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ON-SITE CHILD SAFETY SEAT INVESTIGATION

CASE NUMBER - IN-04-037

LOCATION - ILLINOIS

VEHICLE - 2002 GMC ENVOY

CRASH DATE - October 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.

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15. <i>Supplementary Notes</i> On-site child safety seat investigation involving a 2002 GMC Envoy with manual safety belts, and dual redesigned front air bag system and back seat LATCH system.					
16. <i>Abstract</i> This report covers an on-site child safety seat investigation that involved a 2002 GMC Envoy (case vehicle), which ran-off-road and rolled over. This crash is of special interest because the back seat passengers (3-year-old, female and 2-month-old male) were both restrained in child safety seats and did not sustain any serious injuries as a result of the crash. The case vehicle was traveling west in the westbound lane of a two-lane, undivided state highway. The driver stated that she momentarily fell asleep, and the right side wheels drifted off the north side of roadway. The driver awoke, steered left, crossed the westbound lane into the eastbound lane, steered right, then steered left again as the case vehicle departed the north side of the roadway. The case vehicle rotated counterclockwise and rolled over passenger side leading one-and-one half rolls and came to rest on its roof. The driver and front right passenger front air bags and seat back-mounted side impact air bags did not deploy in the crash. The back left passenger (3-year-old, female) was restrained in a convertible child safety seat, and the back right passenger (2-month-old, male) was restrained in a rear-facing infant seat. Both passengers remained restrained in their child safety seats throughout the crash. The child safety seats were not damaged and remained in place throughout the crash. The back left passenger was uninjured, and the back right passenger sustained a small contusion on the left side of his head due to contact with the inside left surface of his infant seat. Both passenger's were transported to a hospital and were treated and released. The driver and front right passenger were both restrained by their integral, three-point, lap-and-shoulder safety belt systems. They remained restrained in their seats throughout the crash and were transported to a hospital and treated and released. The driver sustained a cervical strain due to contact with the intruding roof and a left knee abrasion due to contact with the left front door. The front right passenger sustained a scalp laceration and abrasion to the back of his head due to contact by flying broken glass. He also sustained two abrasions and a laceration in the area of his right thumb as he was crawling out the case vehicle following the crash.					
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TABLE OF CONTENTS

IN-04-037

Page No.

BACKGROUND 1

SUMMARY 1

CRASH CIRCUMSTANCES 3

CASE VEHICLE: 2002 GMC ENVOY 6

 CASE VEHICLE DAMAGE 6

 AUTOMATIC RESTRAINT SYSTEM 8

 CRASH DATA RECORDING 8

 CHILD SAFETY SEAT 9

 CASE VEHICLE BACK LEFT PASSENGER KINEMATICS 12

 CASE VEHICLE BACK LEFT PASSENGER INJURIES 13

 CASE VEHICLE BACK RIGHT PASSENGER KINEMATICS 13

 CASE VEHICLE BACK RIGHT PASSENGER INJURIES 14

 CASE VEHICLE DRIVER KINEMATICS 14

 CASE VEHICLE DRIVER INJURIES 15

 CASE VEHICLE FRONT RIGHT PASSENGER KINEMATICS 15

 CASE VEHICLE FRONT RIGHT PASSENGER INJURIES 16

EVENT DATA RECORDER DATA 18

CRASH DIAGRAM 20

This on-site investigation was brought to NHTSA's attention on or before October 30, 2004 by a newspaper clipping service. This crash involved a 2002 GMC Envoy (case vehicle), which ran-off-road and rolled over. The crash occurred in October, 2004, at 4:47 p.m., in Illinois and was investigated by the applicable city police department. This crash is of special interest because the case vehicle's back seat passengers [3-year-old, White (non-Hispanic) female and 2-month-old, White, (non-Hispanic) male] were both restrained in child safety seats and did not sustain any serious injuries as a result of the crash. In addition, the case vehicle was equipped with redesigned air bags, seat back-mounted side impact air bags and an Event Data Recorder (EDR). This contractor interviewed the driver and front right passenger on November 18 and 30, 2004, and inspected the case vehicle, both child safety seats and downloaded the EDR on November 30, 2004. The scene was inspected on December 1, 2004. This report is based on the police crash report, scene, vehicle and child safety seat inspections, occupant medical records, interviews with the case vehicle's driver and front right passenger, occupant kinematic principles and this contractor's evaluation of the evidence.

SUMMARY

The case vehicle was traveling west in the westbound lane of a two lane undivided state highway. The driver stated that she momentarily fell asleep, and the right side wheels drifted off the north side of roadway. The driver awoke, steered left, crossed the westbound lane and traveled into the eastbound lane. The driver then steered right to avoid an oncoming car. The case vehicle crossed the westbound lane, departed the north side of the roadway, and the driver steered left to avoid a car parked in the grass. The case vehicle began to rotate counterclockwise, traveled through a shallow ditch and across the east leg of a U-shaped gravel driveway. The case vehicle continued to rotate counterclockwise and was nearly broadside as it approached the west leg of the U-shaped driveway. The right side wheels furrowed into the ground and the case vehicle tripped and began to roll over passenger side leading. The case vehicle rolled over a total of six quarter turns (i.e., one-and-one-half rolls) on primarily level ground across a distance of about 16 meters (52.5 feet). The reconstructed speed range of the case vehicle at rollover initiation was approximately 38 km.p.h (24 m.p.h) to 50 km.p.h. (31 m.p.h.). The case vehicle came to rest on its top facing southeast partially in the ditch near the roadway. The driver was unsure if she applied the brakes at any time prior to the rollover; however, the EDR data indicated no brake application prior to algorithm enable. The weather at the time of the crash was clear, the light condition was daylight, the roadway pavement was dry bituminous, traffic density was light and the site of the crash was rural.

