Child Safety Seat Fatality Investigation/Vehicle Rollover
Dynamic Science, Inc./Case Number: DS05018
1996 Isuzu Oasis LS Minivan
North Dakota
September 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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15. Abstract

The focus of this on-site investigation was on a child safety seat installed in the second row right seating position of a 1996 Isuzu Oasis minivan. This single vehicle crash occurred in September, 2005 at 1550 hours in the state of North Dakota. The crash occurred on a two-lane divided highway. The posted speed limit was 105 km/h (65 mph). The case vehicle is a 1996 Isuzu Oasis LS minivan that was being driven by a restrained 29-year-old female. There were two additional occupants in the vehicle–a 3 year-old female restrained in a booster seat in the second row left seating position and a 7-month-old male infant secured in a child safety seat in the second row right seating position. The baby was secured in an Evenflo Discovery Infant child safety seat that was equipped with a stay-in-vehicle base. The case vehicle was traveling north. The vehicle drifted across the southbound lane and onto the left shoulder. The driver over-corrected several times and the vehicle overturned. During the rollover sequence, the infant seat became disconnected from its stay-in-vehicle base. Subsequently, the child and the infant seat were ejected; the base remained inside the case vehicle. The infant came to rest near the case vehicle, still secured in the child seat. The driver and the 3-year-old occupant were not injured. The driver exited the vehicle on her own and removed the 7-month-old from the car seat. The infant was transferred to the ambulance and taken to a local medical center. A CT scan revealed a right frontal skull fracture and subarachnoid hemorrhage. The child never regained consciousness and was declared brain dead the following day. The child was removed from the ventilator and expired at 0640 hours. The case vehicle was towed from the scene and eventually released into the custody of the owner.

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Dynamic Science, Inc.
Crash Investigation
Case Number: DS05018

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BACKGROUND

The focus of this on-site investigation was on a child safety seat installed in the second row right seating position of a 1996 Isuzu Oasis LS minivan. This single vehicle crash occurred in September, 2005 at 1550 hours in the state of North Dakota. The crash occurred on a two-lane divided highway. The posted speed limit was 105 km/h (65 mph).

Figure 1. 1996 Isuzu Oasis LS minivan

The case vehicle is a 1996 Isuzu Oasis LS (VIN: JR2RJ1871TCxxxxxx) minivan that was being driven by a restrained 29-year-old female (Figure 1). There were two additional occupants in the vehicle–a 3 year-old female, restrained in a booster seat in the second row left seating position, and a 7-month-old male infant, secured in a child safety seat in the second row right seating position. The baby was secured in an Evenflo Discovery Infant child safety seat that was equipped with a stay-in-vehicle base.

The case vehicle was traveling north at an unknown rate of speed. The coroner's report indicated that prior to the crash the mother had been glancing in the rearview mirror, in order to check on the infant male and her daughter. She was singing songs with her daughter. With the driver distracted, the vehicle drifted across the southbound lane and onto the left shoulder. As the van came into contact with gravel on the west shoulder, the driver steered sharply to the right in an attempt to reenter the roadway. This over-steering caused the vehicle to begin a clockwise yaw as it traversed both travel lanes and exited the roadway to the east.

The case vehicle departed the east side of the roadway while still in the clockwise rotation. The vehicle tripped and began to overturn. During the rollover sequence the infant seat became disconnected from its stay-in-vehicle base. Subsequently the child and the infant seat were ejected; the base remained inside the case vehicle. The infant came to rest near the case vehicle, still secured in the child seat.

The driver and the 3-year-old occupant were not injured. The driver exited the vehicle on her own and removed the 7-month-old from the car seat. She then began running down the highway, where she was subsequently picked up by a passing motorist. An ambulance was called and intercepted the transporting private vehicle. The infant was transferred to the ambulance and taken to a local medical center, where he was admitted to the pediatric intensive care unit. A CT scan revealed a right frontal skull fracture and subarachnoid hemorrhage. The child never regained consciousness and was declared brain dead the following day. The child was removed from the ventilator and expired at 0640 hours.

The case vehicle was towed from the scene and eventually released into the custody of the owner.

This case was identified by NHTSA from an on-line news article. DSI was notified on September 20, 2005 with instructions to determine if the child was in the child seat at the time of the crash and if the child seat was anchored to the vehicle. The investigating officer was not available until September 26, 2005. On September 26, 2005, DSI contacted the investigator and it was determined that the child had been in the child seat and the child seat had been secured in a stay-in-vehicle base. DSI obtained permission to inspect the vehicle and car seat. On September 27, 2005, DSI was assigned the case. The vehicle and seat inspections took place September 29, 2005. The investigating officer was present during the inspections.

