On-Site Child Safety Seat Investigation
Dynamic Science, Inc. (DSI), Case Number DS08013
1999 Ford Contour LX
California
April 2008

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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.

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient Catalog No.
DS08013		

4. Title and Subtitle	5. Report Date
Child Safety Seat Investigation	June 16, 2009
	6. Performing Organization Report No.

7. Author(s)	8. Performing Organization Report No.
Dynamic Science, Inc.	

9. Performing Organization name and Address	10. Work Unit No. (TRAIS)
Dynamic Science, Inc. 299 West Cerritos Avenue Anaheim, CA 92805	11. Contract or Grant no. DTNH22-07-00045

12. Sponsoring Agency Name and Address	13. Type of report and period Covered [Report Month, Year]
U.S. Dept. of Transportation (NVS-411) National Highway Traffic Safety Administration 1200 New Jersey Ave, SE Washington, DC 20590	14. Sponsoring Agency Code

15. Supplemental Notes

16. Abstract

This on-site investigation focused on two occupants who were restrained in child safety seats and the rollover dynamics of a 1999 Ford Contour. The vehicle was being driven by a restrained 29-year-old female. The second row was occupied by a 3-year-old female and a 5-year-old female who were seated in forward facing child safety seats. The vehicle drifted off the left roadside; alerted, the driver steered right, then left, inducing a counterclockwise yaw. The vehicle partially departed the left roadside and climbed an embankment. As the vehicle rotated along the embankment, it overturned two quarter turns.

The driver sustained minor injuries; the 3-year-old sustained a minor injury; and the 5-year-old was not injured. None of the occupants were transported or treated for injuries. The Ford was towed due to damage and was later declared a total loss by the insurance company.

17. Key Words	18. Distribution Statement
Child safety seat, rollover	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No of pages	22. Price

Dynamic Science, Inc.
Crash Investigation
Case Number: DS08013

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Background

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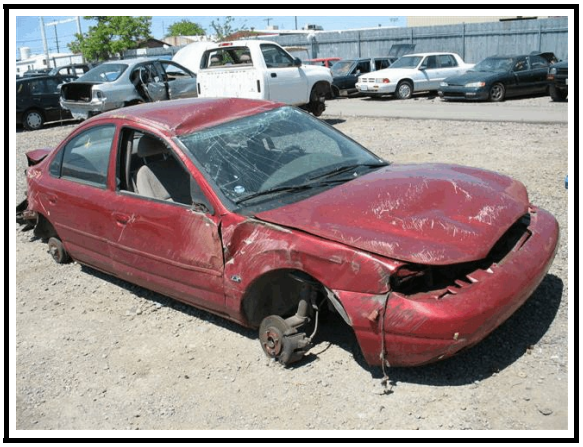

Figure 1. Subject vehicle, 1999 Ford Contour LX

This child safety seat investigation was initiated by NHTSA in response to an internet news article that reported two properly restrained children were uninjured in a rollover crash. The crash occurred in April 2008. On April 24, DSI was notified of the incident and instructed to locate the subject vehicle and the child safety seats. On April 28, 2008, DSI obtained a copy of the police report. The subject vehicle had been sold to an auto salvage facility, and the child safety seats were in the possession of the driver of the subject vehicle. On April 29, 2008, DSI obtained permission to inspect the subject vehicle and the child safety seats. The auto salvage company indicated the vehicle's tires, engine and transmission had already been removed, and that the body and interior were intact. The case was assigned on April 29, 2008. The vehicle was inspected on May 1, 2008.

Summary

Crash Site

The crash site consisted of a physically divided east/west roadway. The roadway was configured with two eastbound travel lanes that were separated from two westbound lanes by a wide median that ascended above grade. The control loss occurred in the inboard eastbound lane (**Figure 2**). The roadway was of asphalt composition and was bordered on either side by narrow paved shoulders. Beyond the paved shoulders were ditches and lateral to the ditches were raised embankments. The right shoulder measured 1.3 m (4.4 ft) in width, and the first lane from the right measured 3.81 m (12.5 ft) in width. The second lane from the right measured 3.7 m (12.0 ft) in width, and the right shoulder measured 0.6 m (1.9 ft) in width. The travel lanes were

Figure 2. Crash site, eastbound approach

separated by raised pavement markers and reflectors. Bordering the outboard lane was a solid white fog line. Bordering the inboard lane was a solid yellow stripe.

