

Rollover Investigation
Dynamic Science, Inc. / Case Number: DS07017
2005 Chevrolet Trailblazer
Arizona
February 2007

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The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points be coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety systems.

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16. Abstract <p>This single vehicle rollover crash occurred in January 2007 at 1246 hours. The crash occurred in Arizona. The case vehicle was being driven by a restrained 49-year-old male. There were six additional occupants in the vehicle. All the occupants were restrained. The Chevrolet Trailblazer was traveling westbound on a two-lane divided interstate highway. The driver fell asleep. The case vehicle drifted to the left into the median. Upon waking, the driver steered to the right but over-corrected. The case vehicle began a clockwise motion on the dirt median onto the shoulder. Upon entering the shoulder, the left side tires dug into the asphalt surface causing the vehicle to begin rolling onto its left side. The case vehicle continued to roll over across both lanes of travel, the emergency shoulder and the dirt shoulder. The case vehicle rolled six quarter turns. The case vehicle came to rest on its roof facing northeast on the dirt shoulder. The driver sustained minor contusions and abrasions. The front right occupant sustained multiple minor lacerations. She was evaluated at the scene. The second row left occupant sustained minor contusions and abrasions and a neck strain. The second row middle occupant sustained no injuries. The second row right occupant sustained multiple contusions and abrasions. The third row left occupant complained of pain to his left shoulder. The third row right occupant sustained a skull fracture, as well as miscellaneous lacerations, contusions and abrasions. The Chevrolet Trailblazer was towed from the scene and later declared a total loss by the insurance company.</p>					
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BACKGROUND

This single vehicle rollover crash occurred in January 2007 at 1246 hours. The crash occurred in Arizona. The 2005 Chevrolet Trailblazer (**Figure 1**) was being driven by a restrained 49-year-old male. There were six additional occupants in the vehicle. All the occupants were restrained.

The Chevrolet Trailblazer was traveling westbound at a driver-reported speed of 113 km/h (70 mph) on a two-lane divided interstate highway. The driver fell asleep. The case vehicle drifted to the left into the median. Upon waking, the driver steered to the right but over-corrected. The case vehicle began a clockwise motion on the dirt median onto the shoulder. Upon entering the shoulder, the left side tires dug into the asphalt surface causing the vehicle to begin rolling onto its left side. The case vehicle continued to roll over across both lanes of travel, the emergency shoulder and the dirt shoulder. The case vehicle rolled six quarter turns. The case vehicle came to rest on its roof facing northeast on the dirt shoulder. The driver sustained minor contusions and abrasions. He was transported to a local hospital where he was treated and released. The front right occupant sustained multiple minor lacerations. The second row left occupant sustained minor contusions and abrasions and a neck strain. He was transported to a local hospital where he was treated and released. The second row middle occupant sustained no injuries. She was evaluated at the scene. The second row right occupant sustained multiple contusions and abrasions. She was evaluated at the scene and then transported by air ambulance to an area trauma center where she was admitted. The third row left occupant complained of pain to his left shoulder. He was transported to a local hospital for evaluation. The third row right occupant sustained a skull fracture, as well as miscellaneous lacerations, contusions and abrasions. He was evaluated at the scene. He was then transported by air ambulance to an area trauma center where he was admitted. The Chevrolet Trailblazer was towed from the scene and later declared a total loss by the insurance company.



Figure 1. Case vehicle, 2005 Chevrolet Trailblazer

This rollover investigation was identified by NHTSA during a review of General Estimates System (GES) police crash reports. DSI received the reports during the week of April 9th. On April 24, 2007, DSI located the case vehicle and obtained permission for the inspection. DSI was assigned the case on April 25, 2007. The case vehicle was inspected on April 25, 2007. Efforts were undertaken to download the electronic data recorder but were not successful due to an air bag module communication error.