SUMMARY

Crash Site

This single vehicle crash occurred in September, 2005 at 1550 hours in the state of North Dakota. The crash occurred on the west side of a two-lane divided highway (Figure 2). The roadway was of asphalt construction and was straight with a -2.8% downgrade. The west side of the roadway was bordered by an asphalt shoulder, an area of gravel with a -5.4% downgrade, and an area of low grass. The posted speed limit was 105 km/h (65 mph).

Figure 2. Overview of travel path (north)

Pre-Crash

The case vehicle is a 1996 Isuzu Oasis LS (VIN: JR2RJ1871TCxxxxxx) minivan that was being driven by a restrained 29-year-old female. There were two additional occupants–a 3 year-old female secured in a booster seat in the second row left seating position and a 7-month-old male secured in a child safety seat in the second row right seating position. The infant's child safety seat was equipped with a stay-in-vehicle base.

The case vehicle was traveling northbound at an unknown rate of speed. The coroner's report indicated that prior to the crash the mother had been glancing in the rearview mirror, in order to check on the infant male and her 3-year-old daughter. She was singing songs with her daughter. With the driver distracted, the vehicle drifted across the southbound lane and onto the left shoulder. As the minivan came into contact with the gravel on the west shoulder, the driver steered sharply to the right in an attempt to reenter the roadway. This over-steering caused the vehicle to begin a clockwise yaw as it traversed both travel lanes and exited the roadway to the east (Figure 3).

Figure 3. Area of roadway departure

Crash

The case vehicle departed the east side of the roadway while in the clockwise rotation. The vehicle tripped as it departed the right side of the roadway, and began to overturn. During the rollover sequence the infant seat became disconnected from its stay-in-vehicle base. Subsequently the child and the infant seat were ejected; the base remained inside the case vehicle. The infant came to rest near the case vehicle, still secured in the child seat.

Figure 4. Final rest. Looking southwest. Ejected child seat in foreground.

Post-Crash

The driver and the 3-year-old occupant were not injured. The driver exited the vehicle on her own and removed the 7-month-old from the car seat. She then began running down the highway, where she was subsequently picked up by a passing motorist. An ambulance was called and intercepted the private vehicle. The infant was transferred to the ambulance and taken to a local medical center, where he was admitted to the pediatric intensive care unit. A CT scan revealed a right frontal skull fracture and subarachnoid hemorrhage. The child never regained consciousness and was declared brain dead the following day. The child was removed from the ventilator and expired at 0640 hours.

The case vehicle was towed from the scene and was eventually released into the custody of the owner.

VEHICLE DATA -1996 Isuzu Oasis LS Minivan

The 1996 Isuzu Oasis LS four-door minivan with a rear liftgate was located on a flatbed trailer in the yard of one of the driver's relatives. It was identified by the Vehicle Identification Number (VIN): JR2RJ1871TCxxxxxx. The vehicle has seating for six occupants and was equipped with a 2.2 liter 4 cylinder engine, a 4 speed automatic transmission, front wheel drive and disc brakes.

The vehicle was equipped with National XT 3000 P205/65R15 tires on alloy rims. During the inspection none of the four tires were flat, but it was determined that both left side tires had been flattened as a result of the rollover trip initiation. They were subsequently re-inflated to facilitate transport of the vehicle. Both right side tires were inflated, but the tow company added additional air to them prior to placing the vehicle onto the flatbed. Although tire pressure was recorded, it was not encoded on this table because it was not representative.

Tire	Tread	Measured pressure	Manufacturer recommended pressure	Restricted	Damage
LF	6.0 mm (0.23 in)	Flat at scene and subsequently inflated	241 kPa (35 psi)	No	None
LR	5.0 mm (0.19 in)	Flat at scene and subsequently inflated	241 kPa (35 psi)	No	None
RR	5.0 mm (0.19 in)	Not flat, but air added post crash	241 kPa (35 psi)	No	None
RF	5.0 mm (0.19 in)	Not flat, but air added post crash	241 kPa (35 psi)	No	None

The front row of the 1996 Isuzu Oasis LS minivan was configured with two fabric covered bucket seats with adjustable head restraints. The front right head restraint was damaged due to right B pillar vertical and lateral intrusion. The driver's seat track was set to the middle track position, the seat back angle was 77 degrees and the seat cushion angle was 15 degrees. The right front seat was adjusted to between the middle and rearmost track position, with a seat back angle of 77 degrees and seat cushion angle of 15 degrees.