The roadway character was straight and slightly ascending near the area of the impact. Four profile measurements of the roadway were taken at 30.5 m (100 ft) intervals, beginning 91.4 m (300 ft) west of the area of final rest and ending at the area of final rest. The profile measurements were as follows: 1.9 degrees at 91.4 m (300 ft), 1.5 degrees at 61.0 m (200 ft), 0.9 degrees at 30.5 m (100 ft), and 0.7 degrees at the area of final rest.

To the left of the inboard lane was a strip of slightly descending unpaved ground that measured 1.5 m (5.0 ft) in width, followed by a shallow ditch, and then a raised embankment. The embankment rose approximately 2.1 m (7.0 ft) above the roadway and was comprised of dirt, rock and vegetation.

Pre-Crash

The crash occurred during daylight. Conditions were clear, and the roadway was dry. The speed limit at the crash site was 89 km/h (55 mph). The Ford was traveling eastbound in the inboard lane at a driver estimated speed of 97 km/h (60 mph). The driver became distracted as she searched for a compact disc that was somewhere in the passenger compartment. When the driver's attention returned to the roadway, she observed that her left side tires had departed the roadway and were tracking on the dirt shoulder.

In an attempt to return to the roadway, the driver steered to the right. The vehicle returned to the roadway but the driver lost control of the vehicle. The driver attempted to regain control by steering back to the left. The vehicle initiated a counterclockwise yaw and rotated approximately 90 degrees to the left. Again, the vehicle departed the roadway on the left side. The vehicle's left rear rim and tire deposited a gouge and a skid mark on the roadway at the area of departure. The gouge measured 1.5 m (4.9 ft) in length; the skid mark measured 6.8 m (22.3 ft) in length. The gouge was straight, overlapped the skid mark, and was located in the middle section of the skid.

Crash

The vehicle's front end impacted the embankment in an endswipe configuration. The endswipe was a low Delta V event and did not interrupt the rotational dynamics of the vehicle. The Ford continued its counterclockwise rotation for another 90 degrees, and the vehicle's right rear quarter panel impacted the embankment. The vehicle continued its counterclockwise rotation for approximately another 45 degrees, reentered the roadway, and then initiated a left side leading trip-over. The vehicle rolled two quarter turns and came to rest on its roof. The vehicle came to rest on the inboard lane, heading southeast. Based on scene evidence, the distance from the vehicle's trip point to the final resting point was 8.0 m (26.3 ft). The distance from the right side impact with the embankment and the point of trip was 2.9 m (9.5 ft). From the point of the roadside departure to the area of final rest, the Ford traveled approximately 27.0 m (88.6 ft).

Post-Crash

The driver exited the vehicle unassisted through the left side door. She then assisted the two children from the vehicle. The second row left occupant was seated in a child safety seat (CSS) and

restrained by its 5-point harness. The driver opened the second row left side door, unbuckled the 5-point harness, then assisted the child from the vehicle through the second row left side door. The second row right occupant was seated in a belt positioning high back booster CSS and was restrained by the vehicle's 3-point manual lap and shoulder safety belt. The driver opened the second row right side door, unbuckled the occupant's safety belt, and assisted the occupant from the vehicle through the second row right side door.

The driver sustained a contusion to the left shoulder and complained of pain to the neck. The second row left occupant sustained an abrasion to the chin. The second row right occupant was not injured. None of the occupants were transported for medical treatment. The 1999 Ford Contour was towed from the scene due to damage. It was later declared a total loss by the insurance company and was sold to an auto salvage facility.

Vehicle Data

The 1999 Ford Contour LX four door sedan was identified by the Vehicle Identification Number (VIN): 1FAFP653XXKxxxxxx. The vehicle's date of manufacture was August 1998, and the mileage was 151,825 km (94,342 miles). The Ford was equipped with a 2.0-liter, 4-cylinder engine, automatic transmission, front-wheel drive, ventilated disc brakes, front and rear strut suspension with a stabilizer bar and coil springs, and power steering. Assisted Braking System (ABS) was optional on this model and it was not known if the vehicle was equipped with anti-lock brakes.

The vehicle was not equipped with electronic stability control (ESC), traction control, anti-roll technology, or a tire pressure monitoring system. At the time of the vehicle inspection the tires were missing from the vehicle and they were not inspected. Therefore, no tire data was available.

