	ICD-9	SOURCE
Aorta tear (traumatic occlusion of the infra renal abdominal aorta), retro peritoneal hemorrhage	520299.4,4	902.0	Lap belt
Left radius fracture	752800.2,2	813.83	Child seat
Left ulna fracture	753200.2,2	813.83	Child seat
L3 Chance fracture	650616.2,8	805.4	Lap belt (flexion injury)
Right forehead abrasion	290202.1,7	910.0	Possibly seat bottom
Laceration, left abdomen	590600.1,2	879.2	Lap belt
Abdominal contusion, center	590402.1,.4	922.2	Lap belt

Occupant Kinematics

The case vehicle was traveling west at approximately 105 km/h (65 mph). The vehicle left the road on the left side and struck a wooden fence rail (impact 1). This was a minor impact and had a negligible effect on the vehicle and its occupants. The vehicle continued on a struck a metal culvert that was sunk into an embankment (impact 2).

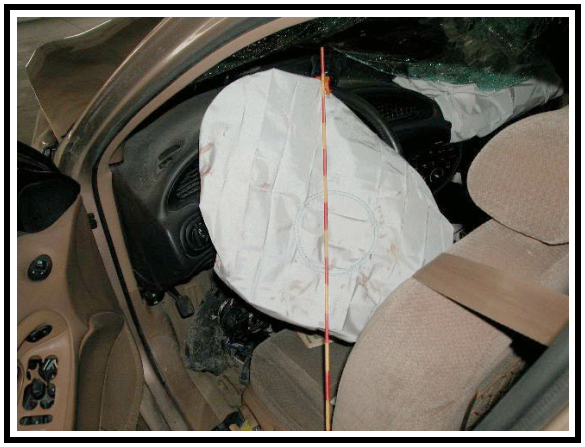


Figure 17. Driver's air bag

The 62-year-old female (157 cm/62 in, 59 kg/130 lbs) driver of the case vehicle had fallen asleep. She was seated in essentially an upright position on the fabric covered split bench seat. The seat had been adjusted to between the forward most and middle track position. The seat back was slightly reclined. She was wearing the available lap and shoulder belt. The manual shoulder belt upper anchorage was in the mid position. At impact 2, the driver's front air bag deployed. The driver responded to the 12 o'clock direction of force by exhibiting a forward trajectory and loading the manual restraint system–causing the chest and abdominal abrasions. Her face contacted the deployed air bag–causing the facial contusions. Her left knee contacted the lower instrument panel–causing an abrasion. There was some loading to the seat back from the rear seat occupants, but this does not appear to have had any negative effect to the driver. The driver exited the vehicle on her own.

Figure 18. Left knee contact

The 9-year-old front right male occupant (34 kg/75 lbs, height and weight unknown) was seated in essentially an upright position on the fabric covered split bench seat. The seat had been adjusted to between the rear most and middle track position. The seat back was slightly reclined. He was wearing the available lap and shoulder belt incorrectly. The shoulder belt had been placed under his right arm. The belt was equipped with a switchable retractor that was in ELR mode at the time of the crash. The manual shoulder belt upper anchorage was in the full down position. At impact 2, the front right passenger's front air bag deployed. This occupant responded to the 12 o'clock direction of force by exhibiting a forward trajectory and loaded the lap belt with his abdomen–causing an abrasion to the left side--and pitching forward. The pitching forward motion resulted in an L3 Chance fracture. This occupant engaged the deployed air bag with his face–causing the brain injuries and lip laceration. His right elbow engaged the right door side panel–causing a minor abrasion. This occupant also sustained a fracture of the 11th rib on the left side. This occurred as a result of the loading to the shoulder portion of the lap and shoulder belt, which was tucked under his arm. His seat belt was cut and he was removed by the responding EMTs.

Figure 19. Lap and shoulder belt, front right occupant

Figure 20. Front right passenger air bag

The 4-year-old rear left seat male occupant (113 cm/45 in, 20 kg/44 lbs) was seated in essentially an upright position on the fabric covered bench seat. The seat back was slightly reclined by design. He was wearing the available lap and shoulder belt. It was likely that the lap portion had been placed across his abdomen at the level of his umbilicus. His stature would have placed the shoulder belt toward the upper part of his chest near his neck. The belt was equipped with a switchable retractor that was in ELR mode at the time of the crash. At impact 2, this occupant responded to the 12 o'clock direction of force by exhibiting a forward trajectory and loaded the lap belt with his abdomen. His legs extended forward and struck the back of the driver's seat. His head pitched forward rapidly over the shoulder harness causing a fracture/transection of the cervical spine and cord at C7. This occupant also sustained a laceration/transection of the right subclavian vein and right internal jugular vein. This was due to movement of the head first forward and then sharply to the left as it pivoted on shoulder belt. After first pitching forward, this occupant rebounded rearward and struck the back of the seat with his head–causing both brain injuries.