The second row seating area was configured with two fabric covered bucket seats with adjustable head restraints and non-adjustable seat tracks. The second row right head restraint was damaged due to intrusion. The second row left seat had a seat back angle of 77 degrees and seat cushion angle of 14 degrees. The second row right seat had a seat back angle of 79 degrees and seat cushion angle of 14 degrees.

The third row seating area was configured with a fabric covered bench seat with a folding back and adjustable head restraints that were not damaged.

VEHICLE DAMAGE

Exterior Damage - 1996 Isuzu Oasis LS

Damage Description:	The vehicle sustained 41.0 cm (16.1 in) of crush to the roof area, with the greatest crush being located along the right side rail. This would indicate that the vehicle had rolled with its left side leading. There was integrity loss through the windshield bond separation and all of the right side window glazing fractured. Those windows disintegrated as the vehicle rolled onto its roof; the majority of the impact took place along the right roof side rail area. The windshield glazing pulled away from the bond itself, which constituted integrity loss. The sunroof glazing also disintegrated. Both right side doors and the hatchback were jammed shut.	
CDC:	00TDRO4	
Delta V:	Total	Unknown
	Longitudinal	Unknown
	Latitudinal	Unknown
	Energy	Unknown

Figure 5. Top/right side of case vehicle

Interior Damage - 1996 Isuzu Oasis LS

The vehicle sustained significant intrusion along the right roof, pillars and side rail areas (Figure 6). These field measurements were obtained from the floor vertically, and an exemplar vehicle was located in order to obtain comparative, undamaged measurements (Figure 7).

The specific passenger compartment intrusions were documented as follows:

Position	Intruded Component	Magnitude of Intrusion	Direction
RF	A Pillar	32.0 cm (12.6 in)	Lateral
RF	B Pillar	31.0 cm (12.2 in)	Lateral
RR	B Pillar	31.0 cm (12.2 in)	Lateral
RF	A Pillar	27.0 cm (10.6 in)	Vertical
RF	Windshield header	26.0 cm (10.2 in)	Vertical
RF	Roof	26.0 cm (10.2 in)	Vertical
RF	Roof side rail	21.0 cm (8.3 in)	Vertical
RR	C Pillar	17.0 cm (6.7 in)	Lateral
RR	Roof	13.0 cm (5.1 in)	Vertical
RR	Roof side rail	10.0 cm (3.9 in)	Vertical

Occupant contact evidence inside the case vehicle was very minimal. There was scuffing along the right rear door which may have come from the infant seat as it was being ejected from the vehicle. There was also molding broken along the rear of the right B pillar. The avenue of occupant ejection was determined to have been through the right rear glazing area, which disintegrated as the vehicle was rolling over. The only other possible contact point found was an area of scuffing along the roof in the front row seating area.

Figure 6. Overview of passenger compartment intrusion

Figure 7. View of exemplar vehicle interior

Manual Restraint Systems - 1996 Isuzu Oasis LS

The front seats in the Isuzu Oasis were equipped with manual 3-point lap and shoulder safety belts. Both front seat shoulder belt adjusters were found in the full down position, and both belts had sliding latchplates. The driver's seat belt exhibited signs of being worn during this crash; no failures to the safety system were noted. The driver's belt was equipped with an emergency locking retractor (ELR) and the front right belt had a switchable ELR/ALR (Automatic Locking Retractor).

The second row left seat was occupied by a 3-year-old female. The girl had been in a high back Century Next Step booster seat. It was secured to the vehicle by the use of the manual 3-point lap and shoulder belt. There were visible signs of loading to the seat belt webbing which were consistent with its having been used during the crash. This seat belt consisted of a switchable seat belt retractor (ELR/ALR) and had a sliding latch plate. When viewed at the time of the vehicle inspection the retractor was noted to have been switched to the ALR mode. It did not have an adjuster mechanism for the shoulder belt webbing. All seat belt components were found to be fully operational; however, the lap and shoulder belt appeared to have been routed incorrectly as the belt webbing was bunched through the rear frame of the booster seat.

The second row right seat was occupied by a 7-month-old male who was seated in an Evenflo Discovery infant seat with a detachable base. The base had been anchored to the fabric bucket seat by the use of the vehicle's 3-point manual lap and shoulder belt. Unlike the 3-year-old's seat belt, the 7-month-old's belt webbing exhibited no signs of loading. The infant's seat belt retractor was switchable (ALR/ELR) and the belt had a sliding latchplate. At the time of the vehicle inspection, it was determined that the belt had been switched to the ALR mode. There were no problems noted to any of the second row right seat belt components.