The vehicle manufacturer's recommended tire size was P185/70R14, and the recommended tire pressure was 234 kPa (34 psi).

The Ford's interior was equipped with seating for five occupants. The front row seating was configured with fabric-covered bucket seats and adjustable head restraints for the two outboard positions. The second row seating was configured with a fabric-covered bench seat with no head restraints.

Vehicle Damage

Exterior Damage

The 1999 Ford Contour sustained minor front end damage as a result of the frontal endswipe impact with the embankment. The front bumper fascia was cracked and detached on the left corner. However, the damage was primarily surface scratching to the bumper fascia with no measurable crush. The direct damage to the front bumper was distributed from bumper corner to bumper corner and measured 148 cm (58.3 in). The Collision Deformation Classification (CDC) for this impact was 03FDLS1.

The vehicle sustained moderate damage to the right rear quarter panel as a result of the second

impact with the embankment (**Figure 3**). The direct damage began 24 cm (9.5 in) forward of the rear axle and extended 107 cm (42.1 in) rearward to the rear bumper corner. Six crush measurements were taken at mid-door level as follows: C1 = 10 cm (3.9 in), C2 = 14 cm (5.5 in), C3 = 7 cm (2.8 in), C4 = 7 cm (2.8 in), C5 = 4 cm (1.6 in), C6 = 0 cm. Maximum crush at mid-door level was located at C2 and measured 14 cm (5.5 in). The CDC for the side impact was 04RBEW2.

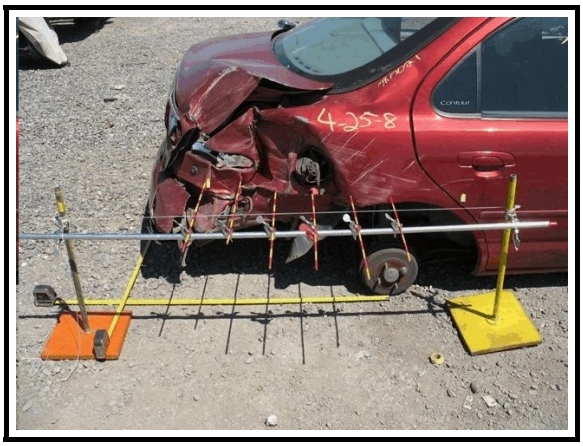

Figure 3. Right side damage, showing stands

The Barrier algorithm of the WinSmash program computed a Total Delta V of 8.0 km/h (5.0 mph), based on the Ford's right side crush profile. The longitudinal and lateral components were 4.0 km/h (2.5 mph) and -6.9 km/h (-4.3 mph), respectively.

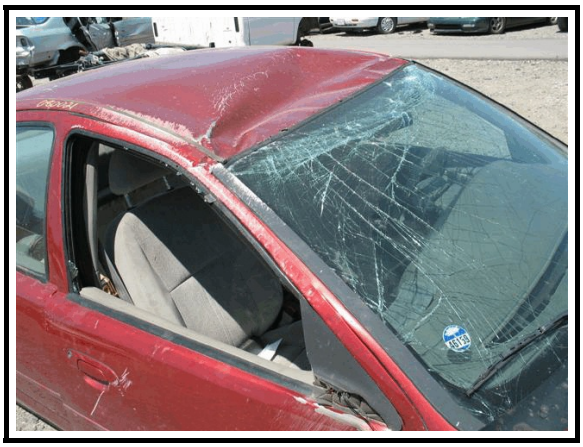

Figure 4. Roof damage sustained during rollover

The vehicle sustained moderate damage during the rollover event (**Figure 4**). The windshield was cracked and in place. The first row right window glazing disintegrated. The doors all remained closed and operational. The direct damage to the top plane began on the leading edge of the hood, extended rearward 237 cm (93.3 in), and ended on the roof near the B-pillar. The direct damage to the roof was distributed laterally 110 cm (43.3 in) from roof side rail to roof side rail. The left and right A-pillars sustained direct damage. Direct damage was distributed down the vehicle's entire left side and measured 442 cm (174.0 in) in length. The maximum lateral crush was located at the right A-pillar and measured 5 cm (2.0 in). The maximum vertical crush was located at the right A-pillar and measured 7 cm (2.8 in). The CDC for the rollover event was 00TYDO3.

The vehicle's right side sustained damage during post-crash efforts to turn the vehicle upright.

