

Child Safety Seat Investigation/ Vehicle to Vehicle
Dynamic Science, Inc. / Case Number: DS05004
2000 Ford Expedition
California
March 2005

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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 <p>This on-site investigation focused on a forward facing child safety seat (CSS) that was installed in the second row left position of a 2000 Ford Expedition. The Ford Expedition was occupied by a restrained 29-year-old female driver and a 3-year-old female second row left seat passenger, who was restrained in a forward facing CSS. The CSS was anchored to the vehicle using the available lap and shoulder belt. The other vehicle was a 1984 GMC Vandura minivan being driven by a 28-year-old male. The front of the Ford Expedition was struck by the GMC Vandura in a head-on configuration after the GMC crossed the center divider and traveled into the westbound travel lanes. The impact resulted in sufficient longitudinal deceleration of the Ford to command the deployment of the frontal air bag system. Both vehicles came to rest in the westbound travel lanes. The driver of the Expedition sustained a subdural hematoma, bilateral lung contusions, a left femur fracture, a minor splenic injury, a left tibia fracture and multiple lacerations and contusions. She was transported by air to a local trauma center for treatment. She was hospitalized for six days. The 3-year-old occupant of the Expedition sustained a right arm fracture. She was transported by air to a local pediatric trauma center for treatment. The driver of the GMC Vandura was fatally injured.</p>			
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BACKGROUND

Description

This on-site investigation focused on a forward facing child safety seat (CSS) that was installed in the second row left position of a 2000 Ford Expedition. The Ford Expedition was occupied by a restrained 29-year-old female driver and a 3-year-old female second row left seat passenger, who was restrained in a forward facing CSS. The CSS was anchored to the vehicle using the available lap and shoulder belt. The other vehicle was a 1984 GMC Vandura minivan driven by a 28-year-old male. The front of the Ford Expedition was struck by the GMC Vandura in a head-on configuration after the GMC crossed the center divider and traveled into the westbound



Figure 1. Front, 2000 Ford Expedition

travel lanes. The impact resulted in sufficient longitudinal deceleration of the Ford to command the deployment of the frontal air bag system. Both vehicles came to rest in the westbound travel lanes. The driver of the Expedition sustained a subdural hematoma, bilateral lung contusions, a left femur fracture, a minor splenic injury, a left tibia fracture and multiple lacerations and contusions. She was transported by air to a local trauma center for treatment. She was hospitalized for six days. The 3-year-old occupant of the Expedition sustained a right arm fracture. She was transported by air to a local pediatric trauma center for treatment. The driver of the GMC Vandura was fatally injured.

This child safety seat case was identified by NHTSA from a news report. DSI was notified on March 18, 2005. DSI located the vehicle and child safety seat on March 25, 2005. DSI was assigned the case on March 28, 2005. The vehicle and child safety inspection were conducted on March 28, 2005.

SUMMARY

Crash Site

This two vehicle crash occurred in an unincorporated area of southern California in March 2005 at 1940 hours. At the time of the crash, there were no adverse weather conditions and the asphalt roadway was dry. The east/west roadway was configured with three lanes in both directions which were separated by a raised concrete curbed median containing plants and wood chips. The east and west travel lanes are separated by broken white lines. There is a gentle right hand curve for eastbound travel with a slight up hill grade. Both the north and south roadway edges are bordered by raised concrete sidewalks. It was dark at the time of the crash and the streetlights were on. The speed limit in both directions is 80 km/h (50 mph).

Pre-Crash

The case vehicle was a 2000 Ford Expedition sport utility vehicle that was being driven by a lap and shoulder belt restrained 29-year-old female. The second row left seat was occupied by a 3-year-old female (91 cm/36, 18 kg/40 lbs) seated in a forward facing child safety seat.

The other vehicle was a 1984 GMC Vandura minivan being driven by a 28-year-old male. His driver's license had been suspended. The driver was a member of Alcoholics Anonymous. There is a history of this driver having seizures and passing out.