SUMMARY

Crash Site

The crash occurred at 1246 hours in January 2007. This single vehicle crash occurred on an east/west divided interstate highway (**Figure 2**). The westbound and eastbound lanes were divided by a depressed median. The westbound lanes were separated by a dashed white line. The left lane edge was bordered by a solid yellow line, followed by an asphalt shoulder with a rumble strip. The right lane edge was bordered by a solid white line, followed by an asphalt shoulder with a rumble strip. The interstate was level at this location. The asphalt roadway was clear of debris and dry with no obstructions present. The weather was clear. The posted speed limit was 121 km/h (75 mph).



Figure 2. Path of travel (west)

Pre Crash

The Chevrolet Trailblazer was being driven by a restrained 49-year-old male. There were six additional occupants in the vehicle as shown in the following table.

Seat Position	Age/Sex
Front right (02)	44/Female
Second row left (03)	29/Male
Second row middle (04)	8/Female
Second row right (05)	11/Female
Third row left (06)	15/Male
Third row right (07)	5/Male

The Chevrolet Trailblazer was traveling westbound at a driver-reported speed of 113 km/h (70 mph) on a two-lane divided interstate highway. The driver fell asleep and the case vehicle drifted to the left into the median. Upon waking, the driver steered to the right but over-corrected. The case vehicle began a clockwise motion on the dirt median onto paved portion of the roadway.

Crash

Upon entering the paved roadway, the left side tires dug into the asphalt surface causing the vehicle to begin rolling onto its left side. The case vehicle continued to roll over across both lanes of travel, the emergency shoulder and the dirt shoulder. The case vehicle rolled six quarter turns. The case vehicle came to rest on its roof facing northeast on the dirt shoulder.

Post Crash

The driver sustained contusions to his scalp and chest wall and abrasions to his right hand. He was able to exit the vehicle under his own power. He was transported to a local hospital where he was treated and released.

The front right occupant (02) sustained a scalp laceration and multiple lacerations to the right elbow. She was able to exit the vehicle under her own power. She was evaluated at the scene. She was then transported by air ambulance to an area trauma center where she was admitted and hospitalized for one day.

The second row left occupant (03) sustained minor contusions and abrasions and a neck strain. He was able to exit the vehicle under his own power. He was transported to a local hospital where he was treated and released.

The 8-year-old second row middle occupant (04) did not sustain any visible injuries. It appears that EMS personnel cut her seat belt to get her out of the vehicle. She was evaluated at the scene. She was then transported by ambulance to an area hospital where she was examined and released.

The 11-year-old second row right occupant (05) sustained multiple contusions and abrasions. She was evaluated at the scene and then transported by air ambulance to an area trauma center where she was admitted.

The 15-year-old third row left occupant (06) complained of pain to his left shoulder. He was transported to a local hospital for evaluation.

The 5-year-old third row right occupant (07) sustained a skull fracture, as well as miscellaneous lacerations, contusions and abrasions. He was evaluated at the scene. He was then transported by air ambulance to an area trauma center where he was arrived with a Glasgow Coma Score (GCS) of 15. He was hospitalized one day.

The Chevrolet Trailblazer was towed from the scene and later declared a total loss by the insurance company.

Vehicle Data - 2005 Chevrolet Trailblazer

The 2005 Chevrolet Trailblazer four-door sport utility vehicle was identified by the Vehicle Identification Number (VIN): 1GNES16S956xxxxxx. The Trailblazer was equipped with 6-cylinder 4.2 liter engine, a four-speed automatic transmission, rear wheel drive, and four-wheel ABS. The Trailblazer had a Static Stability Factor (SSF) of 1.17. The Trailblazer was configured with Continental Contitrak P245/65R17 tires. The vehicle manufacture's recommended cold tire pressure was 207 kPa (30 psi). The tire manufacturer's maximum recommended tire pressure was 303 kPa (44 psi). The specific tire information is as follows:

Position	Measured Pressure	Measured Tread Depth	Restricted	Damage
LF	Flat	7 mm (9/32 in)	No	Rim cracked
LR	Unknown	Unknown	No	Carcass gone
RR	Flat	7 mm (9/32 in)	No	None
RF	214 kPa (31 psi)	6 mm (8/32 in)	Yes	None