The CDC for the case vehicle was determined to be **00-TDDO-4**. The WinSMASH reconstruction program could not be used to reconstruct the case vehicle's Delta V because rollovers are out-of-scope for the WinSMASH program. Based on the damage to the case vehicle's roof, this contractor estimates the severity of the rollover to be severe.

The back left passenger was seated in a convertible child safety seat that was used in its forward-facing configuration. The child seat was manufactured by Britax on November 11, 2003 and was identified by Model name "Marathon", Model number E9L0605, and Batch number

504641. The child seat was purchased new in December 2003 and was used on a daily basis. The child seat was designed with a five-point harness with a non-recessed buckle, and a top tether and lower anchor system. There were four sets of slots to thread the harness straps through. The harness straps were threaded through the middle slots, and the harness retainer clip was positioned at the child's armpit level. The child seat was installed tightly in the case vehicle via the lower anchors and upper tether of the case vehicle's LATCH system. The child seat was in a slightly reclined position and a towel had been placed under the child seat, not for positioning, but to protect the leather seat. The child safety seat remained secured in the vehicle during the crash and was not damaged.

Immediately prior to the crash, the case vehicle's back left passenger [3-year-old, White (non-Hispanic) female; 94 centimeters and 15 kilograms (37 inches, 33 pounds)] was restrained in her convertible child safety seat. The child was seated in an approximate upright position. The child was holding her blanket and teddy bear and was asleep with her head nodded to the right. The child remained securely restrained in her child safety seat throughout the crash and was not injured. The installation and usage of the child safety seat prevented the back left passenger from sustaining any injuries.

The back left passenger was removed from the case vehicle by the driver. The back left passenger was transported by ambulance to a local hospital where she was treated and released.

The back right passenger was seated in a rear-facing infant seat with a locking base. The infant seat was manufactured by Evenflo on April 26, 2002 and was identified by Model name "Cozy Carry 5" and Model number 2731151P1. The infant seat base was manufactured by Evenflo in February, 2002 and was identified with Model number 639004P1. The infant seat and base were purchased new for the left rear passenger and were used on a daily basis when she was an infant. The infant seat and base were then used on a daily basis for the back right passenger. The infant seat was designed with a five-point harness with a non-recessed buckle. There were three sets of slots to thread the harness straps through. The harness straps were threaded through the top slots, and the harness retainer clip was positioned at the child's armpit level. The base had separate routing paths for a vehicle's safety belt and for a separate belt that attaches to the lower anchors. In this crash, the base was secured tightly in the case vehicle by the separate belt routed through the "Latch Belt Only" path and attached to the case vehicle's lower anchors, and the infant seat was locked to the base. A towel was placed under the base to help level the infant seat.

Immediately prior to the crash, the case vehicle's back right passenger [2-month-old, White (non-Hispanic) male; 61 centimeters and 7 kilograms (24 inches, 16 pounds)] was restrained in his rear-facing infant seat. The infant was reclined in the seat and was wearing a heavy coat. The infant remained securely restrained in his infant seat throughout the crash. However, he contacted the left side of his head on the inside left surface of his infant seat during the rollover causing a small contusion on the left side of his head. The installation and usage of the infant seat prevented the back right passenger from sustaining severe injuries.

The back right passenger was removed from the case vehicle by the front right passenger. He was transported by ambulance to a local hospital and treated and released.

The driver [30-year-old, White (non-Hispanic) female] and front right passenger [34-year-old, White (non-Hispanic) male] were restrained by their integral, three-point, lap-and-shoulder safety belt systems. They remained restrained in their seat positions during the rollover. The driver impacted her head on the intruding roof surface and her left knee on the driver's door at the beginning of the third quarter roll as the case vehicle landed hard on its left roof and roof side rail. She sustained a cervical strain and a left knee abrasion due to these contacts. The front right passenger sustained a scalp abrasion and laceration to the back of his head from flying glass. He also sustained two abrasions and a laceration in the area of his right thumb as he was crawling out of the vehicle following the crash. Both the driver and front right passenger exited the vehicle under their own power following the crash. The use of their safety belts prevented the driver and front right passenger from sustaining more serious injury in this crash.

Both the driver and front right passenger were transported from the scene by ambulance to a local hospital. They were both treated and released from the emergency room.

CRASH CIRCUMSTANCES

Crash Environment: The trafficway on which the case vehicle was traveling was a two-lane, undivided, state highway, traversing in an east-west direction. Each travel direction contained one travel lane and gravel shoulders. Each travel lane was approximately 3.3 meters (10.8 feet) wide and each gravel shoulder was 1 meter (3.3 feet) wide. The case vehicle's approach roadway traversed up an approximate 3% grade and was controlled by no-passing lines. Pavement markings consisted of white edge lines and double yellow no-passing lines. The posted speed limit was 64 km.p.h. (40 m.p.h.). At the time of the crash the light condition was daylight, the atmospheric condition was clear, and the roadway pavement was dry, bituminous with an estimated coefficient of friction of 0.72. Traffic density was light and the site of the crash was rural. See the Crash Diagram at the end of this report.

