CRASH DATA RESEARCH CENTER
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CALSPAN ON-SITE ROLLOVER CRASH INVESTIGATION
SCI CASE NO: CA07-021

VEHICLE: 2007 CHEVROLET HHR
LOCATION: FLORIDA
CRASH DATE: MAY, 2007

Contract No. DTNH22-07-C-00043

Prepared for:

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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 are coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

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

TECHNICAL REPORT STANDARD TITLE PAGE

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16. Abstract

This on-site investigation focused on the rollover crash dynamics of a 2007 Chevrolet HHR and the fatal injury sources of a 67 year old unrestrained ejected passenger. The Chevrolet HHR was traveling southbound on a two-lane divided interstate roadway driven by a 49 year old female. The driver relinquished directional control and allowed the vehicle to drift toward the center median. The driver responded to the vehicle's errant trajectory by a series of left and right steering maneuvers causing the vehicle to depart the right shoulder. The vehicle subsequently tripped and rolled over leftward six quarter turns. The Chevrolet HHR was designed and configured to transport five occupants. At the time of the crash, the Chevrolet was occupied by a total of six occupants (driver plus five adult passengers). The driver and front right passengers were restrained by the vehicle's safety belts. The four occupants in the rear of the HHR were unrestrained. During the rollover sequence, the unrestrained 67-year-old female seated in the vehicle's right rear position was ejected and suffered fatal injuries.

This crash was identified by the Calspan Special Crash Investigations team through an Internet news search. Calspan forwarded the notification to the Crash Investigation Division (CID) of the National Highway Traffic Safety Administration and the CID assigned an on-site investigation due to the agency's interest in rollover crashes that involve late model year vehicles. Calspan SCI initiated follow-up investigation and established cooperation with the investigating police department and the vehicle's insurance company. The Chevrolet had been deemed at total loss and was located at an insurance salvage yard. The on-site portion of this investigation was conducted during the week of July 16, 2007.

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BACKGROUND

This on-site investigation focused on the rollover crash dynamics of a 2007 Chevrolet HHR **(Figure 1)** and the fatal injury sources of a 67 year old unrestrained ejected passenger. The Chevrolet HHR was traveling southbound on a two-lane divided interstate roadway driven by a 49 year old female. The driver relinquished directional control and allowed the vehicle to drift toward the center median. The driver responded to the vehicle's errant trajectory by a series of left and right steering maneuvers causing the vehicle to depart the right shoulder. The vehicle subsequently tripped and rolled over leftward six quarter turns. The Chevrolet HHR was designed and configured to transport five occupants. At the time of the crash, the Chevrolet was occupied by a total of six occupants (driver plus five adult passengers). The driver and front right passengers were restrained by the vehicle's safety belts. The four occupants in the rear of the HHR were unrestrained. During the rollover sequence, the unrestrained 67-year-old female seated in the vehicle's right rear position was ejected and suffered fatal injuries.

Figure 1: Left side view of the 2007 Chevrolet HHR.

This crash was identified by the Calspan Special Crash Investigations team through an Internet news search. Calspan forwarded the notification to the Crash Investigation Division (CID) of the National Highway Traffic Safety Administration and the CID assigned an on-site investigation due to the agency's interest in rollover crashes that involve late model year vehicles. Calspan SCI initiated follow-up investigation and established cooperation with the investigating police department and the vehicle's insurance company. The Chevrolet had been deemed at total loss and was located at an insurance salvage yard. The on-site portion of this investigation was conducted during the week of July 16, 2007.

SUMMARY

Crash Site

The crash occurred during the evening hours of May 2007. At the time of the crash, it was daylight and the weather was clear and dry. The crash occurred on the west roadside of a north/south two-lane divided interstate roadway. The interstate speed limit was 113 km/h (70 mph). The respective travel directions of the interstate were separated by a depressed grass median. The southbound lanes measured 3.7 m (12 ft) in width. The width of the west (outboard) shoulder measured 3.3 m (10.8 ft) and contained rumble strips that ran parallel to the travel lane. The west roadside consisted of grass and was open terrain. The width of the roadside measured 25.8 m (84.8 ft) and terminated at a 2.4m (8 ft) tall chain link fence line. At the end of the rollover event, the Chevrolet slid to rest on its roof and came to rest in contact with

the fence. The SCI inspection of the scene identified a 2 m (6 ft) damaged section of the fence that was attributed to the vehicle's contact.

From the road edge, there was a gradual roadside slope in the west direction for drainage. The cross slope was estimated at less than two percent over a lateral distance of 9.0 m (29.4 ft) At that location, the roadside transitioned to a predominately level grade westward to the fence line. The change in the slope caused the tires of the vehicle to furrow resulting in a tripped rollover. The police report indicated the vehicle began to rollover approximately 9 m (30 ft) west of the road edge consistent with the transition. Due to the passage of time between the crash date and the SCI inspection, the physical evidence of the vehicle's roll trajectory was masked by the growth of the vegetation. **Figure 2** is a lookback view from the Chevrolet's final rest area along the approximate rollover trajectory of the vehicle. **Figure 3** is a lookback view from the vehicle's approximate trip location toward the roadside departure. A schematic of the crash is included at the end of this report as **Figure 12**.

Figure 2: Look back view from the Chevrolet's final rest position.

Figure 3: Look back view from Chevrolet's approximate trip location.

Vehicle Data

2007 Chevrolet HHR

The 2007 Chevrolet HHR was identified by the Vehicle Identification Number (VIN): 3GNDA33P77S (production sequence deleted) and was manufactured in December 2006. The four-door, front-wheel drive compact wagon was designed with a 263 cm (103.5 in) wheelbase and had a Gross Vehicle Weight Rating (GVWR) of 1,923 kg (4,240 lb). The drive train consisted of a transverse mounted 2.4 liter, I4 engine linked to a four-speed automatic transmission. The service brakes were four-wheel disc with antilock. The vehicle was not equipped with Electronic Stability Control (ESC); ESC was not an available option. The interior was configured with front bucket seats and 60/40 spilt fold-down rear seats (right side wide). The manual restraint system consisted of three-point lap and shoulder belts in the five seat positions. The front seats were equipped with retractor pretensioners. The Chevrolet was equipped with Certified Advanced Compliant (CAC) frontal air bags for the driver and front right passenger. A CAC vehicle is certified by the manufacturer to be compliant to the Advanced Air Bag portion of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The HHR was also equipped with roof rail mounted side impact curtain air bags. Neither the frontal

air bags nor the side impact curtain air bags deployed in this rollover crash. The Chevrolet was also equipped with an Event Data Recorder (EDR) that was downloaded at the time of the SCI inspection. The vehicle's tires were Firestone Fire Hawk GTA P215/50R17 steel belted radials mounted on OEM five spoke alloy wheels. The vehicle manufacturer recommended front and rear tire pressure was 241 kPa (35 PSI). The specific tire data at the time of the SCI inspection was as follows:

Position	Measured Tire Pressure	Measured Tread Depth	Damage
Left Front	Tire flat	8 mm (10/32 in)	Tire debeaded, Suspension fractured
Left Rear	Tire Flat	8 mm (10/32 in)	Tire debeaded
Right Front	Tire Flat	8 mm (10/32 in)	Tire debeaded, Suspension fractured
Right Rear	221 kPa (32 PSI)	8 mm (10/32 in)	None

Crash Sequence

Pre-Crash

The Chevrolet HHR was southbound driven by a restrained 49 year old female. The Chevrolet was occupied a 17 year restrained male front right passenger, a 49 year old unrestrained female rear left passenger, an unrestrained 14 year old male rear center passenger, a 67 year old unrestrained female rear right passenger and a 25 year old unrestrained female in the rear cargo area of the vehicle. The occupants of the vehicle had been in a resort area of the state for several days and were returning home at the time of the crash. The driver indicated that it had been an active several day vacation and everyone was tired.

Immediately prior to the crash, the driver was operating the vehicle in the outboard (right) lane at a driver reported speed of 113 to 121 km/h (70 to 75 mph). It should be noted that the vehicle's Event Data Recorder (EDR) recorded that the vehicle's pre-crash speed was 126 km/h (78 mph) five seconds prior to Algorithm Enable (AE). Refer to the *Event Data Recorder* section of this report for more detail. The traffic was light with no reported vehicles in their immediate vicinity. During the travel, the driver allowed the Chevrolet to drift from the outboard lane toward the highway's centerline divider. The driver over-reacted to the errant trajectory by applying a rapid right steer. The vehicle responded by returning to the outboard lane and then crossed through the lane and onto the shoulder. The driver then applied a rapid left steering maneuver and lost directional control of the vehicle.

The police documented a 45 m (148 ft) counterclockwise yaw mark along the shoulder consistent with the driver's left steer input. The mark reportedly reentered the outboard lane and stopped. The driver had responded to the counterclockwise yaw by steering back to the right. The right steering input corrected the counterclockwise yaw and initiated a clockwise yaw. The clockwise yaw was evidenced by a 58.5 m (192 ft) mark that was also police documented. The mark departed the right lane, traveled through the shoulder and departed the pavement edge. At the time of the SCI inspection, two tire marks 32 m (84 ft) and (41 ft) in length respectively were documented on the shoulder in the area of the road departure. These marks were attributed to the left front and left rear tires of the HHR, refer to **Figure 4**. An additional unrelated tire mark was

also identified during the SCI inspection. This mark was located north of the referenced tire mark.

Figure 4: Trajectory view of the HHR and the documented yaw marks.

Crash

The HHR departed the right side of the road and traversed the negative grade of the cross slope at a 20 to 30 degree heading (right of its original southbound travel direction) and with a clockwise rotation. The Chevrolet travelled approximately 46 m (150 ft) along this trajectory and rotated nearly broadside. As the roadside terrain transitioned to a level grade, lateral forces built up at the left tires and tripped the vehicle in a left side leading rollover. The vehicle rolled six quarter turns over a distance of approximately 53 m (175 ft). The unrestrained right rear passenger was ejected during the later stages of the rollover event through the right rear window. She was most likely ejected as the vehicle was rolling between the fifth and sixth quarter turn. She reportedly was found near the back of the HHR and partially under the vehicle. The HHR came to rest on its roof facing northeastward. The right rear quarterpanel of the vehicle was in contact with the fence at rest.

Post-Crash

The police and emergency personnel responded to the crash site. The ejected right rear passenger sustained fatal injuries and was removed by the medical examiner. The driver sustained a police reported incapacitating head injury and was hospitalized. The four additional passengers in the vehicle sustained non-life threatening injuries and were transported by ground ambulance to a local hospital. The HHR was deemed a total loss by the insurance company and was transported to a salvage yard.

Vehicle Damage

2007 Chevrolet HHR

Figure 5: Front right oblique view.

The exterior damage to the Chevrolet was consistent with a six quarter turn rollover event. **Figure 5** is a front right oblique view of the vehicle. The vehicle's two side planes and top plane were deformed from multiple ground impacts. The surface abrasions (scratches) to the left roof rail were oriented in two directions indicative of two ground contacts. The front and back end planes did not sustain direct contact damage indicating the roll was primarily lateral in direction. The most severe damage was located in the forward roof area and to the right A-pillar. The right roof rail deformed inboard and down. The right fender was deformed downward. The damage at these locations occurred during the first ground impact when the

vehicle was rolling between quarter turns 2 and 3. At this time, the vehicle's momentum/energy was the greatest. The roof deformation extended from the header to the right D-pillar area.

The windshield fractured from ground contact and separated along the right A-pillar and across the header. The glazing of all the side windows had disintegrated with the exception of the partially open driver's window and the quarter window glazing of the rear left door. The front left, rear left and rear right doors were operational post-crash. The right front door was jammed shut. The rear lift gate of the vehicle had been removed and was inside the cargo area of the vehicle upon initial inspection. There was no evidence that the rear latch had released. The upper hinges of the lift gate appeared to have been cut.

During the rollover, both the left and right front wheels impacted the ground. These two separate impacts fractured the control arms of the respective suspensions. The left front tire was lying flat on the ground at the time of the inspection. The right front wheel was canted at a 60 degree angle.

Figure 6: View of the roof deformation.

The deformation of the roof was documented along the windshield header. A string line parallel to the lateral belt line was established and the vertical crush was measured relative to the string. The Field L (upper left A-pillar to upper right A-pillar) measured 99 cm (39 in). The residual crush profile was as follows: C1 = 0, C2 = 22 cm (8.7 in), C3 = 18 cm (7.2 in), C4 = 15 cm (6.1 in). The maximum vertical crush measured 22 cm (8.7 in) and was located on the windshield header 28 cm (11 in) left of the centerline. The maximum lateral crush was located at the right upper A-pillar and measured 24 cm (9.5 in). The Collision Deformation Classification (CDC) of the rollover event was 00-TDDO4. As the HHR slid to final rest, the right rear quarterpanel of the vehicle contacted the chain link fence bordering the road side. This contact resulted in minor body panel deformation and abrasions. The CDC of the contact was 03-RBAW1.