The third row bench seat consisted of two seating positions that were both equipped with 3-point manual lap and shoulder seat belts. No one was seated on the third row bench seat.

Supplemental Restraint System - 1996 Isuzu Oasis LS

The 1996 Isuzu Oasis was equipped with two frontal air bags. One was mounted in the center of the steering wheel, while the passenger bag was mounted in the upper area of the front dashboard. Neither air bag deployed.

Child Safety Seat - Century Next Step Booster Seat

The second row right seat was occupied by a 3-year-old female who was seated in a forward facing Century Next Step booster seat (Figure 8). It had been manufactured on December 20, 2001 with a model number of 44905 HCB. Its internal 5-point harness had the shoulder straps located in the middle position (three slot settings available on the back). There was a retainer clip present. According to the label affixed to the side of this particular seat, it was designed to have the internal harness worn by children ranging in size from 9.1-18.1 kg (20-40 lbs). Once a child had grown to the point where their shoulders were at the top of the upper slots, the internal harness was to be removed and the vehicle's seat belt was to be placed around the child and the booster seat. The size range for a child to be using the seat in this manner was 13.6-36.3 kg (30-80 lbs).

Figure 8. Century Next Step booster seat

Booster Seat Installation

This Century Next Step booster seat was anchored to the case vehicle by the use of the manual 3-point lap and shoulder belt. There were visible signs of loading to the seat belt webbing which were consistent with its having been used during the crash. This seat belt consisted of a switchable seat belt (ELR/ALR) and had a sliding latch plate. When viewed at the time of the vehicle inspection it was noted to have been switched to the ALR mode. All seat belt components were found to be fully operational. When inspected, this seat was still tightly anchored to the case vehicle. It exhibited 3.8 cm (1.5 in) of lateral movement and 2.5 cm (1.0 in) of forward top movement.

Figure 9. High back booster seat belt routing path - webbing bunched up

Child Safety Seat - Evenflo Discovery Infant Safety Seat

The second row right seat was occupied by a 7-month-old male who was seated in a rear-facing Evenflo Discovery Infant safety seat (Figure 10). According to information provided by the manufacturer, this particular infant seat was designed for infants within the 2-10 kg (5-22 lbs) range. The weight of this child was 8.0 kg (17.6 lbs), but his height is not known. The separate base provides quick access in and out of the car. The internal harness has two slot positions which provide flexibility to secure an infant comfortably.

Figure 10. Evenflo Discovery Infant Safety Seat

The infant seat used in this particular crash was manufactured on March 23, 2002 with a model number of 4791270P1. The internal 3-point harness had its shoulder strap webbing located in the upper slot (top) and the handle was found in the downward position. Post-crash photos also show the handle in the down position. The infant seat base did not exhibit any signs of stressing or flexing as a result of the crash (Figure 11). This particular base was no longer in the case vehicle, but was being held at the highway patrol office when it was inspected. An examination of the seat and seat base revealed that the locking mechanism attaching the seat to the seat base was functioning correctly. There were no indications of stressing or flexing at the locking points. It appears likely that the child safety seat had been placed on the seat base, but had not been properly locked down.

Infant Seat Installation

The infant seat base had been anchored to the case vehicle by the use of the vehicle's 3-point lap and shoulder harness. The lap and shoulder belt had been switched to the ALR mode and was still in the ALR mode at the time of inspection.

Figure 11. Stay-in-vehicle base

Infant Seat Damage

The infant seat, minus the detachable base, had been ejected from the case vehicle. The avenue of ejection was through the right rear glazing area, which disintegrated during the rollover sequence. There was no visible damage to the base or to the mechanism whereby the child seat was secured to the base. There were no signs of any failures in this area.