Pre-Crash: The case vehicle was traveling west in the westbound lane up an approximate 3% grade (**Figure 1**). The driver was intending to continue westbound and turn right (north) onto a county road, which was located at the top of the hill. The case vehicle's driver stated that she momentarily fell asleep, and the right side wheels drifted off the north side of roadway (**Figure 2** below). The driver awoke, steered left, crossed the westbound lane and traveled into the eastbound lane. The driver steered right to avoid an oncoming car, and the case vehicle crossed the westbound lane and approached the north side of the roadway (**Figure 3** below). The driver stated she then steered left to avoid a car parked in the grass as the case vehicle departed the north side of the roadway. The scene evidence shows the driver did steer left, and the case vehicle began to rotate counterclockwise as it traveled down the approximate 17% negative front slope of a



Figure 1: Approach of case vehicle westbound up hill, number shows distance to roadway departure

shallow ditch (Figure 4). The case vehicle traveled through the ditch and up the approximate 10% positive back slope of the ditch, across the east leg of a U-shaped gravel driveway, and into the grass between the east and west legs of the driveway. The case vehicle continued to rotate counterclockwise and was nearly broadside as it approached the west leg of the U-shaped driveway (Figure 5). The driver was unsure if she applied the brakes at any time prior to the rollover. The EDR pre-crash data indicated no brake application during the five seconds prior to algorithm enable. The rollover occurred on the north side of the roadway at the east edge of the west leg of the U-shaped driveway.



Figure 2: Case vehicle first departed north side of roadway near reflector, indicated by arrow



Figure 3: Location where case vehicle departed north side of roadway, arrow shows tire impressions under the snow



Figure 4: Approach of case vehicle to first driveway, orange paint shows tire impressions under the snow



Figure 5: Approach of case vehicle to area of rollover initiation, indicated by arrow

Crash: As the case vehicle approached the west leg of the driveway, it rotated counterclockwise to a near broadside orientation. The right side wheels furrowed into the ground, and the case vehicle tripped and began to roll over passenger side leading. The area of rollover initiation was on an approximate 2% positive grade at the east edge of the west leg of the U-shaped driveway (Figure 6 below). The case vehicle rolled over a total of six quarter turns (i.e., one-and-one-half rolls) on primarily level ground across a distance of approximately 16 meters (52.5 feet). Using a rollover deceleration range from the published literature of -0.36g to -0.61g, the calculated speed

range of the case vehicle at rollover initiation was 38 km.p.h. (24 m.p.h.) to 50 km.p.h. (31.0 m.p.h.). The time duration of the rollover was 3.03 seconds to 2.31 seconds, and the average rotational velocity of the case vehicle during the rollover was approximately 178 degrees/second to 234 degrees/second.



Figure 6: Area of case vehicle’s rollover initiation at east edge of west leg of driveway, shown by arrow



Figure 7: Overview of rollover damage to case vehicle’s front, top and left side



Figure 8: Crush to case vehicle’s left front roof, each black mark on yellow tape and black/white section on vertical scale=0.31 meter (1 ft)



Figure 9: View east back through area of case vehicle’s final rest (indicated by arrow) to area of rollover and approach

During the rollover, the case vehicle sustained several significant impacts with the ground. The most severe occurred at the beginning of the third quarter roll as the case vehicle landed on the left fender and left roof side rail (**Figure 7**). This impact crushed the left front roof about 36 centimeters (14.2 inches) (**Figure 8**). The case vehicle’s driver and front right passenger air bags, as well as their seat back-mounted side impact air bags did not deploy during the rollover.

Post-Crash: The case vehicle came to rest on its top facing southeast partially in the ditch near the roadway (**Figure 9**).

The 2002 GMC Envoy was a four-wheel drive, four-door sport utility vehicle (VIN: 1GKDT13S522-----) equipped with a 4.2L, 6 cylinder engine; automatic transmission and four wheel, anti-lock brakes. The front seating row was equipped with redesigned driver and front right passenger air bags, driver and front right passenger seat back-mounted side impact air bags and driver and front right passenger integral, three-point, lap-and-shoulder safety belts. The back seat was equipped with three-point, lap-and-shoulder safety belts in the outboard seat positions and an integral, three-point, lap-and-shoulder safety belt in the center seat position. In addition, the case vehicle was equipped with a LATCH system for securing child safety seats and an EDR housed within the air bag system’s Sensing and Diagnostic Module (SDM). The mileage at the time of the inspection is unknown because the case vehicle was equipped with an electronic odometer. The case vehicles wheelbase was 287 centimeters (113 inches).

CASE VEHICLE DAMAGE

Exterior Damage: The case vehicle’s rollover involved the top and both sides of the vehicle. There was direct damage to the hood, windshield, roof, both front fenders, front and back doors on both sides, both right and left quarter panels and both right side wheels. In addition, the backlight, left front, left rear, and right front windows were broken out, and the left rear wheel had a large amount of grass and dirt jammed in the tire bead. The most severe crush occurred to the roof and roof side rail over the driver’s seat position, and secondarily to the roof and roof side rail over the back left seat position. The maximum roof crush over the driver’s seat position was 36 centimeters (14.2 inches). The maximum roof crush over the back left seat position was 25 centimeters (9.8 inches). The right side wheelbase was reduced by 5.0 centimeters (2.0 inches) and the left side wheelbase was reduced by 3.0 centimeters (1.2 inches). Induced damage involved the entirety of the case vehicle.

The case vehicle’s recommended tire size was: P245/65R17 and the vehicle was equipped with tires of this size. The case vehicle’s tire data are shown in the table below.