Interior Damage

The interior damage of the HHR consisted of the intrusion of the roof and right side pillars and the occupant interior contact points. The roof was intruded over the first and second row. The right B-pillar and right roof area deformed around, and were in contact with, the head restraint of the front right seat. Refer to **Figure 7.** The roof deformed in a V-shape pattern inboard of the right front seat. The documented intrusions to the interior of the Chevrolet are listed in the table below.

Figure 7: View of the front right seat back and intrusion.

Position	*Component*	*Intrusion*	*Direction*
Row 1 Left	Header	22 cm (8.6 in)	Vertical
Row 1 Left	Roof	28 cm (11.1 in)	Vertical
Row 1 Center	Header	27 cm (10.5 in)	Vertical
Row 1 Center	Roof	35 cm (13.8 in)	Vertical
Row 1 Right	Header	20 cm (7.7 in)	Vertical
Row 1 Right	Roof	19 cm (7.5 in)	Vertical
Row 1 Right	A-Pillar	23 cm (9 in)	Lateral
Row 1 Right	Roof side rail	21 cm (8.3 in)	Lateral
Row 1 Right	B-pillar	14 cm (5.5in)	Lateral
Row 2 Left	Roof	6 cm (2.5 in)	Vertical
Row 2 Center	Roof	30 cm (12 in)	Vertical
Row 2 Right	Roof	27 cm (10.5 in)	Vertical
Row 2 Right	C-pillar	11 cm (4.2 in)	Lateral
Row 2 Right	Roof side rail	23 cm (9.2 in)	Lateral

At the time of the SCI inspection, the six-way powered driver seat was adjusted in a mid to forward track position that measured 6 cm (2.5 in) rear of full forward. The total seat track travel measured 23 cm (9 in). The seat back was reclined 60 degrees aft of vertical and the head restraint was removed. The seat recline mechanism was not damaged by occupant loading. Examination of the bolster and foot well was unremarkable for occupant contact evidence. A driver head contact was located 48 cm (19 in) aft of the header and 55 cm (21.5 in) right of the left B-pillar (**Figure 8**). The contact measured 51 cm x 30 cm (20 in x 12 in) in gross overall area. In the center of the area was a 30 cm x 30 cm (12 in x 12 in) region of blood/dirt and debris.

Figure 8: Driver head contact.

The front right passenger seat was jammed in place by the right roof rail and roof intrusion. The seat track position was located in a mid track position 15 cm (6 in) rear of full forward. The location of the seat was measured with reference to the driver's seat. The seat back was reclined 20 degrees aft of vertical. The horizontal distance from the seat back to the face of the instrument panel measured 74 cm (29 in). There were no identifiable occupant contacts in the front right area.

During the inspection of the rear seat area, it was observed that the right split bench seat was folded down. The seat could not be returned to the upright position due to the interference with the intruded right roof rail and C-pillar. Refer to **Figure 9.** The seat back latch was noted to be jammed in the unlatched

Figure 9: Rear right seat back.

position (denoted by the orange band in the Figure and highlight by the circle). It may have been unlatched prior to the crash, unknown to the occupants. During the rollover event, the occupant in the cargo area probably loaded the seat back causing it to fold forward prior to the roof/pillar intrusion.

The right rear passenger was ejected through the window opening of the right rear door. Multiple areas of contact evidence were observed on the door and window frame that indicated this as the ejection portal. **Figures 10 and 11** are views of the right rear door and contact evidence. A 41 cm x 10 cm (16 in x 4 in) area located on the apex of the door panel (window sill) was scuffed and abraded in a vertical direction. The decorative top of the door lock fractured from the stem and was missing. The quarter window glazing was disintegrated and the frame was deformed outboard. Several strands of hair were found embedded into the upper third aspect of the frame. The injuries sustained by the ejected right rear passenger were consistent with the physical evidence identified on the door panel.

Figure 10: View of the right rear door.

Figure 11: Close-up view of the ejection portal.

Manual Safety Belt Systems

The Chevrolet HHR was equipped with three-point lap and shoulder belts in the five seat positions. The driver's restraint consisted of continuous loop webbing, sliding latch plate, adjustable D-ring and an Emergency Locking retractor. The retractor was equipped with a pretensioner. The pretensioner was not commanded to actuate in the crash. The driver's D-ring was adjusted to the full up position. The driver's webbing was stowed within the retractor at initial inspection. Upon examination, the webbing was found to be creased in two locations indicative of loading. A 9 cm (3.5 in) crease was located on the lap portion of the webbing 50 cm (19.8 in) above the outboard floor anchor. A 20 cm (8 in) section of the shoulder belt webbing was creased in the area of the D-ring. Minor abrasions were noted to the friction surface of the latch plate. The evidence identified by the inspection of the driver's restraint indicated that the driver was restrained at the time of the crash and loaded the belt system. The data downloaded from the vehicle's Event Data Recorder (EDR) also indicated the driver was restrained at the time of the crash.

The front right restraint consisted of continuous loop webbing, sliding latch plate, an adjustable D-ring and an Automatic Locking/Emergency Locking retractor (ALR/ELR). The retractor was equipped with a pretensioner that was not commanded to actuate in the crash. The right D-ring was adjusted to a mid position. The webbing was stowed on the retractor and extended upon inspection. The webbing was soiled over a 25 cm (10 in) section that began 91 cm (36 in) above the outboard anchor. Possible blood fluid contamination was observed on the latch plate. Given the soiled condition of the belt system and the location of that evidence, it was probable that belt system was in use at the time of the crash. The downloaded EDR data also indicated the front right passenger belt was buckled at the time of the crash.

The safety belts in the second row of the HHR consisted of continuous loop webbing, a sliding latch plate and an ALR/ELR retractor. None of the manual restraints in second row was in use at the time of the crash. The left rear safety belt was stowed in the retractor and operational. Examination of the restraint was unremarkable for historical use or crash related physical evidence. The rear center safety belt was integrated into the right side of the rear folding rear back. The latch plate of the safety belt was latched into the buckle receiver upon initial inspection and was located under the folded seat back. Inspection of the webbing and hardware of the restraint was unremarkable for historical use or crash related evidence. The webbing of the right rear safety belt was stowed within the retractor and jammed due deformation of the body. The condition of the retractor indicated the belt system was not in use at the time of the crash.