The seating in the Trailblazer was configured with front bucket seats with adjustable head restraints, a second row 60/40 split bench seat with adjustable head restraints for the outboard seating positions and seating for three, and a third row split bench seat with seating for two. The driver's seat was adjusted to the rear most seat track position. The seat back was at a 28 degree angle from vertical and the seat cushion was at a 12 degree angle from horizontal. The front right seat was adjusted to the full forward seat track position. The seat back was at a 29 degree angle from vertical and the seat cushion was at a 12 degree angle from horizontal. The second row seat back was at a 25 degree angle from vertical and the seat cushion was at an 18 degree angle from horizontal. The third row seat back was at a 26 degree angle from vertical and the seat cushion was at a 13 degree angle from horizontal.

Vehicle Damage

Exterior Damage -2005 Chevrolet Trailblazer

The 2005 Chevrolet Trailblazer sustained moderate damage due to the rollover event (**Figure 3**). The direct damage on the roof began near the top of the tailgate and was 121 cm (47.6 in) wide. The damage narrowed down to 10 cm (3.9 in) along the right A pillar area down to the hood. There was direct contact damage along the right side of the vehicle that began at the right front bumper corner area and extended 465 cm (183.0 in) rearward.

The maximum crush was located at the right A pillar and measured 12 cm (4.7 in) vertically and 13 cm (5.1 in) laterally (**Figure 4**). The Collision Deformation Classification (CDC) was 00TDDO3.

All the doors were jammed shut. The left front door was pried open during the vehicle inspection. The side glazing was disintegrated for both sides of the vehicle with the exception of the rear most left window which had popped out. The left rear tire was torn from the rim.



Figure 3. Overview of roof crush as seen from the front of the vehicle



Figure 4. Maximum crush

Interior Damage -2005 Chevrolet Trailblazer

The 2005 Chevrolet Trailblazer sustained moderate interior damage as a result of passenger compartment intrusion (**Figure 5**). There was intrusion damage along the entire right roof rail area and its supporting structures. There were scuffs and blood located on the roof, primarily about the front right seat (**Figure 6**). The roof structure intruded to a degree that it was in contact with the front right head restraint.

The specific passenger compartment intrusions were documented as follows:

Position	Intruded Component	Magnitude of Intrusion	Direction
1R	A pillar	18 cm (7.0 in)	Vertical
1R	A pillar	13 cm (5.1 in)	Lateral
1R	Roof side rail	14 cm (5.5 in)	Vertical
1R	B pillar	8 cm (3.1 in)	Vertical
1R	B pillar	18 cm (7.0 in)	Lateral
1R	Roof	25 cm (9.8 in)	Vertical
2R	Roof side rail	24 cm (9.4 in)	Vertical
2R	Roof	28 cm (11.0 in)	Vertical
3R	Side rail	22 cm (8.7 in)	Vertical
2M	Roof	21 cm (8.3 in)	Vertical



Figure 5. Overview of right side intrusion



Figure 6. Blood and scuff marks to right interior roof

Manual Restraints -2005 Chevrolet Trailblazer

The 2005 Chevrolet Trailblazer was configured with 3-point manual lap and shoulder belts for each of the seven seating positions. The front seats were equipped with integral safety belts and buckle pretensioners that did not actuate. The second row middle seat was also equipped with an integral safety belt. The driver's safety belt was configured with a sliding latch and an Emergency Locking Retractor (ELR). The remaining safety belts were configured with sliding latch plates and switchable ELR/Automatic Locking Retractors (ALR). There were indications of historical usage on all of the safety belts. The second row middle safety belt was cut, possibly by emergency personnel (**Figure 7**). The second row right was found to be jammed in the stowed position.

The Chevrolet Trailblazer was equipped with LATCH (Lower Anchors and Tethers for Children) system anchors in the second row seats. The LATCH system provides two lower anchors and one top tether anchor to be used to secure a child seat.