The Ford Expedition was traveling westbound in the middle lane at an unknown speed. The GMC Vandura was traveling eastbound in the middle lane at an unknown speed.

Crash

For unknown reasons, the GMC Vandura veered to the left and onto the median. The vehicle first struck and overrode a street sign. The vehicle then traveled onto the westbound travel lanes. The Ford Expedition struck the GMC Vandura in a head-on configuration (12FDEW5). The impact resulted in sufficient longitudinal deceleration of the Ford to command the deployment of the frontal air bag system. The missing vehicle routine of the WinSmash program computed a total delta v of 77.1 km/h (47.9 mph)¹. The longitudinal and lateral components were -76.0 km/h (-47.2 mph) and 13.4 km/h (8.3 mph), respectively. The Ford Expedition rotated counterclockwise and came to rest on the roadway facing southwest. The GMC Vandura rotated sharply counterclockwise and came to rest on the roadway facing north.

Post-Crash

The driver of the Vandura was fatally injured. He sustained a broken neck and numerous soft tissue injuries. Several witnesses to the crash responded immediately after the vehicles came to rest. One of the witnesses had paramedic experience. He observed the driver of the Vandura lying on his right side across the right passenger seat and believed him to be already deceased. A second witness noted that the driver was warm, diaphoretic and had no pulse. EMS personnel pronounced the driver dead at 1950 hours.



Figure 2. Approach to point of impact (west)

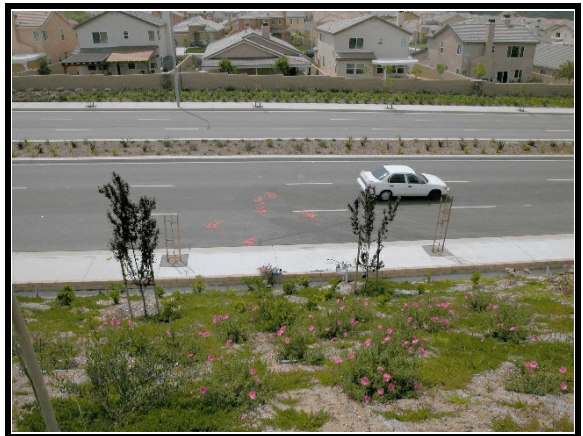


Figure 3. Overview of impact area and final rest (south)

¹Calculated using stiffness values derived from NCAP test number 3485.

The driver of the Expedition remained in her seat with the seat belt on. The first responding witness noted that she was unconscious and slumped to her right against the center console. She was removed from the vehicle by fire department personnel. She sustained a subdural hematoma, bilateral lung contusions, a left femur fracture, a minor splenic injury, a left tibia fracture and multiple lacerations and contusions. She was transported by air to a local trauma center for treatment. She arrived at the hospital with a Glasgow Coma Scale (GCS) score of 13 (4/5/4). She was only oriented to her name. She was hospitalized for a total of six days.

The 3-year-old occupant of the Expedition was found still secured in the CSS. She was crying and screaming and attempting to unbuckle herself from the CSS. One of the witnesses finished unbuckling the child and pulled her from the vehicle through the left window. The witness with the paramedic training did a quick check of the child. He found some crepitous in the right shoulder and noted scratches to her face. Fire department personnel arrived shortly after the crash and began treating the child. She sustained fractures to the right humerus, right radius, right ulna, and left clavicle. She also sustained soft tissue injuries to her head, legs, face and chest. She was transported by air to a local pediatric trauma center for treatment. She was treated and released at 0021 hours the following morning—approximately four hours post-crash.

Both vehicles were towed from the scene due to damage. The Expedition was declared to be a total loss by the insurance company and was later sold to a private party. The GMC Vandura was placed on hold by the police pending the completion of their investigation.

VEHICLE DATA - 2000 Ford Expedition

The 2000 Ford Expedition XLT four-door sport utility vehicle was identified by its Vehicle Identification number (VIN): 1FMRU15L1YLxxxxxx. The vehicle was equipped with a 5.4 liter, eight cylinder engine, 4-speed automatic with over-drive, four-wheel disc brakes, rear wheel drive, power steering, and a tilt steering wheel.