Air Bag Systems

The Chevrolet HHR was equipped with CAC frontal air bags for the driver and front right passenger and roof rail mounted side impact curtains that provided coverage from the A- to C-pillars. The side impact curtains were designed to deploy on the near side of a side impact crash. The front and side air bag systems were monitored and controlled by a Sensing Diagnostic control Module (SDM) that was located under the vehicle's center console. The SDM had Event Data Recording (EDR) capabilities. None of the air bags were commanded to deploy during this rollover event crash.

Event Data Recorder

The EDR in the HHR was downloaded at the time of the SCI inspection with the Bosch Crash Data Retrieval (CDR) Hardware and software version 2.9. External power was supplied to the Chevrolet's electrical system and the crash data was downloaded via the Diagnostic Link Connector (DLC).

During the rollover crash, a Non-Deployment Event was created and stored on Key Cycle 252. The data was retrieved by the SCI investigator on Key Cycle 253 and the data appeared to be consistent with the rollover crash event. There were four additional non-deployment events of lesser magnitude that were not recorded. These lesser events (both) preceded and followed the recorded event in time. The stored event data indicated there were no Diagnostic Trouble Codes (DTC's) present prior to the event and the Air Bag warning lamp was "*Off*". The driver and front right passenger safety belts were buckled. None of the vehicle's air bag systems or pretensioners was commanded to actuate. The maximum recorded total delta V was 6.9 km/h (11.1 mph). The stored pre-crash data indicated the HHR was traveling 126 km/h (78 mph) five

seconds prior to Algorithm Enable (AE) and the throttle position was 100 percent. Three seconds prior to AE the vehicle's speed was 132 km/h (82 mph) with 50 percent throttle. One second prior to AE the vehicle's speed reduced to 116 km/h (72 mph) with 38 percent throttle. The speed data was consistent with the driver's statement to the police investigator. Additional data fields, recorded one second prior to AE, indicated the transmission selector was positioned in fourth gear; however, the automatic transmission had downshifted to third gear. The antilock brake system was not activated during the recorded pre-crash time period. Refer to the downloaded data included at the end of this report as *Attachment A* for further detail.

Occupant Data

Driver

Age/Sex:	49 year old/Female
Height:	Unknown
Weight:	Unknown
Seat Track Position:	Mid-track position
Restraint Use:	Three-point lap and shoulder
Usage Source:	SCI vehicle inspection, EDR
Medical Treatment:	Hospitalized, length unknown

Note: The driver declined to be interviewed for this investigation.

Driver Injury

Injury	***Injury Severity (AIS Update 98)***	***Injury Source***
Unknown incapacitating injuries	Unknown	Unknown

Source – Police report. The requested medical records were not received.

Driver Kinematics

The restrained 49 year old female driver was seated in a mid-track position in an unknown posture. The driver lost directional control of the vehicle through a series of steering maneuvers resulting in an unrecoverable clockwise yaw and right roadside departure. Once off road, the vehicle tripped into a left side leading six quarter turn rollover.

As the vehicle began to roll, the ELR retractor of the safety belt locked. The driver was displaced toward the right and loaded the lap section of the locked safety belt. The HHR rolled two to three quarter turns and the vehicle impacted the ground with its roof and right A-pillar area. The driver continued to load the safety belt system and was displaced vertically toward the roof. Due to the extent of the roof intrusion, her head likely contacted the roof (although this contact was not identified). The driver rode down the duration of the rollover by loading the safety belt system and came to rest inverted within the front left interior. The driver sustained unknown incapacitating injuries in the crash and was hospitalized an unknown duration.

Front Right Passenger

Age/Sex:	17 year old/Male
Height:	Unknown
Weight:	113 kg (250 lb) estimated
Seat Track Position:	Mid-track position
Restraint Use:	Three-point lap and shoulder
Usage Source:	SCI vehicle inspection, EDR
Medical Treatment:	Treated and released

Front Right Passenger Injury

Injury	***Injury Severity (AIS 98 Update)***	***Injury Source***
Right scalp contusion, NFS	Minor (190402.1.1)	Right roof rail
Right ear laceration, NFS	Minor (290600.1,1)	Flying glass, possible
Left shoulder laceration, NFS	Minor (790600.1,2)	Flying glass, possible
Bilateral lower extremity abrasions	Minor (890202.1,3)	Right lower instrument panel

Source: Medical records from the treating hospital.

Front Right Passenger Kinematics

The 17 year old male was seated in an unknown posture and was restrained by the vehicle's manual safety belt. As the Chevrolet began to overturn, the ALR/ELR retractor locked. The passenger responded to the left side leading roll by loading the right door panel with his right flank and the locked belt system with his pelvis. The vehicle rolled two to three quarter turns, impacted the ground with its roof and right roof side rail; the passenger's head contacted the right roof rail resulting in a contusion to the right scalp. The window glazing disintegrated and his right ear was lacerated by the flying glass. The roof and right B-pillar deformed downward and inboard around the head restraint of the front right seat. The passenger continued to load the right door panel and safety belt through the duration of the rollover and came to rest inverted within the front right of the vehicle.

Rear Left Passenger

Age/Sex:	49 year old/Female
Height:	Unknown
Weight:	Unknown
Seat Track Position:	Not adjustable
Restraint Use:	None
Usage Source:	SCI vehicle inspection
Medical Treatment:	Transported and hospitalized 11 days

Rear Left Passenger Injury

Injury	*Injury Severity (AIS 98 Update)*	*Injury Source*
Left cheek laceration	Minor (290600.1,2)	Intruded roof
Left scalp contusion	Minor (190402.1,2)	Intruded roof
Left orbital blowout fracture mainly involving the lamina papyracea medially. Small minimally displaced orbital floor fracture	Serious (251204.3,2)	Intruded roof
Left shoulder abrasion	Minor (790202.1,2)	Intruded roof
Multiple left rib fractures and a right second rib fracture, NFS	Moderate (450220.2,3)	Intruded roof, possible
Bilateral pulmonary contusions	Severe (441410.4,3)	Intruded roof, possible
Multiple bilateral lower extremity abrasions and contusions, NFS	Minor (890202.1,3) (890402.1,3)	Driver seat back

Source: Medical records from the treating hospital.

Rear Left Passenger Kinematics

The 49 year old left rear passenger was seated in an unknown posture and was unrestrained. As the Chevrolet began to rollover, the passenger was displaced to the right and began to load the center rear passenger. The vehicle rolled two to three quarter turns and impacted the ground with its roof and right roof side rail. The passenger responded to this impact with a vertical trajectory and she impacted the intruded headliner/roof with her head. Her contact to the roof resulted in the identified left cheek laceration, left scalp contusion, left orbital fracture and left shoulder abrasion. The passenger's lower extremities contacted the driver's seat back resulting in multiple abrasions and contusions. As the HHR continued to roll to final rest, the rollover dynamics displaced the passenger in an unknown manner. Her rib fractures and pulmonary contusions possibly resulted from additional contact with the intruded roof. The passenger came to rest within the vehicle in an unknown posture.

