Child Safety Seat / Single Vehicle Rollover
Dynamic Science, Inc. / Case Number: DS04002
1991 Mercury Topaz
Arizona
January, 2004

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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

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16. Abstract

This single vehicle crash occurred in January, 2004 at 1600 hours. The crash occurred after the case vehicle departed an asphalt covered two lane eastbound interstate roadway. The case vehicle is a 1991 Mercury Topaz GS four-door sedan. The case vehicle was being driven by an improperly restrained 29-year-old male. There were four additional occupants in the vehicle. The front right seat was occupied by a restrained 20-year-old female. The rear left seat was occupied by a restrained 9-year-old female. The rear middle seat was occupied by a 3-year-old male who was seated in a forward facing child safety seat. The rear right seat was occupied by a restrained 27-year-old female.

The case vehicle was traveling eastbound in the far left lane. The rear right occupant gave directions to the driver of the vehicle. The driver appears not to have understood the directions and looked back to the rear right occupant. The case vehicle then veered to the left with the left side tires going off the roadway on the north edge. The driver likely steered to the right and the vehicle re-entered the roadway and crossed into the far right eastbound lane. The driver likely steered to the left losing control of the vehicle. The vehicle went into a counterclockwise skid and crossed the far left eastbound lane. The vehicle then went off the north roadway edge and entered the depressed dirt median and rolled over at least six quarter turns. The vehicle came to final rest on its top facing west in the depressed dirt median.

All five occupants were transported from the scene with reports of minor injuries. The case vehicle was towed from the scene due to damage and later declared a complete loss by the insurance company.

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Dynamic Science, Inc.
Crash Investigation
Case Number: DS04002

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BACKGROUND:

Description:	This Child Safety Seat case was initially identified by a NHTSA review of GES police reports. DSI was notified on February 17, 2004 with instructions to determine if both the case vehicle and the child safety seat would be available for inspection. On February 20, 2004, DSI spoke with the tow yard operator and located the case vehicle and the child safety seat. Permission was given to inspect the case vehicle. This was an on-scene investigation. The case vehicle and scene were inspected on March 5, 2004.
Investigation Type:	Child Safety Seat Investigation
Crash Location:	Arizona
Crash Date:	January, 2004
Notification Date:	February 17, 2004
Field Work Completed:	March 5, 2004

SUMMARY

Crash Site

This single vehicle crash occurred in January, 2004 at 1600 hours. The crash occurred after the case vehicle departed an asphalt covered two lane eastbound interstate roadway. There is a paved 3.5 m (11.5 ft) shoulder with a grooved pattern rumble strip[1] on the south side of the roadway edge. There is a paved 1.2 m (4.1 ft) shoulder with a grooved pattern rumble strip on the north side of the roadway edge. A depressed dirt median separates the east-west interstate. The median starts at the level of the roadway and gradually descends until it is approximately 0.9 m (3.0 ft) below the roadway. The roadway was dry and the weather clear. The roadway has a positive 1.4% grade. The speed limit is 121 km/h (75 mph).

Figure 1. Approach to left hand road departure

[1]Rumble strips are raised or grooved patterns constructed primarily along paved shoulders. When vehicle tires pass over the strips, they produce a sudden rumbling and vibration in the car. Both the sound and the vibration alert fatigued or distracted drivers that they are beginning to drift off the road.

Pre-Crash

The case vehicle is a 1991 Mercury Topaz GS four-door sedan (VIN: 2MEPM36X7MBxxxxxx). The case vehicle was being driven by an improperly restrained (using motorized shoulder harness only) 29-year-old male. There were four additional occupants in the vehicle. The front right seat was occupied by a properly restrained 20-year-old female (62 kg/136 lbs, unknown height). The rear left seat was occupied by a restrained 9-year-old female (33 kg/72 lbs, unknown height). The rear middle seat was occupied by a 3-year-old male (unknown height/weight) who was seated in a forward facing child safety seat. The rear right seat was occupied by a restrained 27-year-old female (77 kg/170 lbs, unknown height).

Figure 2. Vehicle in counterclockwise yaw traveling east toward road departure (police photo)

Figure 3. Area of road departure

Crash

The case vehicle was traveling eastbound in the far left lane. The rear right occupant gave directions to the driver of the vehicle. The driver appears not to have understood the directions and looked back to the rear right occupant. The case vehicle then veered to the left with the left side tires going off the roadway on the north edge. The driver likely steered to the right and the vehicle re-entered the roadway and crossed into the far right eastbound lane. The driver likely steered to the left losing control of the vehicle. The vehicle went into a counterclockwise skid and crossed the far left eastbound lane. The vehicle then went off the north roadway edge and entered the depressed dirt median and rolled over at least six quarter turns (00TDDO3). The vehicle came to final rest on its top facing west in the depressed dirt median.