He came to rest in his seat belt slumped to the right. Civilian responders initially provided CPR on the child while he was in the vehicle in an upright position. They were in contact with emergency personnel via cell phone. They obtained permission to remove the child from the vehicle. They cut the seat belt off him and placed him flat on the roadway and continued CPR. He was declared dead after hospital arrival.

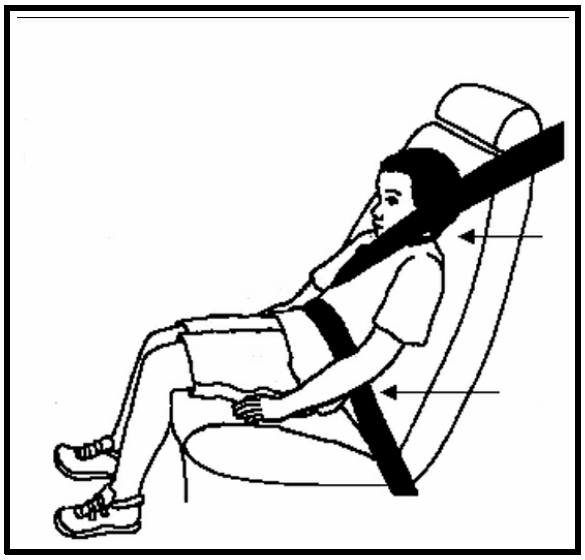


Figure 21. Exemplar view of likely seat belt orientation for rear left occupant (feet/legs would most likely have been stretched out).

Figure 22. Left rear seating area

Figure 23. Rear left seat belt–shows loading and point where it was cut off

The 2-year-old rear middle female occupant was seated in a forward facing Century Breverra Classic child seat with a 5-point harness. The manufacturer recommends usage with children who weigh between 14-18 kg (30-40 lbs) and whose height is between 89-109 cm (35-43 in). The child seat was anchored to the vehicle using the available lap belt. The lap belt was routed through the correct slots. There were loading marks to the lap belt. It also appears that the child seat was not tightly anchored to the vehicle seat. The 5-point harness was in use during the crash. There are loading marks to both the seat and harness that indicate that the harness was being used. However, it does not appear that the shoulder straps were secured properly. In normal usage the straps are passed from the front to rear through either the upper or lower horizontal slots in the seat back–dependent on the height of child. The straps are then threaded through the metal adjuster bar above the slots on the back of seat. However, loading evidence found on the back of the child seat between the upper and lower slots would indicate that the straps had been routed from one slot to another in some fashion. The most likely configuration would have been the straps initially being routed through the bottom slot from the front, up to the top slot and back out to the front, and then back through the bottom slot before being secured by the metal locking mechanism.