Rear Center Passenger

Age/Sex:	14 year old/Male
Height:	170 cm (67 in)
Weight:	61 kg (135 lb)
Seat Track Position:	Not Adjustable
Restraint Use:	None
Usage Source:	SCI vehicle inspection, EDR
Medical Treatment:	Transported and released

Rear Center Passenger Injury

The medical records received from the treating hospital indicated the passenger was not injured.

Rear Center Passenger Kinematics

The 14 year old passenger was seated in an unknown posture in the center rear of the vehicle. He was unrestrained; the passenger was sitting on the safety belt that was buckled behind his back. As the vehicle began to rollover, the center passenger was displaced to the right and into contact with the rear right passenger. This contact resulted in contusions to the left eye and chin of the rear right occupant. The HHR rolled two to three quarter turns and impacted the ground with the roof and right roof side rail. The passenger responded to the ground impact with a lateral and vertical trajectory and further loading of the rear right passenger. The passenger was displaced from the seat due to the rollover dynamics and came to rest on the vehicle's roof in an unknown position. He exited the vehicle's through one of the side windows and was ambulatory at the scene.

Right Rear Passenger

Age/Sex:	67 year old/Female
Height:	170 cm (67 in)
Weight:	145 kg (320 lb)
Seat Track Position:	Not adjustable
Restraint Use:	None used
Usage Source:	SCI vehicle inspection
Medical Treatment:	None, fatally injured

Rear Right Passenger Injuries

Injury	***Injury Severity (AIS Update 98)***	***Injury Source***
Subdural brain hemorrhage	Severe (140650.4,9)	Ground
Subarachnoid brain hemorrhage	Serious (140684.3,9)	Ground
Extensive areas of ecchymosis of the forehead, NFS	Minor (290402.1,7)	Right rear window frame
Scalp hemorrhage over the frontal, right temporal and occipital area	Minor (190402.1,0)	Ground
Chin contusion	Minor (290402.1,8)	Center rear occupant
Left eye contusion	Minor (290402.1,2)	Center rear occupant
Fracture of the left humerus, NFS	Moderate (752600.2.2)	Occupant to occupant contact
Multiple linear abrasions of the bilateral thighs, lower legs and knees	Minor (890202.1,3)	Right rear window sill
Fracture of the right humerus, NFS	Moderate (752600.2,1)	Right rear window sill

Injury	*Injury Severity (AIS Update 98)*	*Injury Source*
Extensive fracturing of right lateral ribs 1-7 and posterior aspect of ribs 2-4, Flailness noted, NFS	Severe (450260.4,1)	Right rear window sill
Large open gaping right arm laceration involving the posterior aspect of the right elbow and uppermost posterior forearm aspect	Minor (790602.1,1)	Right rear door lock stem (Right side hardware)
Liver laceration and parenchyma disruption	Moderate (541820.2,1)	Right rear window sill
Compound fracture of the right lower leg just above the ankle, NFS	Moderate (852002.2,1)	Right rear seat back (possible)
Complete fracture and transection of the 1st and 2nd thoracic vertebrae	Moderate (650430.2,7)	Ground, direct contact
Fracture and subluxation of the 1st and 2nd cervical vertebrae, NFS	Moderate (650216.2,6)	Ground, indirect

Source–Medical Examiner's Autopsy Report

Rear Right Occupant Kinematics

The unrestrained rear right passenger was seated in an unknown posture. The passenger was displaced to the right and contacted the right door panel in response to the rollover of the Chevrolet. The passenger's right flank was loaded by the displaced rear and center and rear left passengers. As the vehicle rolled between two and three quarter turns, the right roof and right roof side rail impacted the ground. The passenger responded to the ground impact with a rightward trajectory and loaded the right door panel and window sill. The right humerous and right ribs fractured as a result of the contact. The rear center and rear left passenger loaded the passenger's left side and fractured the left humerous. The passenger's head contacted the frame of the right rear quarter window resulting in a forehead contusion and likely contacted the ground. The frame was deformed outward upon inspection and strands of hair were found in the frame.

As the vehicle continued to rollover, the passenger was continually loaded by the center and left passengers and began to be ejected through the windows opening. The passenger's right upper extremity contacted and fractured the decorative top of the door lock stem resulting in a laceration. The centripetal force of the rollover completely ejected the passenger through the opening resulting in a liver laceration and multiple bilateral lower extremity abrasions. During the ejection sequence, the rear right seat back folded forward due to possible loading from the 25 year old female in the cargo area. As the seat folded forward, the seat contacted and possibly fractured the passenger's right lower extremity late in her ejection sequence.

The passenger was most likely completely ejected between the fifth and sixth quarter turns and traveled 6 to 9 m (20 to 30 ft) to rest. The passenger impacted the ground in a head first orientation resulting in soft tissue injuries to the face and scalp, brain hemorrhages, indirect loading and fracture of the cervical spine and direct loading and fractures of the thoracic spine. She was found partially under the vehicle at final rest.

Rear Cargo Area Passenger

Age/Sex:	25 year old/Female
Height:	Unknown
Weight:	Unknown
Seat Track Position:	Rear cargo area
Restraint Use:	None
Usage Source:	No safety belt available
Medical Treatment:	Treated and released

Rear Cargo Area Passenger Injury

Injury	***Injury Severity (AIS 98 Update)***	***Injury Source***
Right hip contusion	Minor (890402.1,1)	Side panel
Forehead abrasion above right eyebrow	Minor (290202.1,7)	Row 2 right seat back
Forehead contusion above right eyebrow	Minor (290402.1,7)	Row 2 right seat back
Right shoulder contusion	Minor (790402.1,1)	Row 2 right seat back
Cervical strain, NFS	Minor (640278.1,6)	Row 2 right seat back, indirect

Source: Medical records from the treating hospital.

Rear Cargo Area Passenger Kinematics

The 25 year old female was unrestrained and seated in the rear cargo area of the HHR in an unknown posture. As the vehicle departed the road and began to roll, the passenger was displaced to the right and contacted the side panel. Upon ground contact, the passenger responded to the impact by loading the right side of the cargo area. This loading possibly resulted in the right hip contusion. In the later stages of the rollover (prior to complete roof deformation) the passenger loaded the right folding seat back and displaced the seat forward. The folding seat loaded and fractured the right lower extremity of the rear right passenger during the process of her ejection. The seat back loading was the possible source of the forehead abrasion, forehead contusion, and the right shoulder contusion. The passenger's face/head contact to seat back transmitted loading through the neck resulting in the (indirect) cervical strain. The rear cargo passenger came to rest on the roof of the vehicle in an unknown orientation. The passenger crawled from the vehicle unassisted and was found outside the vehicle by the first responders.