Figure 4. Final rest, facing west (police photo)

Post-Crash

According to the police report, the driver of the case vehicle sustained Level 3 (Non incapacitating) injuries. He was able to exit the vehicle on his own through the passenger's side window. He was transported by ground ambulance to a local hospital but, according to hospital records, was not treated or admitted.

The 20-year-old female front right occupant sustained abrasions to her right hip and thigh. She was able to exit the vehicle on her own through the passenger's side window. She was

transported by ground ambulance to an area hospital where she was treated and released.

Figure 5. Final rest, looking north (police photo)

The 9-year-old female rear left occupant sustained a neck strain, multiple small abrasions to her face, abrasions to her left arm, a laceration to the left thumb, and a laceration to her inner arm near the elbow. She was able to exit the vehicle on her own. She was transported to a local area hospital by ground ambulance. She underwent x-rays for possible left hand and neck fractures. These were negative. She arrived dazed but did not sustain any loss of consciousness. She was treated for her injuries and released.

According to the police report, the 3-year-old male rear middle occupant sustained Level 3 (Non-incapacitating) injuries. The child seat remained anchored to the vehicle and the child remained in the child seat until being removed by one of the vehicle occupants. He was transported by ground ambulance to a local hospital but, according to hospital records, was not treated or admitted.

The 27-year-old female rear right occupant sustained abrasions to the right hand and shoulder. She was able to exit the vehicle on her own. She was transported to a local area hospital by ground ambulance. She underwent x-rays for possible upper extremity fracture. These were negative. She was treated for her injuries and released.

The case vehicle was towed from the scene due to damage and later declared a total loss by the insurance company.

VEHICLE DATA -1991 Mercury Topaz four-door sedan

The 1991 Mercury Topaz four-door sedan was equipped with an automatic transmission, front wheel drive, and a 4 cylinder 2.3 liter engine.

VIN:	2MEPM36X7MBxxxxxx
Odometer:	86,248 km (53,592 miles)
Reported Defects:	None
Cargo:	Child seat, water cooler, personal items

The 1991 Mercury Topaz was equipped with All Season P185/70R14 tires on the left side, a Mohave R/S P185/70R14 tire on the right rear, and an Ameri P185/70R14 tire on the right front. The specific tire data is as follows:

Tire	Tread	Pressure	Recommended pressure
LF	5 mm (6/32 in)	200 kPa (29 psi)	207 kPa (30 psi)
LR	5 mm (6/32 in)	186 kPa (27 psi)	207 kPa (30 psi)
RF	4 mm (5/32 in)	Flat	207 kPa (30 psi)
RR	5 mm (6/32 in)	179 kPa (26 psi)	207 kPa (30 psi)

The front seating positions in the 1991 Mercury Topaz were configured with bucket seats with adjustable head restraints. The rear seating positions were configured with a bench seat.

VEHICLE DAMAGE

Exterior Damage - 1991 Mercury Topaz

Damage Description:	The driver, rear left, and front right doors were jammed shut. The glazing at all locations was either disintegrated or holed. There was intrusion to the left roof, left roof rails, and A/B/C pillars. The front right tire was flattened during the rollover.	
CDC:	00TDDO3	
Delta V:	Total	Unknown
	Longitudinal	Unknown
	Latitudinal	Unknown
	Energy	Unknown

The vertical crush to the greenhouse area is shown below by pillar location, left to right.

Pillar	Left	Right
A	13.0 cm (5.1 in)	7.1 cm (2.8 in)
B	10.0 cm (3.9 in)	0 cm (0 in)
C	6.0 cm (2.4 in)	2.0 cm (0.8 in)

Figure 6. Case vehicle, front

Figure 7. Case vehicle, left side

Interior Damage - 1991 Mercury Topaz

Interior damage to the Mercury Topaz was major and attributed to occupant contacts and passenger compartment intrusion. The windshield was fractured and holed from the rollover. All the right side windows were disintegrated from impact forces. All the side glass was disintegrated, as was the backlight. There was roof intrusion, as well as intrusion at each of the pillar positions. The most substantial intrusion was through the roof and extended longitudinally over the left front and left rear seating positions. The left front, left rear, and right front doors were jammed shut. There was pooled vehicle fluids and several blood patterns on the interior roof above the front two seat positions. There was dirt, stains, and roadside debris over the entire interior roof.