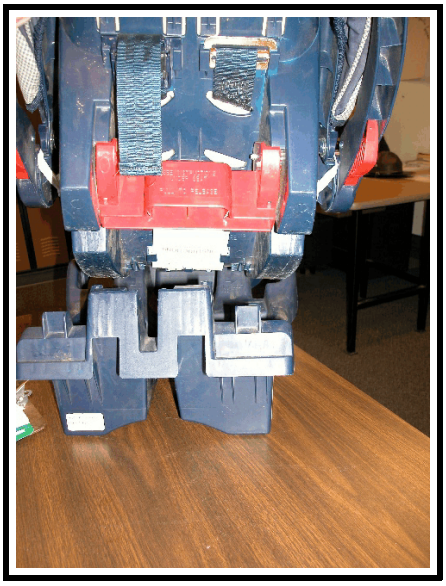

Figure 12. Seat to seat base locking mechanism

Occupant Demographics - 1996 Isuzu Oasis LS

	Driver	Occupant 2	Occupant 3
Age/Sex:	29/Female	3/Female	7 month-old/Male
Seated Position:	Front left	Second row left	Second row right
Seat Type:	Fabric covered bucket seat	Fabric covered bucket seat	Fabric covered bucket seat
Height:	Unknown	Unknown	Unknown
Weight:	Unknown	Unknown	8.0 kg (17.6 lbs)
Occupation:	Unknown	Not Applicable	Not Applicable
Pre-existing Medical Condition:	None noted	None noted	None noted
Alcohol/Drug Involvement:	None	None	None
Driving Experience:	Unknown	Not Applicable	Not Applicable
Body Posture:	Presumed to be upright, forward facing	Unknown	Unknown
Hand Position:	Presumed to both be on steering wheel, actively steering	Unknown	Unknown
Foot Position:	Unknown	Unknown	Unknown
Restraint Usage:	Lap and shoulder belt available, used	Lap and shoulder belt available, used with Century Next Step booster seat equipped with an internal 5-point harness	In an infant safety seat, restrained by its internal 3-point harness. The detachable infant seat base was anchored to the minivan by the use of the vehicle's lap and shoulder belt.
Air bag:	Steering wheel mounted front air bag - non-deployed.	None	None

Occupant Injuries - 1996 Isuzu Oasis LS

Driver: Not injured per the police report.

Second Row Left Occupant: Not injured per the police report.

Second Row Right Occupant: Injuries obtained from medical records.

Injury	OIC Code	Injury Mechanism	Confidence Level
Left subarachnoid hemorrhage	140684.3,2	Ground	Probable
Left pulmonary contusions	441402.3,2	Ground	Probable
Epidural hematoma	140630.4,9	Ground	Probable
Subdural hematoma	140650.4,9	Ground	Probable
Diffuse cerebral edema	140660.3,9	Ground	Probable
Bilateral extensive intracranial hemorrhage with rightward midline shift	140646.5,3	Ground	Probable
Squamousal portion of bilateral temporal bones	150402.2,2 150402.2,1	Ground	Probable
Right lateral wall and roof orbital fractures	251202.2,1 251202.2,1	Ground	Probable
Left lateral orbital wall fracture	251202.2,2	Ground	Probable
Both posterior parietal bone fractures	150402.2,1 150402.2,2	Ground	Probable
Displaced right occipital fracture with extracranial herniation of brain parenchyma	150404.3,1	Ground	Probable

Occupant Kinematics - 1996 Isuzu Oasis LS

Driver Kinematics

During the rollover sequence, the vehicle tripped with its left side leading. The restrained driver moved toward the left door, and then toward the right as the vehicle touched down. She remained in her seat by the use of the 3-point lap and shoulder safety belt system. After the case vehicle came to final rest, the driver was able to exit the vehicle on her own and immediately went to check on her infant son, who had been ejected in his child safety seat. This driver sustained no injuries, and there were no contact points found anywhere along the left interior surfaces that would indicate that this occupant contacted the interior of the case vehicle.

Second Row Left Occupant Kinematics

This 3-year-old female passenger was restrained in a forward facing Century Next Step high back booster seat with an internal 5-point harness. As the vehicle began to rollover to the left, this toddler was secured in the child safety seat and did not come in contact with the passenger compartment interior. According to the police report and the investigating officer, this child was not injured in the crash.

Second Row Right Occupant Kinematics

As the vehicle rolled with the left side leading, this 7-month-old male infant remained secured inside the Evenflo Discovery Infant child safety seat by the use of its 3-point internal harness. As the vehicle rolled onto the roof's right side rail, the infant seat became detached from the base. The infant seat, with the child still in it, was ejected through the right rear window (glazing had disintegrated-see Figure 13). The child and the seat came to rest to the right of the case vehicle. According to police and a witness statement, the mother removed the unconscious child from the safety seat, and began to run down the roadway, towards the nearest town. The child sustained significant head trauma as a result of being ejected.

Figure 13. Second row, right side window

A passerby picked up the occupants of the case vehicle and drove them to town where they were met by an ambulance. The ambulance transported the injured infant to a trauma center ICU, where he was admitted. A CT scan revealed a right frontal skull fracture and subarachnoid hemorrhage. The child never regained consciousness and was declared brain dead the following day. The child was removed from the ventilator and expired at 0640 hours. There were no indications of occupant contact to the window frame or other interior components in this infant's general seating area. It appears that the child's head injuries were related to contact with the ground, which occurred during the ejection (Figure 14).

Figure 14. Possible child seat contact to second row, right side door

Attachment 1. Scene Diagram