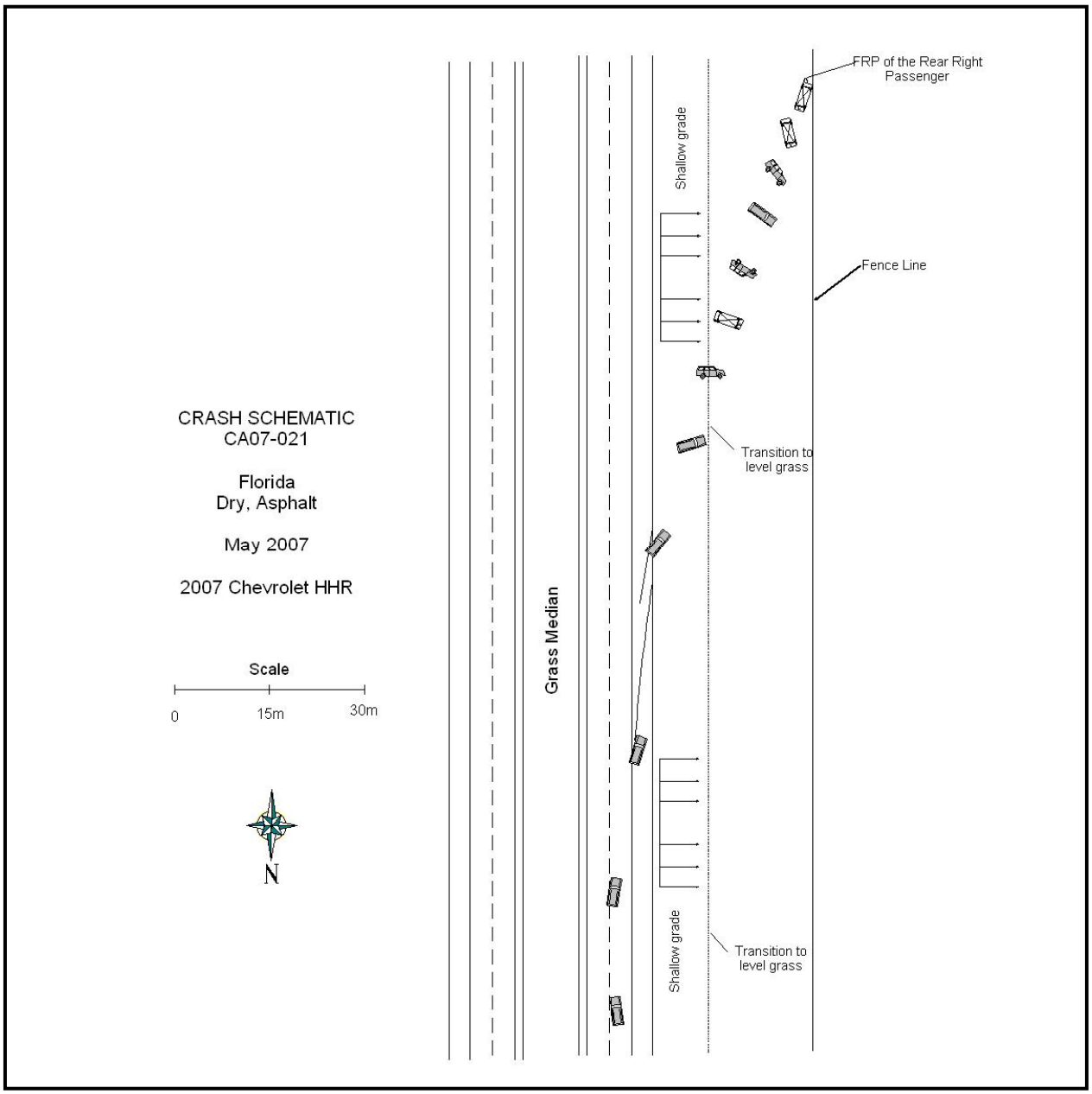


Figure 12: Crash schematic.

ATTACHMENT A: EDR Data

CDR File Information

Vehicle Identification Number	3GNDA33P77S******
Investigator	
Case Number	
Investigation Date	
Crash Date	
Filename	CA07-021 CDR.CDR
Saved on	Tuesday, July 17 2007 at 12:19:09 PM
Collected with CDR version	Crash Data Retrieval Tool 2.900
Collecting program verification number	36C71675
Reported with CDR version	Crash Data Retrieval Tool 2.8045
Reporting program verification number	E9B7C0A4
Interface used to collected data	Block number: 00 Interface version: 53 Date: 12-11-06 Checksum: CA00
Event(s) recovered	Non-Deployment

SDM Data Limitations

SDM Recorded Crash Events:
There are two types of SDM recorded crash events. The first is the Non-Deployment Event. A Non-Deployment Event is an event severe enough to "wake up" the sensing algorithm but not severe enough to deploy the air bag(s). It can contain Pre-Crash and Crash data. The SDM can store up to one Non-Deployment Event. This event can be overwritten by an event that has a greater SDM recorded vehicle forward velocity change. This event will be cleared by the SDM after the ignition has been cycled 250 times.
The second type of SDM recorded crash event is the Deployment Event. It also can contain Pre-Crash and Crash data. The SDM can store up to two different Deployment Events, if they occur within five seconds of one another. Deployment Events cannot be overwritten or cleared from the SDM. Once the SDM has deployed the air bag, the SDM must be replaced.
The data in the Non-Deployment Event file will be locked after a Deployment Event, if the Non-Deployment Event occurred within 5 seconds before the Deployment Event unless a Deployment Level Event occurs within 5 seconds after the Deployment Event, then the Deployment Level Event will overwrite the Non-Deployment Event file.