Figure 8. Overview of vehicle interior (front)

MANUAL RESTRAINT SYSTEMS - 1991 Mercury Topaz

The 1991 Mercury Topaz was configured with automatic 2-point torso belts and manual lap belts for the front seat positions. There were no anchorage adjustments available for the shoulder belts. The rear outboard seating positions were configured with 3-point lap and shoulder belts with sliding latch plates. A 2-point lap belt with a locking latch plate was present for the rear center position.

Figure 9. Spills and blood stains (darker patches are vehicle fluids)

CHILD SAFETY SEAT - 1991 Mercury Topaz

The rear middle seat of the 1991 Mercury Topaz was occupied by a 3-year-old male in a Cosco Regal Ride convertible child safety seat (model number 4359-4123, manufacture date unknown) with an overhead shield. The manufacturer recommends this seat be used in the forward facing mode for children weighing between 10-18 kg (22-40 lbs). It is not known if the child in this crash met these guidelines. According to the National Center for Health Statistics[2], the weight of a 3-year-old male in the 50th percentile would be 14 kg (31 lbs). The seat was being used in the forward facing mode and was anchored to the fabric covered bench seat using the available vehicle lap belt. The lap belt was equipped with a locking latch plate. The vehicle seat back angle was 69.4 degrees; the seat bottom angle was 4.4 degrees. The child seat was not tightly anchored to the vehicle seat. The child seat could be moved forward a minimum of 7.1 cm (2.8 in) at the top and 10.0 cm (3.9 in) at the bottom. The child was secured to the child seat using the available tray shield harness system. The harness was threaded through the middle of the three harness height adjustment slots. A harness clip was available but it is not known if it was used properly. The seat was configured with a recessed buckle. The left arm of the shield was broken away from the seat back during the crash.

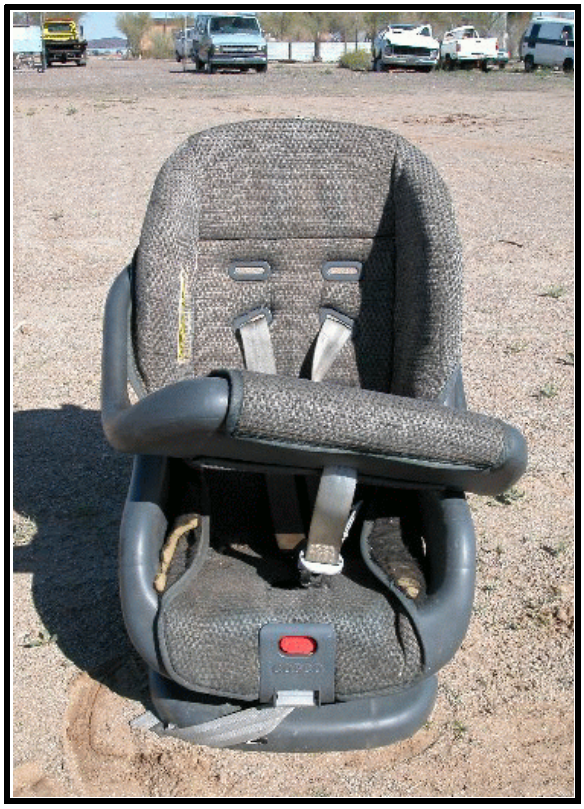

Figure 10. Cosco Regal Ride convertible child seat

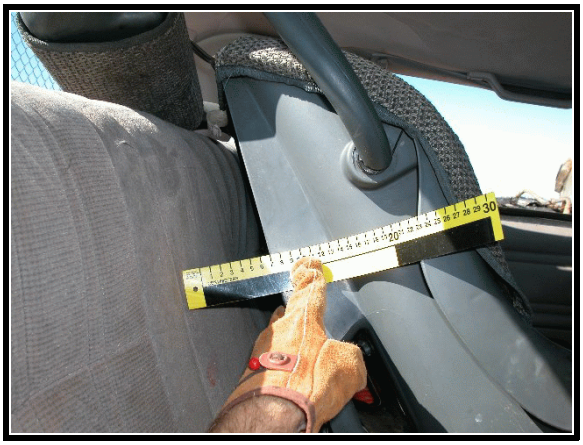

Figure 11. Available child seat movement (top)