Tire	Measured Pressure		Recommend Pressure		Tread Depth		Damage	Restricted	Deflated
	kpa	psi	kpa	psi	milli-meters	32 nd of an inch			
LF	234	34	221	32	4	5	None, some grass in bead	No	No
RF	0	0	221	32	5	6	Rim abrasion, dirt and grass in rim, tire hit back of wheel house	No	Yes
LR	228	33	221	32	4	5	Large amount of grass and dirt in bead	No	No

Tire	Measured Pressure		Recommend Pressure		Tread Depth		Damage	Restricted	Deflated
	kpa	psi	kpa	psi	milli-meters	32 nd of an inch			
RR	0	0	221	32	4	5	Dirt and scratches on rim, minor tire contact to back of wheel house	No	Yes

Vehicle Interior: Inspection of the case vehicle’s interior revealed a few hairs and a scuff on the roof in the driver’s seat position and one hair and a few white flecks on the roof over the back left seat position. No other evidence of occupant contact was observed to any other interior surfaces or components. There were numerous intrusions to the passenger compartment. The most severe intrusions occurred in the driver’s seat position and the back left seat position. The most severe intrusions in the driver’s seat position were: 47 centimeters (18.5 inches) of vertical roof intrusion (**Figure 10**), 34 centimeters (13.4) of vertical windshield intrusion, 31 centimeters (12.2 inches) of vertical left A-pillar intrusion, 27 centimeters (10.6 inches) of vertical windshield header intrusion and 25 centimeters (9.8 inches) of vertical left roof side rail intrusion. The most severe intrusions in the back left seat position were: 25 centimeters (9.8 inches) of vertical roof intrusion (**Figure 11**), 21 centimeters (8.3 inches) of vertical left roof side rail intrusion and 7 centimeters (2.8 inches) of vertical left rear window frame intrusion. There was no evidence of compression of the energy absorbing steering column or deformation of the steering wheel rim (**Figure 12** below).



Figure 10: Overview of front right seating area and roof intrusion into driver’s seating area, each black mark on tape measure = .31 meter (1 ft)



Figure 11: Overview of back seat and roof intrusion to back left seat position

Damage Classification: Based on the vehicle inspection, the CDC for the case vehicle was determined to be **00-TDDO-4** for the rollover. The WinSMASH reconstruction program could not be used to reconstruct the case vehicle’s Delta V because rollovers are out-of-scope for the

WinSMASH program. Based on the roof crush, the severity of the rollover was determined to be severe. The case vehicle was towed due to damage.

AUTOMATIC RESTRAINT SYSTEM

The case vehicle's driver air bag was located in the steering wheel hub and the front right passenger air bag was located in the middle of the front right instrument panel (**Figure 13**). Neither of these air bags deployed because there was no front impact. In addition, the driver and front right passenger seat back-mounted side impact air bags did not deploy because there was no significant side impact.

CRASH DATA RECORDING

The download of the case vehicle's EDR was done during the vehicle inspection via direct connection to the SDM. The EDR reports for the downloaded data are presented at the end of this report (**Figures 26-28**). The downloaded data indicated that a non-deployment event was recorded, multiple events were associated with the record, and one or more of the associated events were not recorded. This most likely indicates that the ground impacts that occurred during the rollover activated the case vehicle's crash sensing algorithm several times.

The system status report for the non-deployment event show that the SIR warning lamp was recorded as on, and the driver's seat belt switch circuit was recorded as buckled. In addition, the maximum SDM recorded velocity change was recorded as -6.68 km.p.h. (-4.15 m.p.h.) occurring 130 milliseconds (0.130 seconds) after algorithm enable (AE). The driver stated the SIR warning lamp was not on when they began their trip. She stated at no time prior to the crash did she notice any illuminated warning lamps on the instrument panel.

The pre-crash data graph indicate that the case vehicle was traveling 85 km.p.h. (53 mph) five seconds prior to AE slowing to 56 km.p.h. (35 mph) one second prior to AE. The brake switch circuit was recorded as off for the entire five seconds prior to AE. The pre-crash data also indicates zero percent throttle at the five, four and three second sample periods prior to AE. The percent throttle then increases from five percent at two seconds to 27 percent throttle at one second prior to AE.



Figure 12: Overview of case vehicle's steering wheel and steering column, and intrusion of left A-pillar, roof side rail and roof



Figure 13: Front right air bag located in middle of instrument panel above glove box door

The back left passenger was seated in a convertible child safety seat (**Figures 14 and 15**) that was used in its forward-facing configuration. The child seat was manufactured by Britax on November 11, 2003 and was identified by Model name “Marathon”, Model number E9L0605, and Batch number 504641. The child seat was purchased new in December 2003 and was used on a daily basis. The child seat consisted of a plastic one-piece shell with a padded pullover cloth cover and was designed with a five-point harness with a non-recessed buckle, and a top tether and lower anchor system. There were four sets of slots to thread the harness straps through. The harness straps were threaded through the middle slots, and the harness retainer clip was positioned at the child’s armpit level. The child seat was installed tightly in the case vehicle via the lower anchors and upper tether of the case vehicle’s LATCH system (**Figures 16-19** below). The child seat was in a slightly reclined position and a towel had been placed under the child seat, not for positioning, but to protect the leather seat.



Figure 14: Back left passenger’s convertible child safety seat, a Britax, “Marathon” with 5-point harness

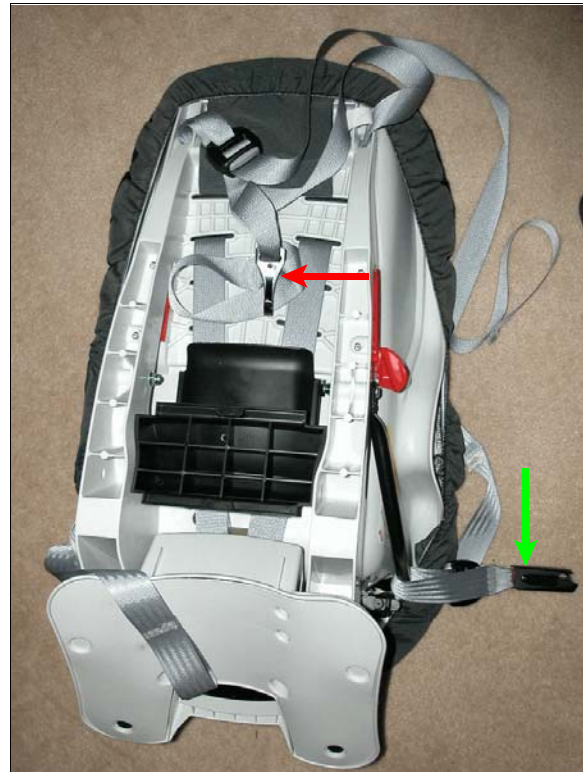


Figure 15: Back of child safety seat, red arrow shows tether strap and clip, green arrow shows right LATCH anchor buckle assembly