SDM Data Limitations:
-SDM Recorded Vehicle Forward Velocity Change reflects the change in forward velocity that the sensing system experienced during the recorded portion of the event. SDM Recorded Vehicle Forward Velocity Change is the change in velocity during the recording time and is not the speed the vehicle was traveling before the event, and is also not the Barrier Equivalent Velocity. This data should be examined in conjunction with other available physical evidence from the vehicle and scene when assessing occupant or vehicle forward velocity change. For Deployment Events and Deployment Level Events, the SDM will record 220 milliseconds of data after deployment criteria is met and up to 70 milliseconds before deployment criteria is met. For Non-Deployment Events, the SDM will record up to the first 300 milliseconds of data after algorithm enable. The minimum SDM Recorded Vehicle Forward Velocity Change, that is needed to record a Non-Deployment Event, is 5 MPH.
-Maximum Recorded Vehicle Velocity Change is the maximum recorded velocity change in the vehicle's combined "X" and "Y" axis.
-Event Recording Complete will indicate if data from the recorded event has been fully written to the SDM memory or if it has been interrupted and not fully written.
-SDM Recorded Vehicle Speed accuracy can be affected if the vehicle has had the tire size or the final drive axle ratio changed from the factory build specifications.
-Brake Switch Circuit Status indicates the status of the brake switch circuit.
-Pre-Crash Electronic Data Validity Check Status indicates "Data Invalid" if the SDM receive an invalid message from the module sending the pre-crash data.
-Driver's and Passenger's Belt Switch Circuit Status indicates the status of the seat belt switch circuit. The Passenger Belt Switch Circuit Status for 2005 vehicles is only available on the Cadillac STS. Also, the Passenger Belt Switch Circuit Status for 2006 Chevrolet Cobalt Sport Coupe (AP) model vehicles, with the option package that includes Recaro brand seats (RPO ALV), will always report a default value of "Buckled".
-The Time Between Non-Deployment and Deployment Events is displayed in seconds. If the time between the two events is greater than 5 seconds, "N/A" is displayed in place of the time. If the value is negative, then the Deployment Event occurred first. If the value is positive, then the Non-Deployment Event occurred first.
-If power to the SDM is lost during a crash event, all or part of the crash record may not be recorded.
-The ignition cycle counter relies upon the transitions through OFF->RUN->CRANK power-moding messages, on the GMLAN communication bus, to increment the counter. Applying and removing of battery power to the module will not increment the ignition counter.
-Steering Wheel Angle data is displayed as a positive value, when the steering wheel is turned to the right, and a negative value, when the steering wheel is turned to the left.
SDM Data Source:

All SDM recorded data is measured, calculated, and stored internally, except for the following:
-Vehicle Status Data (Pre-Crash) is transmitted to the SDM, by various vehicle control modules, via the vehicle's communication network.
-The Belt Switch Circuit is wired directly to the SDM.

Multiple Event Data

Associated Events Not Recorded	4
An Event(s) Preceded the Recorded Event(s)	Yes
An Event(s) was in Between the Recorded Event(s)	No
An Event(s) Followed the Recorded Event(s)	Yes
The Event(s) Not Recorded was a Deployment Event(s)	No
The Event(s) Not Recorded was a Non-Deployment Event(s)	Yes

System Status At AE

Vehicle Identification Number	**NDA33P*7*******
Low Tire Pressure Warning Lamp (If Equipped)	OFF
Vehicle Power Mode Status	Run
Remote Start Status (If Equipped)	Inactive
Run/Crank Ignition Switch Logic Level	Active
Brake System Warning Lamp (If Equipped)	OFF

System Status At 1 second

Transmission Range (If Equipped)	Third Gear
Transmission Selector Position (If Equipped)	Fourth Gear
Traction Control System Active (If Equipped)	Yes
Service Engine Soon (Non-Emission Related) Lamp	OFF
Service Vehicle Soon Lamp	OFF
Outside Air Temperature (degrees F) (If Equipped)	82
Left Front Door Status (If Equipped)	Closed
Right Front Door Status (If Equipped)	Closed
Left Rear Door Status (If Equipped)	Unused
Right Rear Door Status (If Equipped)	Unused
Rear Door(s) Status (If Equipped)	Closed

Pre-crash data

Parameter	-2 sec	-1 sec
Reduced Engine Power Mode	OFF	OFF
Cruise Control Active (If Equipped)	No	No
Cruise Control Resume Switch Active (If Equipped)	No	No
Cruise Control Set Switch Active (If Equipped)	No	No