[2]Obtained from http://www.cdc.gov/growthcharts/

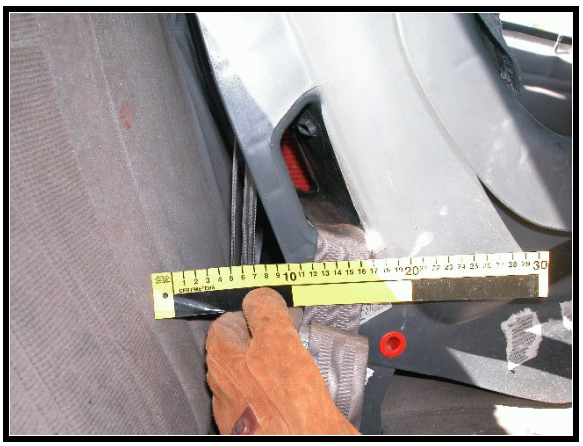

Figure 12. Available child seat movement (bottom)

OCCUPANT DEMOGRAPHICS - 1991 Mercury Topaz

	Driver	Occupant 2
Age/Sex:	29/Male	20/Female
Seated Position:	Front left	Front right
Seat Type:	Fabric covered bucket seat. The seat track was adjusted to the mid position. The seat back was adjusted to a 66 degree from horizontal angle.	Fabric covered bucket seat. The seat track was adjusted to the full forward position. The seat back was adjusted to a 66 degree from horizontal angle.
Height:	Unknown	Unknown
Weight:	Unknown	62 kg (136 lbs)
Occupation:	Unknown	Unknown
Pre-existing Medical Condition:	None noted	None noted
Alcohol/Drug Involvement:	None	NA
Driving Experience:	Unknown	NA
Body Posture:	Presumed to be upright, normal	Presumed to be upright, normal
Hand Position:	Unknown	Unknown
Foot Position:	Right foot on brake, left on floor	Unknown
Restraint Usage:	Automatic shoulder belt available, used. Manual lap belt available, not used.	Automatic shoulder belt available, used. Manual lap belt available, used.
Air bag:	None available	None available

Age/Sex:	9/Female	3year/Female	27/Female
Seated Position:	Rear left	Rear middle	Rear right
Seat Type:	Fabric covered bench seat. Seat back fixed at 69 degree angle from horizontal.	Fabric covered bench seat. Seat back fixed at 70 degree angle from horizontal.	Fabric covered bench seat. Seat back fixed at 69 degree angle from horizontal.
Height:	Unknown	Unknown	Unknown
Weight:	33 kg/72 lbs	Unknown	77 kg/170 lbs.
Occupation:	None	None	Unknown
Pre-existing Medical Condition:	None noted		None noted
Alcohol/Drug Involvement:	NA	NA	NA
Driving Experience:	NA	NA	NA
Body Posture:	Presumed to be normal, upright	Seated in child safety seat	Presumed to be normal, upright
Hand Position:	Unknown	Unknown	Unknown
Foot Position:	Unknown	Unknown	Unknown
Restraint Usage:	Lap and shoulder belt available, used	Lap belt used with child safety seat	Lap and shoulder belt available, used

OCCUPANT INJURIES -1991 Mercury Topaz

Driver: No reported injuries.

Right front occupant: Injuries obtained from emergency room records.

Injury	OIC Code	Injury Mechanism	Confidence Level
Abrasion, right hip	890202.1,1	Lap belt	Probable
Abrasion, right thigh	890202.1,1	Unknown	Unknown

Left rear occupant: Injuries obtained from emergency room records.

Injury	OIC Code	Injury Mechanism	Confidence Level
Neck strain	640278.1,6	Impact forces	Probable
Multiple small abrasions to face	290202.1,0	Flying glass	Possible
Abrasions to left arm	790202.1,2	Flying glass	Possible
Laceration, left thumb	790600.1,2	Flying glass	Possible
Laceration, left inner arm	790600.1,2	Flying glass	Possible

Middle rear occupant: No reported injuries.

Right rear occupant: Injuries obtained from emergency room records.

Injury	OIC Code	Injury Mechanism	Confidence Level
Abrasion, right hand	790202.1,1	Flying glass	Possible
Abrasion, right shoulder	790202.1,1	Door side panel	Probable

OCCUPANT KINEMATICS - 1991 Mercury Topaz

The 29-year-old male driver of the case vehicle was seated in what is presumed to be a normal, upright position in the fabric covered bucket seat. The seat track had been adjusted to the mid position. The seat back was adjusted to a 66 degree from horizontal angle. The automatic shoulder belt was in place and being used, but the manual lap belt was not being used. Prior to any vehicle maneuvers, the right rear occupant had given directions to the driver. The driver appears not to have understood the directions and looked back to the rear right occupant. The case vehicle then veered to the left with the left side tires going off the roadway on the north edge. The driver likely steered to the right and the vehicle re-entered the roadway and crossed into the far right eastbound lane. The driver then steered to the left losing control of the vehicle. The vehicle then went into a counterclockwise rotation. The driver likely pitched to the right to some extent. As the vehicle entered the median, the right side tires began furrowing and the vehicle tripped and began a right side roll about its longitudinal axis. During the initial phase of the rollover, the driver pitched to his left. As the vehicle went onto its roof, the driver's lower legs appear to have contacted the lower instrument panel. The driver remained essentially in place throughout the rollover and there were no reported injuries. He was able to exit the vehicle on his own. He was transported to a local hospital but did not receive any treatment.