Interior Damage

The 1999 Ford Contour sustained minor interior damage as a result of passenger compartment intrusion. The intrusions were confined to the front row seating area. Intrusion of the right A-pillar, the windshield header, and the roof were documented. The vehicle sustained integrity loss due to disintegration of the first row right window glazing.

There was post-crash interior damage to the instrument panel, glove compartment, second row seat cushion and second row safety belts as a result of post-crash salvage facility activity. The specific passenger compartment intrusions were documented as follows:

Row	Position	Intruded Component	Magnitude of Intrusion	Direction
1	Right	A-pillar	7 cm (2.8 in)	Vertical
1	Middle	Roof	6 cm (2.4 in)	Vertical
1	Right	Roof	6 cm (2.4 in)	Vertical
1	Middle	Windshield header	4 cm (1.6 in)	Vertical
1	Right	Windshield header	3 cm (1.2 in)	Vertical
1	Left	Windshield header	3 cm (1.2 in)	Vertical
1	Left	Roof	2 cm (0.8 in)	Vertical

Manual Restraints

The 1999 Ford Contour was equipped with 3-point manual lap and shoulder belts for all five seat positions. The front row safety belts were configured with adjustable D-rings. The driver's side was in the full-up position and the right passenger side was in the full-down position. The first row safety belts were equipped with sliding latch plates.

The driver's safety belt was equipped with an Emergency Locking Retractor (ELR). The front right safety belt was equipped with a switchable ELR/Automatic Locking Retractor (ALR). The Ford was not equipped with safety belt pretensioners.

The driver's safety belt, latch plate and webbing exhibited wear marks that indicated historical usage. No additional evidence of occupant loading to the belt system was observed.

The second row safety belts were configured with sliding latch plates and switchable ELR/ALR. The outboard belts were configured with non-adjustable anchorages. The belts were routed through housing ports located on the C-pillars. The middle belt was configured with an integral retractor and the belt was routed through a port in the rear dash. The left lap and shoulder safety belt was used to secure a forward-facing CSS. The right lap and shoulder belt was used to restrain a child seated in a belt positioning booster CSS.

The second row left safety belt was intact and retracted in the stowed position. The belt, latch plate and webbing exhibited wear marks consistent with historical usage. No additional evidence of usage was observed.

The center and right safety belts had been cut near their anchorage points below the seat bottom. The buckles were still in place. An on-scene photograph revealed that the center position safety belt was in place at the time of the crash.

The second row seat cushion had moved from its normal position during post-crash salvage facility activities. The 1999 Ford Contour was not equipped with Lower Anchors and Tethers for Children (LATCH) hardware.

Supplemental Restraint Systems

The Ford's Supplemental Restraint System included an Event Data Recorder (EDR) and driver and passenger air bags. The vehicle's EDR was not supported by the Bosch Crash Data Recorder (CDR) software; therefore, no imaging of the crash data was attempted.

The redesigned frontal air bags were located in the steering wheel hub and upper instrument panel. There was no switch present for the passenger air bag. There were no air bag deployments during the crash. The driver had recently purchased the vehicle from a family member. She indicated that the air bags were original equipment and had not been serviced.

Child Safety Seats

Second Row Left

The second row left seat was occupied by a 3-year-old female seated in a Cosco/Dorel High Back Booster CSS (**Figure 5**). The model number was 22-208-MTN and the date of manufacture was 10/27/2005. The CSS was used forward facing and was configured with a 5-point harness and retainer clip. The harness straps were routed through the top set of slots and the retainer clip was fastened. The driver of the subject vehicle was the child's mother and she installed the CSS in the vehicle. The CSS was placed on the bench seat cushion and was secured with the 3-point manual safety belt. The safety belt was routed through the back of the CSS frame through the front facing slots, and she stated that the safety belt retractor was in the ALR mode.