The Ford was equipped with Uniroyal Laredo P225/70R16 tires. The specific tire data is as follows:

Tire	Tread	Measured pressure	Manufacturer recommended pressure	Restricted	Damage
LF	4 mm (5/32 in)	Flat	241 kPa (35 psi)	Yes	Rim fractured, tire holed
LR	4 mm (5/32 in)	193 kPa (28 psi)	241 kPa (35 psi)	No	None
RR	5 mm (6/32 in)	200 kPa (29 psi)	241 kPa (35 psi)	No	None
RF	4 mm (5/32 in)	234 kPa (34 psi)	241 kPa (35 psi)	No	None

The seating in the Ford Expedition was configured with leather-covered front bucket seats with integral head restraints, second row 60-40 folding rear split-bench seats, and a removable full folding third row bench seat. The driver's seat was adjusted to the fully forward position. Post-impact, the seat back angle was 70 degrees from horizontal and the seat bottom was pitched upward at a 40 degree angle. The seat was twisted counterclockwise. The front right seat was adjusted to a mid position, 45.0 cm (17.7 in) rearward of the A pillar. The seat back angle measured 65 degrees from horizontal; the seat bottom angle was 20 degrees from horizontal. Both seats were equipped with integral head restraints that were not damaged. The second row left seat back was deformed forward to a point 5 degrees forward of vertical and the seat bottom had a 10 degree angle from horizontal.

VEHICLE DAMAGE

Exterior Damage - 2000 Ford Expedition

Damage Description: The 2000 Ford Expedition sustained severe front end damage as a result of the impact with the Vandura. The direct damage began at the left bumper corner and extended 112.0 cm (44.1 in) laterally. Four crush measurements were taken along the bumper plane: C1=131.0 cm (51.6 in), C2=101.0 cm (39.8 in), C3=57.0 cm (22.4 in), C4=0.0 cm (0.0 in). The right side of the bumper was pushed over the top of the frame rail. The hood was folded rearward and there was damage to the grille and radiator area. Red paint transfers were found along the bumper and grille areas. There was direct damage along the left side of the vehicle to the left rear door area caused by post impact rotation. There was remote buckling to the left side that extended into the left rear quarter panel area. The left front, right front, and left rear doors were jammed shut. The windshield was cracked from impact forces. The left rear side glass was disintegrated due to impact forces. The left wheelbase was shortened by 89.0 cm (35.0 in). The left rim was shattered and the left front tire was flat.

CDC: 12FDEW5

Delta V:	Total	77.1 km/h (47.9 mph)
	Longitudinal	-76.0 km/h (-47.2 mph)
	Latitudinal	13.4 km/h (8.3 mph)
	Energy	624,680 joules (460,740 ft-lbs)



Figure 4. View of bumper from front left



Figure 5. Left side

Interior Damage - 2000 Ford Expedition

The 2000 Ford Expedition sustained heavy interior damage as a result of occupant contacts, passenger compartment intrusion, and multiple air bag deployments.

The specific passenger intrusions were documented as follows:

Position	Intruded Component	Magnitude of Intrusion	Direction
Front left	Instrument panel	40.0 cm (15.7 in)	Longitudinal
Front left	Knee bolster	33.0 cm (12.9 in)	Longitudinal
Front left	Toe pan	38.0 cm (14.9 in)	Longitudinal
Front left	Seat bottom	8.0 cm (3.1 in)	Vertical
Front right	Toe pan	25.4 cm (10.0 in)	Vertical
Second row left	Seat back	10.0 cm (3.9 in)	Longitudinal
Second row middle	Seat back	14.0 cm (5.5 in)	Longitudinal
Second row left	Seat bottom	8.0 cm (3.1 in)	Vertical

The roof was deformed from the frontal impact, causing the ventilation control pods to fall out. The steering wheel rim was deformed forward at the top and the bottom. The tilt steering column was deformed upwards. The adjustable foot controls were deformed. There was blood and tissue on the deformed parking brake. The driver's shoes were found on the floor near the foot controls. The knee bolster was deformed bilaterally. There was blood on the center console. There was a striated scuff mark on the second row left seat back from contact with the lap and shoulder belt during impact.