Figure 7. Second row middle safety belt, cut by EMS

Supplemental Restraint Systems -2005 Chevrolet Trailblazer

The 2005 Chevrolet was equipped with advanced occupant protection systems including multi-stage Certified Advanced 208-Compliant driver and front right passenger air bags. The multi-stage air bags were certified by the manufacturer to meet the advanced air bag requirements of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The driver's air bag was mounted in the center of the steering wheel hub and front right passenger air bag was a mid instrument mount. The vehicle was equipped with a front right Passenger Sensing System (PSS). The PSS works with sensors located in the front right passenger seat and safety belt. These sensors are designed to detect the presence of a properly seated occupant and under certain conditions, the PSS will turn off the passenger front air bag. There is a passenger air bag status indicator located in the rear view mirror which displays ON or OFF when the vehicle is running (**Figure 8**). Whenever the PSS has turned off the front right air bag, the OFF indicator located on the rearview mirror will illuminate. This vehicle was not equipped with any other air bags. There were no air bag deployments in this crash.



Figure 8. Passenger Air Bag On/Off indicator on rearview mirror

Rollover Dynamics

The Trailblazer was equipped with an automatic transmission, rear wheel drive, and four-wheel ABS. The Trailblazer had a Static Stability Factor (SSF) of 1.17 and a Rollover Resistance Rating (RRR) of three out of five stars (with a 20 to 30 percent chance of rolling over). The Trailblazer was traveling westbound at a driver-reported speed of 113 km/h (70 mph). The driver fell asleep and the case vehicle drifted to the left into the median. Upon waking, the driver steered to the right but over-corrected to the right and the vehicle began a clockwise rotation. The Trailblazer traveled on the median for 113 m (370 ft) before returning to the roadway with the left side leading and having rotated approximately 50 degrees. Upon entering the paved roadway, the left side tires dug into the asphalt surface causing the vehicle to begin rolling onto its left side. The Trailblazer rolled six quarter turns while it traveled 64 m (211 ft) in a diagonal across both lanes of travel, the emergency shoulder and the dirt shoulder. The Trailblazer came to rest on its roof facing northeast on the dirt shoulder.

OCCUPANT DEMOGRAPHICS - 2005 Chevrolet Trailblazer

	Driver	Occupant 2
Age/Sex:	49/Male	44/Female
Seated Position:	Front left	Front right
Seat Type:	Bucket	Bucket
Height:	Unknown	Unknown
Weight:	110 kg (243 lbs)	Unknown
Pre-existing Medical Condition:	Hypertension, back problems	Cardiomegaly ¹
Alcohol/Drug Involvement:	None	N/A
Driving Experience:	Unknown	N/A
Body Posture:	Unknown, driver was likely asleep	Unknown
Hand Position:	Unknown	Unknown
Foot Position:	Unknown	Unknown
Restraint Usage:	Lap and shoulder belt available, used	Lap and shoulder belt available, used
Air bag:	Steering wheel mounted frontal air bag available, did not deploy	Instrument panel mounted frontal air bag available, did not deploy

¹Medical condition wherein the heart is enlarged.

	Occupant 3	Occupant 4
Age/Sex:	29/Male	8/Female
Seated Position:	Second row left	Second row middle
Seat Type:	Split bench with separate back cushion	Split bench with separate back cushion
Height:	Unknown	Unknown
Weight:	80 kg (176 lbs)	Unknown
Pre-existing Medical Condition:	None noted	None noted
Alcohol/Drug Involvement:	N/A	N/A
Body Posture:	Unknown	Unknown
Hand Position:	Unknown	Unknown
Foot Position:	Unknown	Unknown
Restraint Usage:	Lap and shoulder belt available, used	Lap and shoulder belt available, used
	Occupant 5	Occupant 6
Age/Sex:	11/Female	15/Male
Seated Position:	Second row right	Third row left
Seat Type:	Split bench with separate back cushion	Split bench with separate back cushion
Height:	Unknown	Unknown
Weight:	Unknown	Unknown
Pre-existing Medical Condition:	None noted	None noted
Alcohol/Drug Involvement:	N/A	N/A
Body Posture:	Unknown	Unknown
Hand Position:	Unknown	Unknown
Foot Position:	Unknown	Unknown
Restraint Usage:	Lap and shoulder belt available, used	Lap and shoulder belt available, used