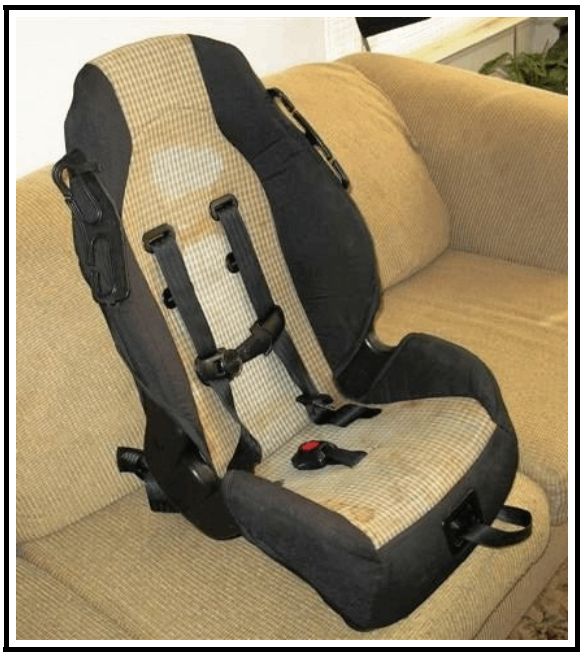

Figure 5. Cosco/Dorel High Back Booster CSS

A usage label on the CSS stated it was to be used by occupants who met the following criteria:

- 85 - 110 cm (34 - 43 in) in height
- 10 - 18 kg (22 - 40 lb) in weight
- greater than one year in age

The 3-year-old child was of an appropriate height, weight and age for the CSS. During the crash, the child and CSS stayed in place. No evidence of occupant contacts were observed on the CSS's harness, cover or shell. The child sustained an abrasion to the chin. The child's mother surmised that the abrasion was the result of the child's chin contacting a zipper on the child's jacket, which she was wearing.

The CSS was a combination model and could be used as a belt positioning booster seat. It was equipped with belt positioning slots on the upper left and right sides. It was also equipped with

LATCH straps and hardware that was not used.

Second Row Right

The second row left seat was occupied by a 5-year-old female seated in a Graco TurboBooster CSS (**Figure 6**). The model number was 8E10VIP and the date of manufacture was 11/28/2007. The CSS was used in a forward facing orientation. It was configured without a harness and was designed to be used only as a belt positioning booster seat. The CSS was equipped with adjustable armrests and retractable cup holders. Shoulder belt positioning slots flanked each side of the headrest. The child's mother assisted the child with the safety belt restraint. The retractor was in the ALR mode. The driver stated during the interview that she did not route the shoulder belt webbing through the belt positioning device. Instead, the shoulder belt webbing was placed below the positioning device in an opening between the CSS back and headrest. The safety belt positioned in this manner located the shoulder belt over the child's shoulder, and the shoulder belt was held in place by belt retractor tension.

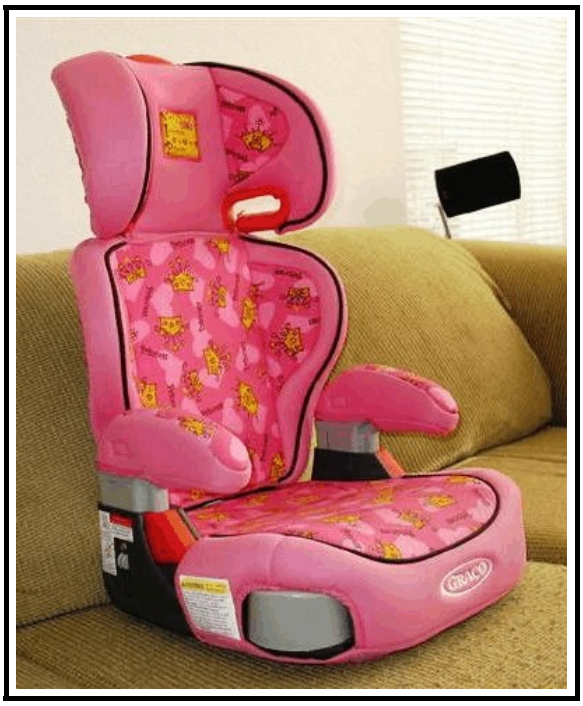

Figure 6. Graco TurboBooster CSS

A usage label on the CSS stated it was to be used by occupants who met the following criteria:

- 96 - 145 cm (38 - 57 in) in height
- 13.6 - 45.4 kg (30 - 100 lb) in weight
- 3 -10 years in age

The 5-year-old child was an appropriate height, weight and age for the CSS. During the crash, the child and CSS stayed in place. There were no occupant contacts observed on the CSS. The child was not injured.