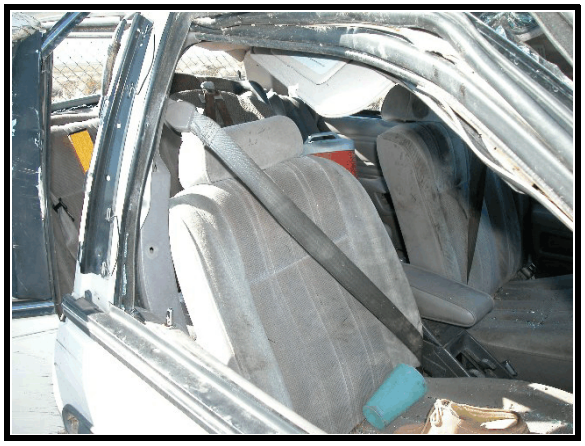

Figure 13. Overview of front seating positions

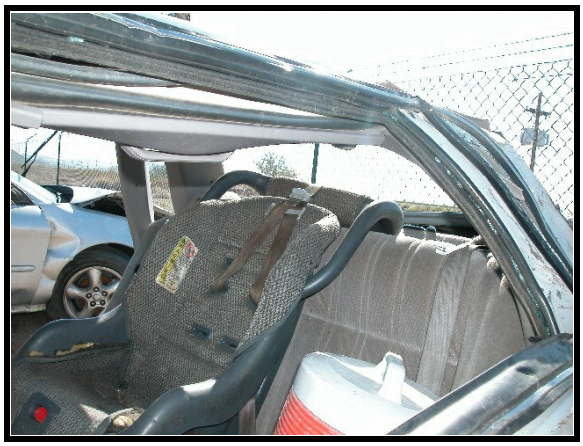

Figure 14. Cosco child seat in place in vehicle

The 20-year-old female front right occupant was seated in what is presumed to be a normal, upright position in the fabric covered bucket seat. The seat track had been adjusted to the full forward position. The seat back was adjusted to a 66 degree from horizontal angle. Both the automatic torso belt and the manual lap belt were being used. As the vehicle went into a counterclockwise rotation, this occupant pitched somewhat to the right. As the vehicle entered the median and began rolling over this occupant pitched to the left. She was essentially held in place by both the torso belt and the lap belt. As the vehicle went over on the roof, she loaded the lap belt–causing the abrasions to the right hip.

The 9-year-old female rear left occupant was seated in what is presumed to be a normal, upright position in the fabric covered bench seat. She was using the available lap and shoulder belt. As the vehicle rolled, she was essentially held in place by the lap and shoulder belt. She sustained a neck strain from impact forces and multiple abrasions that were likely related to both flying glass and post-crash egress from the vehicle. She may have contacted the child seat immediately to her right.

The 3-year-old rear middle occupant was seated in a Cosco Regal Ride convertible child safety seat with an overhead shield. The seat was being used in the forward facing mode and was anchored to the fabric covered bench seat using the available vehicle lap belt. The lap belt was equipped with a locking latch plate. The vehicle seat back angle was 69.4 degrees; the seat bottom angle was 4.4 degrees. Upon inspection, the child seat was not tightly anchored to the vehicle seat. The child seat could be moved forward a minimum of 7.0 cm (2.8 in) at the top and 10.0 cm (3.9 in) at the bottom. The child was secured to the child seat using the available tray shield. The harness was threaded through the middle of the three harness height adjustment slots. A harness clip was available but it is not known if it was used properly. The shield was down and locked. As the vehicle rolled, the child remained in the child seat and the seat remained attached to the vehicle–though likely loose. The child rode down the rollover and there were no reported injuries. The left arm of the shield was broken away from the seat back during the crash. This may have been caused by the left rear occupant.

The 27-year-old female was seated in what is presumed to be a normal, upright position in the fabric covered bench seat. She was using the available lap and shoulder belt. As the vehicle rolled, she was essentially held in place by the lap and shoulder belt. She sustained a right shoulder abrasion, presumably due to contact to the right door panel. She also sustained a right hand abrasion that may have been related either flying glass or her post-crash egress from the vehicle.

Attachment 1. Scene Diagram