The case vehicle’s front right passenger indicated that he had read the child seat’s instruction manual and the case vehicle’s manual on installation of a child safety seat using the vehicle’s seat belts and LATCH system. In addition, both the front right passenger and driver had taken instruction in the proper installation of child safety seats from a child passenger safety technician at their local fire department as part of their county’s “Safe Kids Program”. They had taken part in the program in 2002. The front right passenger indicated that he had installed the child seat in the case vehicle, but the driver had placed the child in the seat prior to the crash. The front right

passenger indicated that normally there was about “two fingers” of space between the back left passenger’s chest and the harness straps, and on the day of the crash the child was not wearing any bulky or heavy cloths.



Figure 16: Lower anchors of case vehicle’s LATCH system at back left seat position, seat cushion has been folded forward



Figure 17: Child seat’s right LATCH anchor buckle and strap



Figure 18: Case vehicle’s back left tether anchor, its located in cargo area behind back left seat



Figure 19: Close view of back left child safety seat’s tether clip and strap

Inspection of the child safety seat revealed no apparent damage or fractures to the shell. In addition, the harness assembly, tether strap, tether clip, and the lower anchor buckles and straps showed no signs of loading. There was a manufacturer’s warning label affixed to both sides of the child seat giving the seat’s weight limitations as follows: “use only in rear-facing position with infant up to 10 kilograms (22 pounds)”, “use only with children who weigh between 2.3 and 29 kilograms (5 and 65 pounds) and whose height is 124 centimeters (49 inches) or less, rear facing 2.3 to 15 kilograms (5 to 33 pounds) and forward facing max 29 kilograms (65 pounds)”. There was also a warning label on both sides of the child seat that indicated to use the vehicle seat belt and not the LATCH connectors for children weighing more than 21 kilograms (48 pounds) and illustrations that showed the proper seat belt routing for both rear and forward facing installations.

The back right passenger was seated in a rear-facing infant seat with a locking base (Figures 20 and 21 below). The infant seat was manufactured by Evenflo on April 26, 2002 and was

identified by Model name “Cozy Carry 5” and Model number 2731151P1. The infant seat base was manufactured by Evenflo in February, 2002 and was identified with Model number 639004P1. The infant seat and base were purchased new for the left rear passenger and were used on a daily basis when she was an infant. The infant seat and base were then used on a daily basis for the back right passenger. The infant seat consisted of a plastic one-piece shell with retractable carry handle and a padded pullover cloth cover. It was designed with a five-point harness with a non-recessed buckle. There were three sets of slots to thread the harness straps through. The harness straps were threaded through the top slots, and the harness retainer clip was positioned at the child’s armpit level. The infant seat was also designed to be secured by a vehicle’s safety belt system (i.e., lap belt or lap-and-shoulder belt) or snapped into the base designed for the seat. The infant seat base was designed to be secured by a vehicle’s safety belt system (i.e., lap belt or lap-and-shoulder belt), or by the lower anchors of a vehicle’s LATCH system. The base had separate routing paths for a vehicle’s safety belt and for a separate belt that attaches to the lower anchors. In this crash, the base was secured tightly in the case vehicle by the separate belt routed through the “Latch Belt Only” path and attached to the case vehicle’s lower anchors (**Figure 22** below), and the infant seat was locked to the base. A towel was placed under the base to help level the infant seat.



Figure 20: Back right passenger’s infant seat, an Evenflo “Cozy Carry” with 5-point harness, the infant seat locks to the base



Figure 21: The infant seat base, an Evenflo model number 639004P1, arrow shows route for separate “LATCH belt”

The case vehicle’s front right passenger indicated that he did not recall if there was a manual with the infant seat and base, but he had read the vehicle’s manual on installation of a child safety seat using the vehicle’s seat belts and LATCH system. In addition, as indicated above, both the front right passenger and driver had taken instruction in the proper installation of child safety seats

from a child passenger safety technician at their local fire department. The front right passenger indicated that he had installed the infant seat and base in the case vehicle, but the driver had placed the infant in the seat prior to the crash. He also stated that the back right passenger was wearing a heavy coat, and there was about “three fingers” of space between the infant’s chest and the harness straps.

Inspection of the infant seat and base revealed no apparent damage or fractures to the seat or the base. In addition, the infant seat harness assembly, and the separate LATCH belt assembly for the base showed no signs of loading. There was a manufacturer’s warning label affixed to both sides of the infant seat illustrating how to secure the infant seat using a vehicle’s lap or lap-and-shoulder safety belt. In addition, the warning stated to place the seat in a rear-facing position and not to place it in the front seat of a vehicle with a passenger side air bag. A similar warning label was placed on top of the infant seat base.

The front right passenger stated they had received a recall notice on the infant seat and received a replacement locking clip for use with a vehicle’s lap and shoulder belt system. He stated that the recall notice indicated the old clip may allow the safety belt to slip.