Figure 24. Position of child seat at time of vehicle inspection

Figure 25. Child safety seat

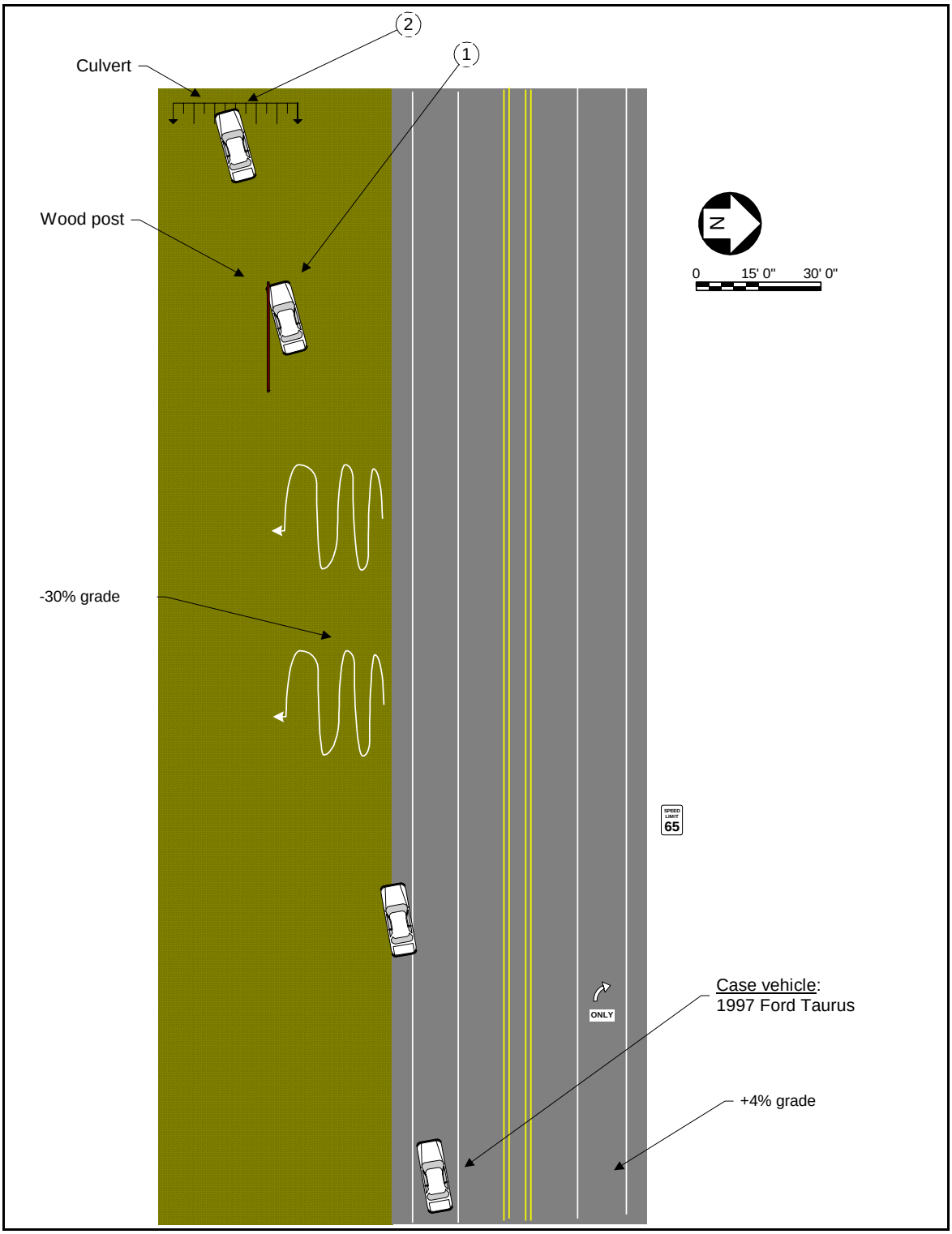
At impact 2, this occupant responded to the 12 o'clock direction of force by exhibiting a forward trajectory and loaded the child safety seat straps–causing the left shoulder abrasion. The child seat pitched forward, both due to the loose lap belt adjustment and the failed right rear seat back. The child sustained a forehead laceration but the injury source is not known. The responding EMT found the seat found tipped forward and leaning to the right with the base 15-20 cm (6-8 in) off the seat bottom.

The 8-year-old rear right female occupant was seated in essentially an upright position on the fabric covered bench seat. The seat back was slightly reclined by design. She was wearing the available lap and shoulder belt. Per the responding EMT, this occupant had the shoulder belt behind her back. The belt was equipped with a switchable retractor that was in ELR mode at the time of the crash. At impact 2, this occupant responded to the 12 o'clock direction of force by exhibiting a forward trajectory and loaded the lap belt with her abdomen–causing the aortic tear and abdominal contusion. Her head pitched forward sharply and she sustained a L3 Chance fracture. This forward motion and the loading of the lap belt was likely exacerbated by the failed right rear seat back which would have pushed her torso further forward and down. After the impact, the case vehicle rotated sharply in a clockwise direction. This occupant would have been pushed to the left by the rotation forces and likely came into contact with the child seat in the rear middle seat position. This contact possibly caused the left ulna and radius fractures. Her seat belt was cut and she was removed by the responding EMTs.

Figure 26. Right rear seat position

Figure 27. Loading to right rear lap and shoulder belt

Attachment 1. Scene Diagram



Attachment 2. Excerpts from Century Breverra Instruction Manual

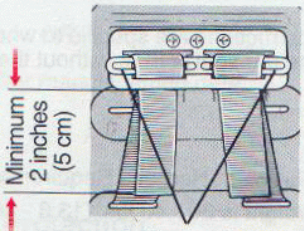
WITH HARNESS
30 - 40 Lbs. (13.6 - 18 Kg)

ADJUST CAR SEAT TO FIT CHILD

* Adjust Harness Straps

Harness straps ***MUST*** be through slots ***at*** or just ***above*** (closest to) child's shoulders.

• To Lengthen or Shorten Harness Strap



Adjuster Bar

1 When shortening, lift adjuster bar and pull ends of harness straps down until all slack is removed.

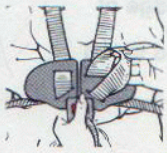
2 When lengthening, lift adjuster bar and pull harness straps from front of car seat to desired length.

⚠WARNING
End of each strap must be at least 2 inches (5 cm) below metal plate.

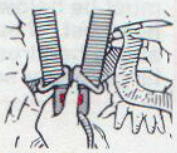
3 Pull harness straps on front side to lock adjuster bar.

4 When adjusting harness straps, pull harness straps through tongue to remove all slack.

Harness straps must be snug on child's chest and low and snug on hips, just touching thighs.