Rollover Dynamics

The driver of the vehicle estimated her pre-crash speed to be approximately 97 km/h (60 mph). She stated that her only avoidance maneuver was steering; she did not recall braking. The first two impacts were low Delta V events. The vehicle was in a counterclockwise rotation during the first two events, and they had minimal effect on the vehicle's speed or rotational dynamics. After the first two events, the vehicle rotated counterclockwise until its orientation was almost perpendicular to the roadway. Prior to reaching the trip point, the vehicle had rotated counterclockwise approximately 225 degrees. After the second event, the vehicle's front end re-entered the roadway in the inboard travel lane. The left front tire engaged the roadway and the left rear tire engaged the ground with sufficient opposing lateral force to induce a left side leading trip-over. The vehicle rolled about its

longitudinal axis for two quarter turns, and came to final rest on its roof. The distance from the vehicle's trip point to the area of final rest was 8.0 m (26.3 ft).

The driver stated she did not consciously apply the brakes during the pre-crash or crash phases of the incident. The vehicle initiated a counterclockwise rotation and departed the roadway at a moderately high speed. As the vehicle's front end returned to the paved surface, it transitioned from a surface with a low coefficient of friction to a surface with a high coefficient of friction. The transition from unpaved ground to dry, paved asphalt was abrupt and the lateral forces against the left side tires immediately induced the trip-over. The rollover was attributed to the rapid transition from a low to a high coefficient of friction while the vehicle was traveling in a lateral trajectory.

Occupant Demographics

	Driver	**Occupant 2**
Age/Sex:	32/Female	3/Female
Seated Position:	Front left	Second left
Seat Type:	Bucket	Bench
Seat Track Position:	Mid-track	Not adjustable
Height:	173 cm (68 in)	89 cm (35 in)
Weight:	70.3 kg (155 lb)	13.6 kg (30 lb)
Alcohol/Drug Involvement:	None	N/A
Body Posture:	Upright, normal	Upright, normal
Hand Position:	Both hands on steering wheel	Arms and hands at sides
Foot Position:	Right foot on accelerator, left foot on floor	Legs forward, feet down
Restraint Usage:	Manual lap and shoulder belt	Lap and shoulder belt used to secure a child safety seat

	Occupant 3
Age/Sex:	5/Female
Seated Position:	Second right
Seat Type:	Bench
Seat Track Position:	Not adjustable
Height:	109 cm (43 in)

Weight:	18.1 kg (40 lb)
Body Posture:	Upright, normal
Hand Position:	Arms and hands at sides
Foot Position:	Legs forward, feet down
Restraint Usage:	Lap and shoulder belt used to secure a belt positioning booster safety seat

Occupant Kinematics

Driver Kinematics

The 29-year-old female driver was seated in an upright posture and was restrained by the vehicle's 3-point manual lap and shoulder belt. The seat track was adjusted to the mid-track, the seat back was slightly reclined, and the safety belt was worn. The driver stated she had both hands on the steering wheel and was actively steering. Her right foot was on the accelerator and her left foot was on the floor. The driver became distracted as she searched for a compact disc that was located within the passenger compartment. When the driver's attention returned to the roadway, she observed that her left side tires had departed the roadway and were tracking on the dirt shoulder. In an attempt to return to the roadway, the driver steered to the right. The vehicle returned to the roadway but the driver lost control of the vehicle. She attempted to regain control, but overcorrected, this time to the left. At this point, the vehicle departed the roadway on the left side and initiated a counterclockwise rotation. The vehicle rotated approximately 90 degrees to the left, and the front end impacted an embankment in an endswipe configuration. This event had minimal impact on the driver's movement within the vehicle. From the time of the first roadside departure to the point of the endswipe impact, the driver remained in place in her seat and was actively steering the vehicle.

The Ford continued its counterclockwise rotation for another 90 degrees, then the vehicle's right rear quarter panel contacted the embankment. During this event, the driver was displaced rearward and to the right in response to the direction of force. She sustained a non-contact injury to her cervical spine due to the impact forces. She complained of pain/soreness to the neck, consistent with mild cervical strain. The vehicle continued its counterclockwise rotation for approximately another 45 degrees, at which point the vehicle tripped over left side leading. During the rollover event, the driver was displaced to the left, loaded the shoulder belt, and probably contacted the left door panel and hardware. She sustained a left shoulder contusion from contact with the safety belt webbing. She stated during the interview that she did not remember contacting any interior components; however, the crank handle to the front left window was broken off either during or after the crash. The vehicle rolled a total two quarter turns before coming to rest on its roof. The driver's head did not contact the roof during the rollover. The driver unbuckled her safety belt and exited the vehicle unassisted, then assisted her children from the vehicle. The 29-year-old driver was not transported and did not seek treatment. She missed one day of work due to soreness. Her injury data was obtained during the driver interview.