CASE VEHICLE BACK LEFT PASSENGER KINEMATICS

Immediately prior to the crash, the case vehicle's back left passenger [3-year-old, White (non-Hispanic) female; 94 centimeters and 15 kilograms (37 inches, 33 pounds)] was restrained in her convertible child safety seat with 5-point harness in the back left seat position (**Figure 23**). The child was seated in an approximate upright position. The child was holding her blanket and teddy bear and was asleep with her head nodded to the right.

The child remained securely restrained in her child safety seat throughout the crash. At final rest the case vehicle was upside down, and she



Figure 22: Lower anchors of case vehicle’s LATCH system at the back right seat position, seat cushion has been folded forward



Figure 23: Overview of back left seat position, child safety seat was secured in this position by the case vehicle’s LATCH system

was upside down still securely restrained in her child safety seat. The driver crawled through the broken left rear window and released the child from her child safety seat and took her out of the case vehicle through the broken left rear window. The installation and usage of the child safety seat prevented the back left passenger from sustaining any injuries in the crash.

CASE VEHICLE BACK LEFT PASSENGER INJURIES

The police crash report indicated the back left passenger sustained a “C” (possible) injury as a result of the crash and was transported from the scene to a local hospital for treatment. She was treated and released from the hospital. The child’s parents reported that she was not injured, but the treating doctor advised them to wake her that night every two hours as a precaution. The child was taken back to the doctor for a routine follow-up examination, and no injuries were diagnosed. The emergency room records reported no injuries to the back left passenger.

CASE VEHICLE BACK RIGHT PASSENGER KINEMATICS

Immediately prior to the crash, the case vehicle's back right passenger [2-month-old, White (non-Hispanic) male; 61 centimeters and 7 kilograms (24 inches, 16 pounds)] was restrained in his rear-facing infant seat in the back right seat position (**Figure 24**). The infant was reclined in the seat and was wearing a heavy coat.

The infant remained securely restrained in his infant seat throughout the crash. However, he contacted the left side of his head on the inside left surface of his infant seat during the rollover causing a small contusion on the left side of his head. The case vehicle was upside down at final rest, and he was upside down still restrained in his infant seat. The front right passenger indicated that he released himself from his seat belt and crawled out of the broken right front window and opened the right rear door to get his son out of the vehicle. He indicated that by this time his son had wiggled partially out of his infant seat and was hanging out of the seat by one leg. The front right passenger released his son from the infant seat and took him out of the case vehicle through the right rear door. The installation and usage of the infant seat prevented the back right passenger from sustaining severe injuries in the crash.



Figure 24: Overview of back right seat position, infant seat and base were secured in this position by the case vehicle’s LATCH system

The police crash report indicated the back right passenger sustained a “C” (possible) injury as a result of the crash and was transported from the scene to a local hospital for treatment. He was treated and released from the hospital. The infant was taken back to the doctor for a routine follow-up examination, and no other injuries were diagnosed. The back right passenger’s injury and injury contact mechanism are presented in the following table.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Contusion {bruise}, small, left temporal area	minor 190402.1,2	Child safety seat’s left side surface	Possible	Emergency room records

CASE VEHICLE DRIVER KINEMATICS

Immediately prior to the crash, the case vehicle's driver [30-year-old, White (non-Hispanic) female; 170 centimeters and 50 kilograms (67 inches, 110 pounds)] was talking with the front right passenger (i.e., her husband). She was seated in an upright driving position, leaning slightly forward, with both hands on the steering wheel, her right foot on the accelerator, and her left foot on the floor. The driver’s seat track was located between its middle and forward-most track position, the seat back was slightly reclined, and the tilt steering wheel was adjusted to its center position. Based on the driver’s interview and supported by the inspection of her safety belt assembly and the EDR data, the driver was restrained by her integral, three-point, lap-and-shoulder safety belt system.

Just prior to the crash, the driver stated she momentarily dozed off, and the case vehicle’s right side wheels drifted off the right (north) side of the roadway onto the gravel shoulder. The front right passenger yelled a warning ,and the driver immediately steered the case vehicle left. The steering maneuver caused the driver to move slightly to her right in the seat as the case vehicle traveled across the westbound lane. It is likely that the driver’s safety belt retractor locked during this maneuver and remained locked throughout the crash restraining the driver in her seat. The case vehicle entered the eastbound lane, the driver saw an approaching car and steered right. The right steering maneuver caused the driver to move to her left as the case vehicle crossed the westbound lane. The driver steered left as the case vehicle departed the roadway to avoid a car parked in the grass by the driveway, and the case vehicle began to rotate counterclockwise. As the case vehicle’s counterclockwise rotation increased, the driver moved to her right and loaded her locked safety belt. The driver continued to move to the



Figure 25: Overview of driver’s seating area and roof intrusion, yellow tape shows area of driver’s head contact

right and load her safety belt as the case vehicle began to rollover, passenger side leading. The driver moved to her right and upward as the case vehicle completed its first two quarter rolls. It is likely that her right hip contacted the center console at this time. At the beginning of the third quarter roll, the case vehicle landed hard on its left roof and roof side rail. This impact caused the driver to move back to her left and toward the roof, and she contacted the left side of her head on the intruding roof surface (**Figure 25** above) straining her neck. The driver’s left knee also contacted the left front door abrading her knee as the case vehicle rolled onto its left side. The driver then moved down into her seat as the case vehicle landed on its wheels and completed its first complete rollover. The driver moved to the right and upward again as the case vehicle rolled over a fifth and sixth quarter turn and came to rest on its roof. The driver contacted the roof again during the fifth and sixth quarter turns. The driver was momentarily pinned between the intruded roof and her seat; however, she was able to release her seat belt and exit the vehicle through the broken left front window. The driver immediately went to her daughter in the back left seat position, crawled through the broken left rear window, unbuckled the child from her child safety seat and pulled her out of the vehicle.