Occupant 7

Age/Sex:	5/Male
Seated Position:	Third row right
Seat Type:	Split bench with separate back cushion
Height:	Unknown
Weight:	Unknown
Pre-existing Medical Condition:	None noted
Alcohol/Drug Involvement:	None, per medical report
Body Posture:	Unknown
Hand Position:	Unknown
Foot Position:	Unknown
Restraint Usage:	Lap and shoulder belt available, used

Occupant Injuries

Driver: Injuries obtained from emergency room records and radiology reports.

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Contusion, scalp, right side	190402.1,1	Roof	Possible
Abrasions, right hand	790202.1,1	Unknown	Unknown
Contusion, chest wall	490402.1,9	Seat belt webbing	Probable

Front right occupant (02): Injuries obtained from H&P report, Operative report and Radiology report.

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Laceration, minor, left scalp, 0.5 cm	190602.1,2	Roof	Possible
Multiple lacerations, minor, right elbow, superior 1.5 cm and inferior 1.0 cm	790602.1,1	Right door panel, including hardware	Possible

Second row left occupant (03): Injuries obtained from ER record, Radiology report and Discharge instructions.

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Cervical strain	640278.1,6	Impact forces	Probable
Contusion, right shoulder	790402.1,1	Unknown	Unknown
Multiple abrasions, left shoulder	790202.1,2	Seat belt webbing	Possible

Second row middle occupant (04): No visible injuries, per the police report.

Second row right occupant (05): Injuries obtained from police report.

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Multiple contusions	990400.1,9	Unknown	Unknown
Multiple abrasions	990200.1,9	Unknown	Unknown

Third row left occupant (06): Evaluated at the scene. Reported soreness to his left shoulder.

Third row right occupant (07): Injuries obtained from emergency room records and radiology reports.

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Vault fracture NFS, occipital, left side	150400.2,2	Roof	Probable
Laceration, minor, left eye (soft tissue), measuring 2.0 cm in length, extending into subcutaneous tissue	297602.1,2	Unknown	Unknown
Laceration, scalp, minor, left side, measuring 1.5 cm in length	190602.1,2	Roof	Probable
Contusion, battle sign type, behind left ear	190402.1,2	Unknown	Unknown
Contusion, axilla (armpit), right side	490402.1,1	Seat belt webbing	Probable
Contusion, abdomen, left lower quadrant	590402.1,2	Seat belt webbing	Probable
Abrasions, hands, bilateral	790202.1,3	Unknown	Unknown

OCCUPANT KINEMATICS

Driver Kinematics

The 49-year-old driver of the Trailblazer was seated in a somewhat upright posture and was restrained by the 3-point manual lap and shoulder belt (**Figure 9**). The seat track was positioned in the rearmost position. The driver had fallen asleep. As the Trailblazer drifted off the left side of the roadway, the driver woke up. He steered the vehicle to the right and the vehicle began a clockwise rotation. The driver pitched to the left due to the rotation. As the vehicle returned to the roadway, the vehicle tripped and began a left side leading rollover. The driver generally stayed in place during the rollover sequence. He sustained contusions to his scalp and chest wall and abrasions to his right hand. He was able to exit the vehicle under his own power. He was transported to a local hospital where he was treated and released.



Figure 9. Driver's seated position

Front Row Right Seat Occupant Kinematics (02)

The 44-year-old female front right seat occupant was seated in an unknown posture and was restrained by the 3-point manual lap and shoulder belt (**Figure 10**). The seat was positioned to the forward most track position. The driver had fallen asleep. As the Trailblazer drifted off the left side of the roadway, the driver woke up. He steered the vehicle to the right and the vehicle began a clockwise rotation. The right front occupant pitched to the left due to the rotation. As the vehicle returned to the roadway, the vehicle tripped and began a left side leading rollover. The right front occupant generally stayed in place during the rollover sequence. It appears that this occupant's head contacted the intruding right side roof. She sustained a scalp laceration and multiple lacerations to the right elbow. She was able to exit the vehicle under her own power. She was evaluated at the scene. She was then transported by air ambulance to an area trauma center where she was admitted and hospitalized for one day.