With Shield



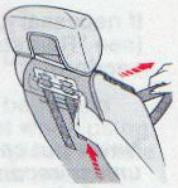
Without Shield

7

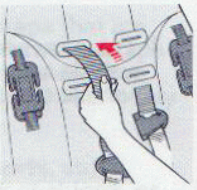
ADJUST CAR SEAT TO FIT CHILD continued

• To Change Harness Strap Slots

1 Lift adjuster bar and pull harness straps out of current slots.

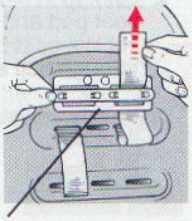


2 Thread harness straps through desired slots ***at*** or just ***above*** (closest to) child's shoulders.



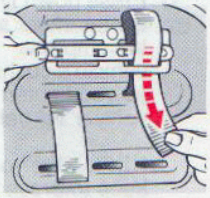
NOTE: For ease in threading harness straps, reach behind pad through flap.

3 Thread harness straps behind opening in metal plate and adjuster bar as shown.

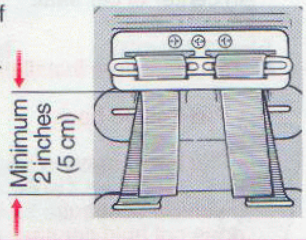


Metal Plate

4 Lift adjuster bar and thread straps over adjuster bar, creating loop, and down behind metal plate as shown.



5 Pull ends of harness strap down.



⚠WARNING
End of each strap must be at least 2 inches (5 cm) below metal plate.

8

WITH HARNESS
30 - 40 Lbs. (13.6 - 18 Kg)

BASIC INFORMATION continued

❋ Height and Weight Limits

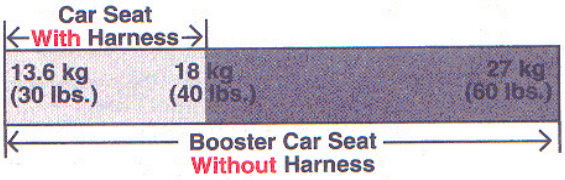
⚠ WARNING
Read this section carefully. Incorrect use can cause serious injury or death.

Find child's weight and follow instructions for harness system use.

The instructions are specific to whether you plan to use the car seat with or without the harness system.

Car Seat With Harness Requirements:

- Weight is 30 - 40 lbs. (13.6 - 18 kg).
- Minimum of 35 inches (89 cm) tall.
- Child's shoulders are not above top harness slots.



Booster Car Seat Without Harness Requirements:

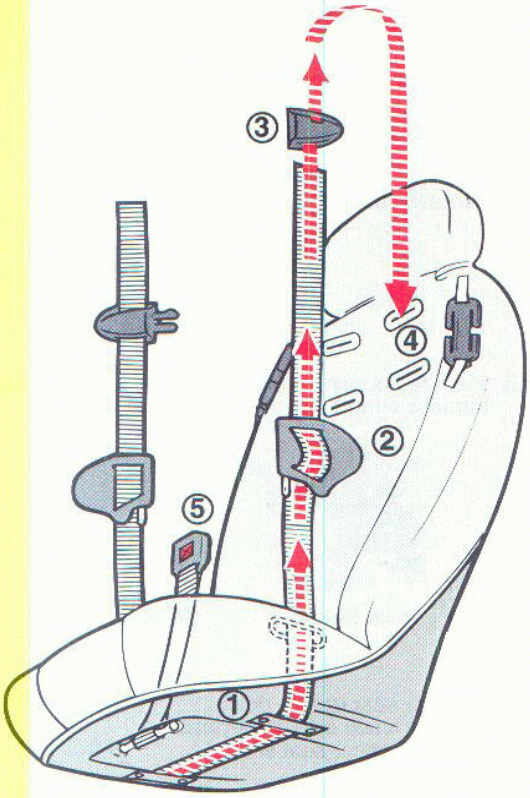
- Weight is 30 - 60 lbs. (13.6 - 27 kg).
- Height from 35 - 50 inches (89 - 127 cm) tall.
- Child's ears are ***not*** above top of booster car seat.

⚠ WARNING
To avoid injuries from whiplash, top of child's ears must be below top edge of headrest. If ears are above headrest, child is too large for car seat.

RE-ASSEMBLY OF HARNESS SYSTEM

Follow steps below to thread harness system as shown.

When re-assembling harness system, be sure harness straps are not twisted.



① Thread end of harness strap through seat pad, both clips on bottom and back up through seat pad.

② Thread end through tongue.

③ Thread end through harness tie.

④ Thread end through slots and adjuster following instructions in "Adjust Harness Straps" in the "Adjust Car Seat To Fit Child" section.

⑤ Pull buckle out of buckle slot.