MANUAL RESTRAINT SYSTEMS - 2000 Ford Expedition

The 2000 Ford Expedition was configured with manual 3-point lap and shoulder belts for each of the outboard seating position. Both front seat safety belts were equipped with retractor pretensioners and adjustable shoulder belt anchorages. The driver's seat belt pretensioner actuated as a result of the impact with the GMC Vandura; the right side pretensioner did not actuate. The driver's seat belt anchorage was in the



Figure 6. Loading/scuff marks to second row, left side safety belt

full down position, the front right seat anchorage was in the mid position. The driver's seat belt was configured with a sliding latch plate and an emergency locking retractor. The remaining outboard seat belts were configured with sliding latch plates and switchable automatic locking/emergency locking retractors. The second and third row middle seats were configured with manual lap belts.

The second row left safety belt was used to secure an occupied forward facing child safety seat. The safety belt was found still anchoring the child seat at the time of the inspection. There was approximately 45.0 cm (17.7 in) of scuffs from loading found on the belt.

FRONTAL AIR BAG SYSTEM - 2000 Ford Expedition

The 2000 Ford Expedition was equipped with dual stage frontal air bags and safety belt retractor pretensioners for the driver and front right passenger positions. The frontal air bags deployed and the driver's pretensioner actuated as a result of the longitudinal deceleration of the Expedition during the impact with the van.

The driver's air bag deployed from the center of the steering wheel through symmetrical H - configuration module cover flaps. The top flap measured 19.0 cm (7.5 in) wide by 15.0 cm (5.9 in) high. The bottom flap measured 19.0 cm (7.5 in) wide by 6.5 cm (2.6 in) high. The bottom flap was found jammed beneath the steering wheel rim. The deployed driver's air bag measured 54.0 cm (21.3 in) in diameter in its deflated state. The air bag was equipped with a single internal tether that was attached to the circular stitching in the center of the air bag face. Two circular vent ports that measured 3.0 cm (1.2 in) in diameter were located at the 11 and 1 o'clock aspects on the back of the air bag. The air bag material was burned at the mid point between the two vent ports and 8.0 cm (3.1 in) above a line between the ports. The melted portion measured 3.0 cm (1.2 in) wide by 4.0 cm (1.6 in) high. The melted portion was surrounded by a wider area of scorching.

The front right passenger's air bag deployed from a mid mount module with a rectangular cover that was hinged at the forward aspect. The module cover flap measured 39.0 cm (15.4 in) wide by 17.0 cm (6.7 in) high. The deployed front right passenger's air bag measured 51.0 cm (20.1 in) wide from seam to seam by 60.0 cm (23.6 in) high. There were no tethers or vent ports.



Figure 7. Driver's air bag



Figure 8. View of vent ports and burns to back of driver's air bag

Child Safety Seat

A Century Breverra Ascend SE 44892 forward facing CSS was positioned in the second row left seat of the Ford Expedition. The model number was 44892UH and the date of manufacture was August 21, 2002. The convertible CSS was configured with a five-point harness system and a two piece locking harness retainer clip. The seat was being used in the forward facing mode using the 5-point harness. The second row left safety belt was used to anchor the child safety seat. The safety belt was found still anchoring the child seat at the time of the inspection. There was approximately 45.0 cm (17.7 in) of scuffs from loading found on the belt. The manufacturer outlined recommended usage of the seat is as follows:

With harness system

Child **must** meet all of the following requirements:

- Weight is 13.6-18.1 kg (30-40 lbs)
- Height is 89.0-109.2 cm (35-43 in)
- Child is able sit upright unassisted
- Child's shoulders are **not** above the top harness

Without harness system

Child **must** meet all of the following requirements:

- Weight is 13.6-36.3 kg (30-80 lbs)
- Height is 89.0-127.0 cm (35-50 in)
- Child is able sit upright unassisted
- Top of child's ears are **not** above the top of headrest

The child in this case met the “with harness system” height recommendation (91 cm/36 in) and the weight recommendation (18 kg/40 lbs). At the time of the CSS inspection, the harness straps were routed through the bottom set of harness slots. The seat was equipped with a tether attachment, which was not used.