CASE VEHICLE DRIVER INJURIES

The police crash report indicated the driver sustained an “A” (incapacitating) injury as a result of the crash and was transported from the scene to a local hospital for treatment. The driver stated that she made one follow-up visit to the doctor, and no additional injuries were diagnosed. The driver also stated that she lost two work days as a result of the crash. The driver’s injuries and injury contact mechanisms are presented in the following table.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Strain, cervical, acute, with straightening of normal lordosis	minor 640278.1,6	Roof {indirect injury}	Certain	Emergency room records
2	Abrasion left knee, not further specified	minor 890202.1,2	Left side interior surface, excluding hardware and/or armrest	Probable	Emergency room records

CASE VEHICLE FRONT RIGHT PASSENGER KINEMATICS

Immediately prior to the crash, the case vehicle's front right passenger [34-year-old, White (non-Hispanic) male; 183 centimeters and 98 kilograms (72 inches, 215 pounds)] was talking with the driver (i.e., his wife). He was seated in an upright posture with his back against the seat, his head against the head rest, both hands on his lap, and both feet on the floor. His seat track was located between its middle and rear-most track position, and the seat back was slightly reclined. Based on his interview and supported by the inspection of his safety belt assembly, the front right passenger was using his integral, three-point, lap-and-shoulder safety belt system.

The front right passenger moved to his right in response to the driver's left steer maneuver after the case vehicle initially drifted off the right (north) side of the roadway. It is likely that the front right passenger's safety belt retractor locked during this maneuver and remained locked throughout the crash restraining him in his seat. The front right passenger then moved to his left in response to the driver's right steer maneuver as the case vehicle entered the eastbound lane, and he moved back to his right in response to the driver's left steer maneuver as the case vehicle departed the north side of the roadway. As the case vehicle rotated counterclockwise prior to the rollover, the front right passenger moved to his right and against his door. The front right passenger stayed against his door and loaded his safety belt as the case vehicle began to rollover, passenger side leading. He moved to his right and upward as the case vehicle completed its first two quarter rolls. At the beginning of the third quarter roll, the case vehicle landed hard on its left roof and roof side rail. This impact caused the front right passenger to move back to his left and toward the roof. It is likely that his left hip contacted the center console at this time and stayed in contact with it as the case vehicle rolled onto its left side. His head may have contacted the roof or the roof console during the rollover, although no evidence of this was found in the vehicle. The front right passenger then moved down into his seat as the case vehicle landed on its wheels and completed its first complete rollover. He then moved to the right and upward and contacted his door as the case vehicle rolled over a fifth and sixth quarter turn and came to rest on its roof. The front right passenger stated he was still in his seat restrained by his safety belt and hanging upside down after the case vehicle came to rest. He stated he immediately released his seat belt, crawled out the broken right front window, opened the right rear door, unbuckled his son from his infant seat and removed him from the case vehicle. The front right passenger sustained two scalp lacerations on the lower left base of his head due to flying glass during the rollover. He also sustained two abrasions and a laceration in the area of his right thumb as he was crawling out of the case vehicle following the crash.

CASE VEHICLE FRONT RIGHT PASSENGER INJURIES

The police crash report indicated the front right passenger sustained an "A" (incapacitating) injury as a result of the crash and was transported from the scene to a local hospital and was treated and released. The front right passenger stated that he made one follow-up visit to the doctor, and no additional injuries were diagnosed. He also stated that he lost two work days as a result of the crash. The front right passenger's injuries and injury contact mechanisms are presented in the following table.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Abrasion left lower {base of} scalp area, not further specified	minor 190202.1,6	Noncontact injury: flying glass, unknown source	Probable	Emergency room records
2	Laceration left lower {base of} scalp area, not further specified	minor 190600.1,6	Noncontact injury: flying glass, unknown source	Probable	Emergency room records

Case Vehicle Front Right Passenger Injuries (Continued)

IN-04-037

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
	Abrasions x 2, right hand-thumb and/or palm area		During extrication from vehicle	Certain	Emergency room records
	Lacerations right hand-thumb and/or palm area		During extrication from vehicle	Certain	Emergency room records

1GKDT13S522xxxxxx System Status At Non-Deployment															
SIR Warning Lamp Status	ON														
Driver's Belt Switch Circuit Status	BUCKLED														
Ignition Cycles At Non-Deployment	3780														
Ignition Cycles At Investigation	3793														
Maximum SDM Recorded Velocity Change (MPH)	-4.15														
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	130														
Event Recording Complete	Yes														
Multiple Events Associated With This Record	Yes														
One Or More Associated Events Not Recorded	Yes														
Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Recorded Velocity Change (MPH)	-0.31	-0.62	-1.24	-1.55	-2.17	-2.48	-2.48	-2.48	-3.10	-3.41	-3.72	-3.72	-4.03	N/A	N/A
PRE-CRASH DATA															
Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status											
-5	53	1728	0	OFF											
-4	51	1536	0	OFF											
-3	45	1408	0	OFF											
-2	42	1344	5	OFF											
-1	35	1280	27	OFF											