Second Row Left Occupant Kinematics

The 3-year-old female occupant was seated in a forward facing orientation in a Cosco Juvenile High Back Booster CSS. The CSS was placed on the bench seat and was secured by the 3-point manual lap and shoulder belt, the retractor was in the ALR mode. The child was restrained by the integral 5-point harness straps. The child's arms were at her sides and her legs were extended forward in a normal position.

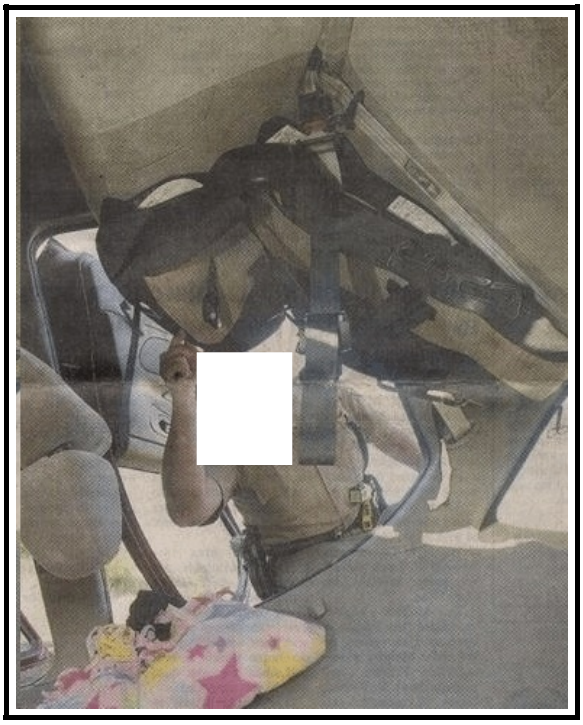

Figure 7. Post-crash view showing Cosco/Dorel CSS, second row left position

As the driver took evasive actions, the child was displaced slightly left, then right. The vehicle then rotated counterclockwise, and the child continued to be displaced slightly right. The low speed frontal endswipe had minimal effect on the occupant's movement within the CSS. The right rear impact slightly displaced the child rearward and to the right in response to the direction of force. The vehicle initiated a trip rollover left side leading, and the occupant was displaced to the left. The child and the CSS remained in place. The vehicle came to final rest on its roof, and the occupant and the CSS were suspended upside down (**Figure 7**). After the crash, the driver unbuckled the child's CSS harness and assisted her from the CSS and then from the vehicle.

The 3-year-old occupant sustained a minor abrasion to her chin. This injury was the likely result of contact with a zipper located on the front of her jacket, which she was wearing. She was not transported and did not seek treatment. Her injury information was obtained during the driver interview.

Second Row Right Occupant Kinematics

The 5-year-old female occupant was seated in forward-facing orientation in a Graco TurboBooster high back belt positioning CSS. The CSS was placed on the bench seat. The child was restrained by the vehicle's 3-point manual lap and shoulder belt and the retractor was in the ALR mode. The shoulder belt was not routed through the available belt positioning device. It was instead placed under the device in a space between the head rest and the back. The child's arms were at her sides, and her legs were extended forward in a normal position.

During the pre-crash avoidance action, the child was slightly displaced first to the left, then to the right. As the vehicle rotated counterclockwise, the child continued to be displaced to the right. The contact to the vehicle's right rear displaced the child rearward and to the right, and she remained in place in the CSS. During the left leading rollover, she was displaced to the left, and the CSS and child remained in place. At final rest, the vehicle was on its roof and the CSS and the occupant were

suspended upside down. After the crash, the driver unbuckled the child's safety belt and assisted her from the vehicle.

The 5-year-old second row right occupant was not injured. She was not transported and did not seek treatment.

Occupant Injuries

Driver

Injury	OIC Code	Injury Mechanism	Confidence Level
Contusion, left shoulder	490402.1,2	Safety belt webbing	Certain
Cervical strain	640278.1,6	Impact forces	Probable

Second Row Left Occupant 2

Injury	OIC Code	Injury Mechanism	Confidence Level
Abrasion, chin	290202.1,8	Clothing, zipper	Probable

Attachment 1. Scene Diagram