An unoccupied Graco back-less booster seat was also present in the vehicle. It was not anchored to the vehicle. The model number was 8491SCT and the date of manufacture was August 20, 2003.



Figure 9. Century Ascend child seat still anchored to vehicle



Figure 10. Century child seat. Scuff to seat back from shoulder belt.



Figure 11. Child seat anchorage



Figure 12. Front of Century child seat after being removed from vehicle

VEHICLE DATA - 1984 GMC Vandura

Description:	1984 GMC Vandura minivan	
VIN:	Unknown	
Odometer:	Unknown	
Engine:	Unknown	
Reported Defects:	None noted	
Cargo:	Unknown	
Damage Description:	Major front end damage. Vehicle towed from the scene.	
Delta V:	Total	95.5 km/h (59.3 mph)
	Longitudinal	-94.0 km/h (-58.3 mph)
	Latitudinal	-16.6 km/h (-10.3 mph)
	Energy	814,694 joules (600,887 ft-lbs)



Figure 13. Exemplar view of 1984 GMC Vandura

OCCUPANT DEMOGRAPHICS - 2000 Ford Expedition

	Driver	Occupant 2
Age/Sex:	29/Female	3/Female
Seated Position:	Front left	Second row left
Seat Type:	Leather-covered front bucket seat with integral head restraint	Leather covered bench seat with folding back
Height:	160 cm (63 in)	91 cm (36 in)
Weight:	61 kg (135 lbs)	18 kg (40 lbs)
Occupation:	Unknown	None
Pre-existing Medical Condition:	None noted	None noted
Alcohol/Drug Involvement:	None	NA
Driving Experience:	Approximately 10 years	NA
Body Posture:	Normal, upright	Normal, upright
Hand Position:	Unknown	Unknown
Foot Position:	Right foot on accelerator, left on floor	Unknown
Restraint Usage:	Lap and shoulder belt available, used.	Lap and shoulder belt used with child safety seat
Air bag:	Steering wheel mounted driver's air bag available, deployed.	None

OCCUPANT DEMOGRAPHICS - 1984 GMC Vandura

Age/Sex:	28/Male
Seated Position:	Front left
Seat Type:	Unknown
Height:	178 cm (70 in)
Weight:	86 kg (190 lbs)
Occupation:	Unknown
Pre-existing Medical Condition:	History of having seizures and passing out
Alcohol/Drug Involvement:	BAC test (negative), drugs (none detected), per coroner's report
Driving Experience:	Unknown
Body Posture:	Unknown
Hand Position:	Unknown
Foot Position:	Unknown
Restraint Usage:	Lap and shoulder belt available, <u>not</u> used per police

OCCUPANT INJURIES - 2000 Ford Expedition

Driver: Injuries obtained from discharge summary, emergency department summary, history and physical report, operative report, and radiology reports.

<u>Injury</u>	<u>OIC Code</u>	<u>Injury mechanism</u>	<u>Confidence Level</u>
Subdural hematoma (minor) right parietal	140652.4,1	Unknown	Unknown
Bilateral lung contusions (minor)	441410.4,3	Driver air bag	Probable
Left comminuted mid shaft femur fracture	851814.3,2	Lower instrument panel /indirect	Certain
Splenic injury NFS (minor)	544299.2,2	Lap belt webbing	Possible
Left open tibia shaft fracture	853420.2,2	Foot controls	Certain
Fractures of the left L2-L4 transverse processes (minimally displaced)	650620.2,8	Driver air bag/indirect	Probable
Lacerations of the right elbow	790602.1,1	Unknown	Unknown
Laceration of the scalp (corresponds to the area of the sub-dural hematoma)	190602.1,1	Unknown	Unknown
Lacerations of the 4 th and 5 th left metacarpal (dorsal aspect)	790602.1,2	Windshield	Possible
Contused right arm (medial)	790402.1,1	Center console	Possible
Contused right breast (laterally)	490402.1,1	Shoulder harness	Probable

Second row left occupant: Injuries obtained from emergency room and radiology records.