Figure 10. Front right seat occupant seated position

Second Row Left Seat Occupant Kinematics (03)

The 29-year-old male second row left seat occupant was seated in an unknown posture and was restrained by the 3-point manual lap and shoulder belt (**Figure 11**). As the Trailblazer drifted off the left side of the roadway, the driver woke up. He steered the vehicle to the right and the vehicle began a clockwise rotation. The second row left occupant pitched to the left due to the rotation. As the vehicle returned to the roadway, the vehicle tripped and began a left side leading rollover. The second row left occupant generally stayed in place during the rollover sequence. He sustained a cervical strain due to impact forces. He also sustained abrasions to the left shoulder that were possibly related to seat belt loading. He was able to exit the vehicle under his own power. He was transported to a local hospital where he was treated and released.



Figure 11. Second row left occupant seated position

Second Row Middle Seat Occupant Kinematics (04)

The 8-year-old female second row middle occupant was seated in an unknown posture and was restrained by the 3-point manual lap and shoulder belt (**Figure 12**). As the Trailblazer drifted off the left side of the roadway, the driver woke up. He steered the vehicle to the right and the vehicle began a clockwise rotation. The second row middle occupant pitched to the left due to the rotation. As the vehicle returned to the roadway, the vehicle tripped and began a left side leading rollover. The second row middle occupant generally stayed in place during the rollover sequence. There were no reported injuries for this occupant.



Figure 12. Second row middle occupant seated position

Second Row Right Seat Occupant Kinematics (05)

The 11-year-old female second row right seat occupant was seated in an upright posture and was restrained by the 3-point manual lap and shoulder belt (**Figure 13**). The driver had fallen asleep. As the Trailblazer drifted off the left side of the roadway, the driver woke up. He steered the vehicle to the right and the vehicle began a clockwise rotation. The second row right occupant pitched to the left due to the rotation. As the vehicle returned to the roadway, the vehicle tripped and began a left side leading rollover. The second row right occupant generally stayed in place during the rollover sequence. She sustained multiple contusions and abrasions. She was evaluated at the scene and then transported by air ambulance to an area trauma center where she was admitted.



Figure 14. Second row right occupant seated position

Third Row Left Seat Occupant Kinematics (06)

The 15-year-old male third row left seat occupant was seated in an upright posture and was restrained by the 3-point manual lap and shoulder belt (**Figure 14**). The driver had fallen asleep. As the Trailblazer drifted off the left side of the roadway, the driver woke up. He steered the vehicle to the right and the vehicle began a clockwise rotation. The third row left occupant pitched to the left due to the rotation. As the vehicle returned to the roadway, the vehicle tripped and began a left side leading rollover. The third row left occupant generally stayed in place during the rollover sequence. He complained of pain to his left shoulder. He was transported to a local hospital for evaluation.



Figure 13. Third row left occupant seated position

Third Row Right Seat Occupant Kinematics (07)

The 5-year-old male third row right seat occupant was seated in an upright posture and was restrained by the 3-point manual lap and shoulder belt (**Figure 15**). The driver had fallen asleep. As the Trailblazer drifted off the left side of the roadway, the driver woke up. He steered the vehicle to the right and the vehicle began a clockwise rotation. The third row right occupant pitched to the left due to the rotation. As the vehicle returned to the roadway, the vehicle tripped and began a left side leading rollover. The third row right occupant generally stayed in place during the rollover sequence. This occupant likely contacted the intruding right side roof/roof rail. He sustained a skull fracture, as well as miscellaneous lacerations, contusions and abrasions. He was evaluated at the scene. He was then transported by air ambulance to an area trauma center where he was arrived with a GCS of 15. He was hospitalized one day.



Figure 15. Third row right occupant seated position

Attachment 1. Scene Diagram