Figure 26: Case vehicle's System Status at Non-Deployment report

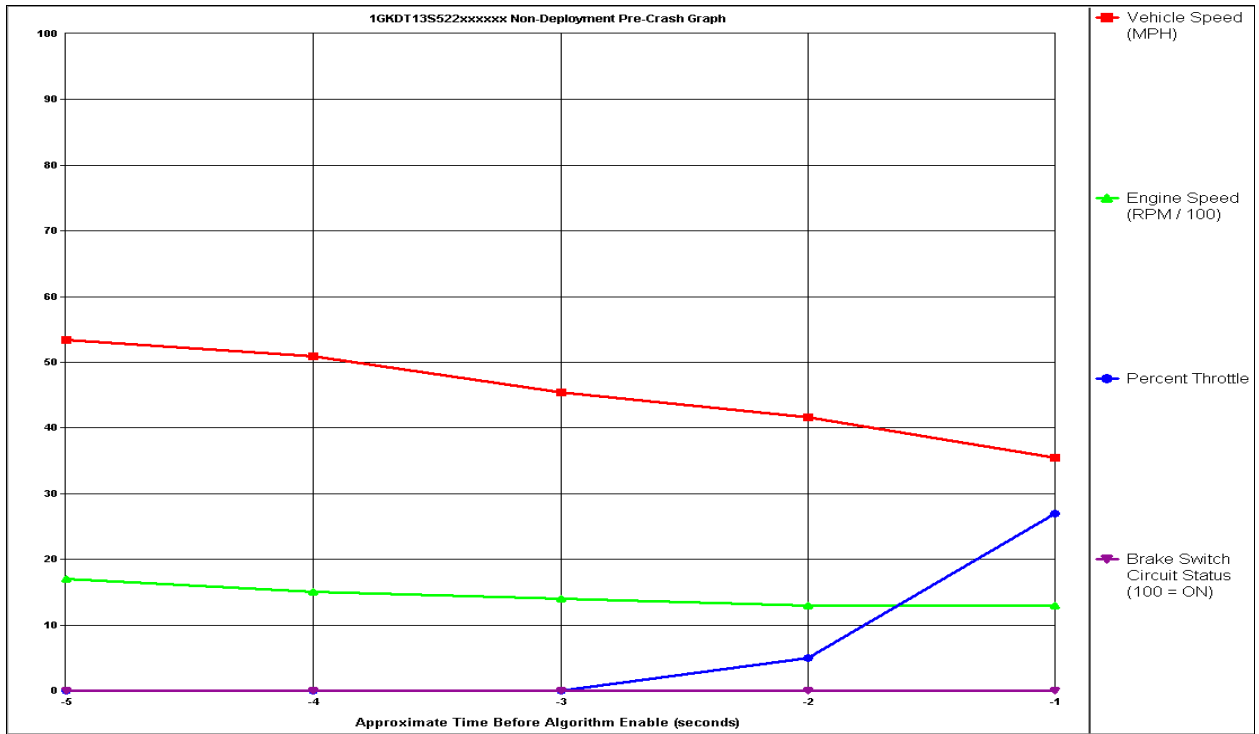


Figure 27: Case vehicle's Non-Deployment Pre-Crash Graph

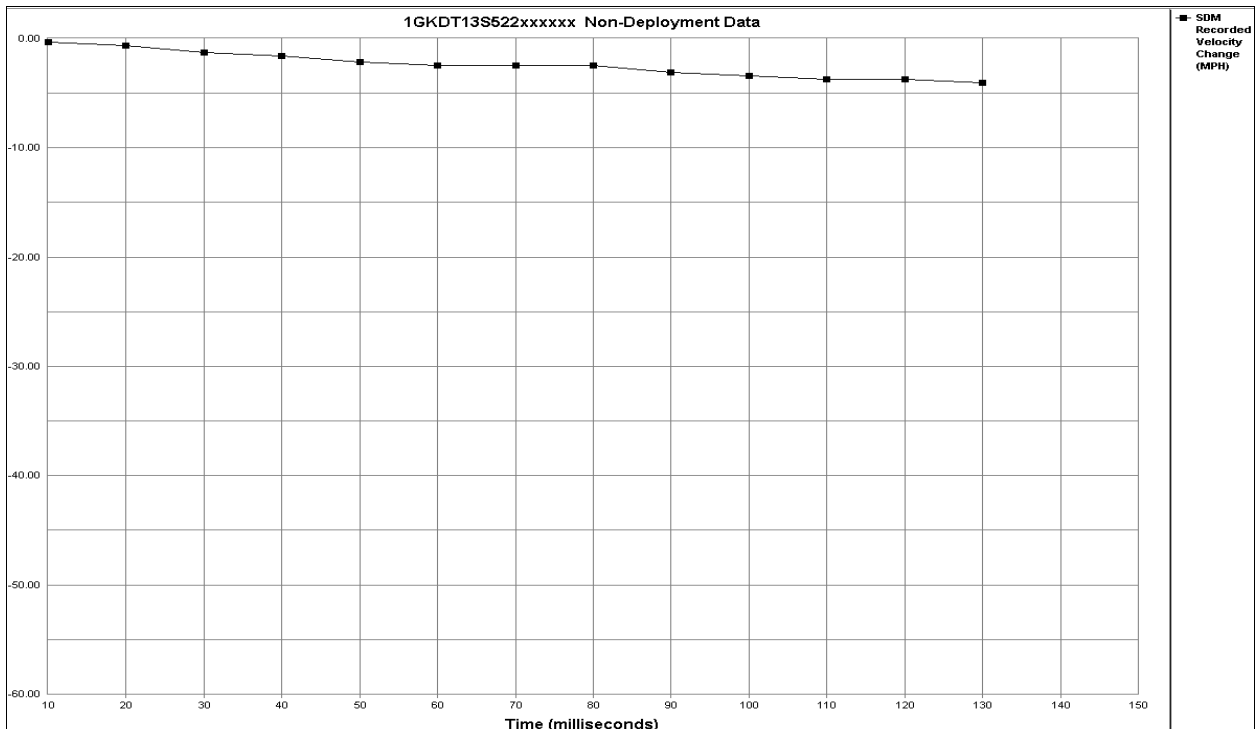


Figure 28: Case vehicle's SDM Recorded Velocity Change graph