<u>Injury</u>	<u>OIC Code</u>	<u>Injury mechanism</u>	<u>Confidence level</u>
Oblique fracture of surgical neck of the right proximal humerus (fracture - fragments are over riding by approx. 1.5 cm (0.6 in.) / displacement)	752604.3,1	Driver seat back	Probable
Torus buckle fracture of the right distal radius	752802.2,1	Driver seat back	Probable
Torus buckle fracture of the right distal ulna	753202.2,1	Driver seat back	Probable
Fracture of medial left clavicle (50% inferior displacement of the distal fracture fragment)	752200.2,2	CSS webbing	Probable
Contusion to forehead (5x5 cm / 2x2 in.)	290402.1,7	Driver seat back	Probable
Multiple abrasions over left leg	890202.1,2	Driver seat back	Probable
Laceration left lower leg	890600.1,2	Driver seat back	Probable
Multiple abrasions right thigh (medial)	890202.1,1	Unknown	Unknown
Laceration, 2 mm, left side of face	290602.1,2	Unknown	Unknown
Chest contusion, unknown location	490402.1,9	CSS webbing	Probable
Left knee contusion	890402.1,2	Driver seat back	Probable

OCCUPANT INJURIES - 1984 GMC Vandura

Driver: Injuries obtained from coroner's office report, coroner investigator's report and police report. No invasive autopsy was conducted.

<u>INJURY</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Broken neck	615099.7,6	Unknown	Unknown
Lacerations, back of head	190600.1,6	Unknown	Unknown
Lacerations, legs	890600.1,3	Unknown	Unknown
Abrasions, both knees	890202.1,3	Unknown	Unknown

OCCUPANT KINEMATICS - 2000 Ford Expedition

Driver Kinematics

The 29-year-old driver of the Ford Expedition was seated in a forward facing fashion. The adjustable foot controls appear to have been in the fully rearward (toward driver) position. The driver was using the available lap and shoulder belt. Her right foot was on the accelerator, her left on the floor. There were no indications from any witness that the driver attempted any evasive maneuvers prior to the crash. At impact, the frontal air bags deployed and the safety belt pretensioner actuated. The female driver initiated a forward and slightly left trajectory. She loaded the safety belt. Her face and torso engaged the deployed air bag. The steering wheel rim was deformed forward. Both of her knees engaged the intruding knee bolster/instrument panel. Her left lower leg/ankle engaged the parking brake—depositing blood and tissue. Her right foot deformed the brake and accelerator pedals.



Figure 14. Overview of driver's seated position



Figure 15. Left knee contact

Second row left occupant kinematics

The 3-year-old female child was restrained in the forward facing CSS by the 5-point harness. The CSS was installed in the second row left position by the available lap and shoulder belt. The belt had not been switched to the automatic locking retractor mode and a locking clip was not being used. The harness was routed through the lower set of harness slots.

At impact, the female child occupant initiated a forward and slightly left trajectory. She loaded the child safety seat harness. The child seat, in turn, loaded the lap and shoulder belt. She pitched forward but was held in place by the child seat harness. It appears that her right arm either flew forward from impact forces or was already out in front of the child in a defensive maneuver. Her right hand likely contacted the back of the driver's seat resulting in an indirect fracture injury to the arm.



Figure 16. Floor pan and foot controls



Figure 17. Child seat position relative to the back of the driver's seat

Attachment 1. Scene Diagram