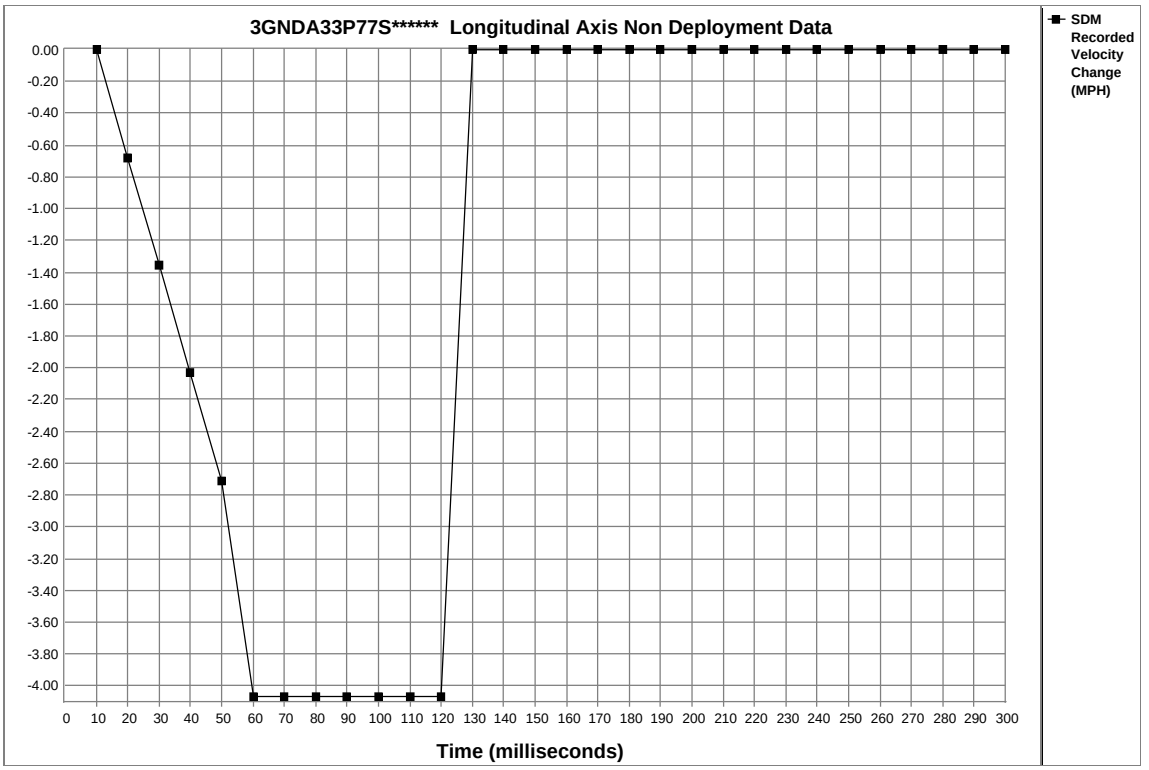
Pre-crash data

Parameter	-5 sec	-4 sec	-3 sec	-2 sec	-1 sec
Vehicle Speed (MPH)	78	76	82	80	72
Engine Speed (RPM)	4544	4480	4416	4288	3840
Percent Throttle	100	95	50	38	38
Accelerator Pedal Position (percent)	100	100	100	100	100
Antilock Brake System Active (If Equipped)	No	No	No	No	No
Lateral Acceleration (feet/s^2)(If Equipped)	Invalid	Invalid	Invalid	Invalid	Invalid
Yaw Rate (degrees per second) (If Equipped)	Invalid	Invalid	Invalid	Invalid	Invalid
Steering Wheel Angle (degrees) (If Equipped)	0	0	0	0	0

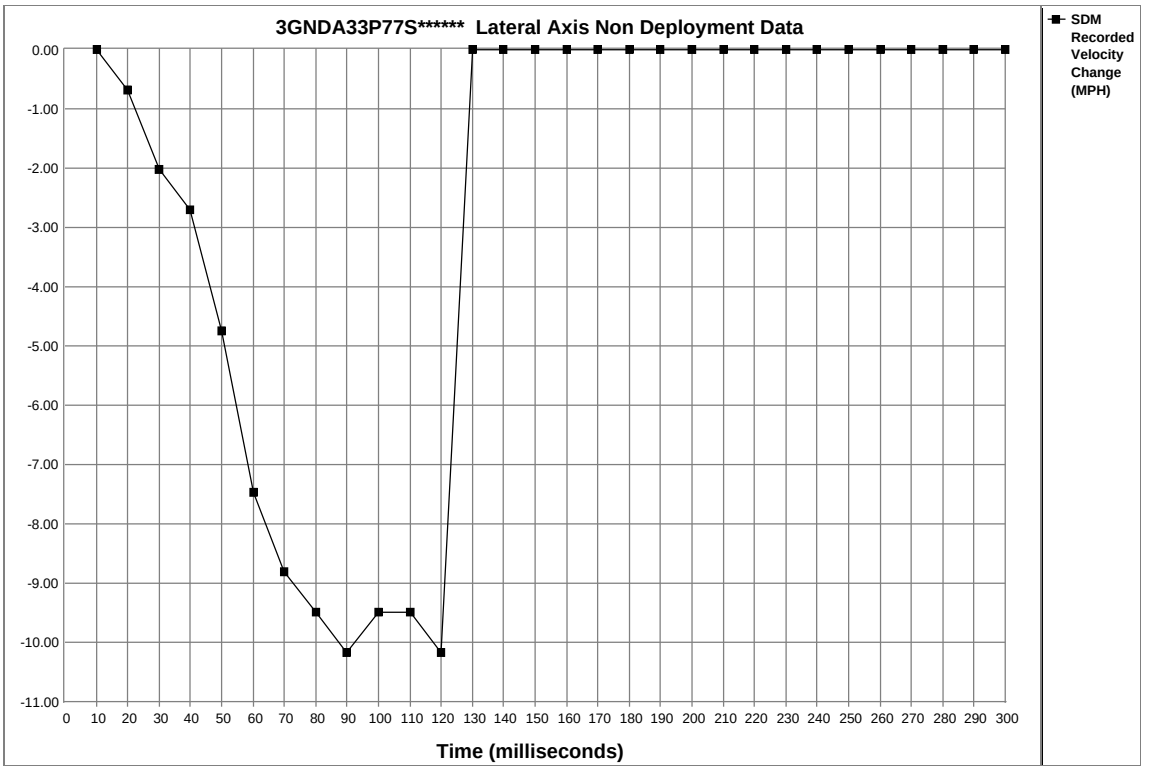
Parameter	-5 sec	-4 sec	-3 sec	-2 sec	-1 sec
Vehicle Dynamics Control Active (If Equipped)	Invalid	Invalid	Invalid	Invalid	Invalid

System Status At Non-Deployment

Ignition Cycles At Investigation	253
SIR Warning Lamp Status	OFF
SIR Warning Lamp ON/OFF Time (seconds)	259450
Number of Ignition Cycles SIR Warning Lamp was ON/OFF Continuously	251
Ignition Cycles At Event	252
Ignition Cycles Since DTCs Were Last Cleared	0
Driver's Belt Switch Circuit Status	BUCKLED
Passenger's Belt Switch Circuit Status	BUCKLED
Diagnostic Trouble Codes at Event, fault number: 1	N/A
Diagnostic Trouble Codes at Event, fault number: 2	N/A
Diagnostic Trouble Codes at Event, fault number: 3	N/A
Diagnostic Trouble Codes at Event, fault number: 4	N/A
Diagnostic Trouble Codes at Event, fault number: 5	N/A
Diagnostic Trouble Codes at Event, fault number: 6	N/A
Automatic Passenger SIR Suppression System Validity Status at AE	Valid
Automatic Passenger SIR Suppression System Status at AE	Air Bag Not Suppressed
Automatic Passenger SIR Suppression System Validity Status at First Deployment Command	Valid
Automatic Passenger SIR Suppression System Status at First Deployment Command	Air Bag Not Suppressed
Maximum SDM Recorded Velocity Change (MPH)	11.09
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	130
Driver First Stage Deployment Loop Commanded	No
Driver Second Stage Deployment Loop Commanded	No
Driver Side Deployment Loop Commanded	No
Driver Pretensioner Deployment Loop Commanded	No
Driver (Initiator 1) Roof Rail/Head Curtain Loop Commanded	No
Driver (Initiator 2) Roof Rail/Head Curtain Loop Commanded	No
Driver Knee Deployment Loop Commanded	No
Passenger First Stage Deployment Loop Commanded	No
Passenger Second Stage Deployment Loop Commanded	No
Passenger Side Deployment Loop Commanded	No
Passenger Pretensioner Deployment Loop Commanded	No
Passenger (Initiator 1) Roof Rail/Head Curtain Loop Commanded	No
Passenger (Initiator 2) Roof Rail/Head Curtain Loop Commanded	No
Passenger Knee Deployment Loop Commanded	No
Second Row Left Side Deployment Loop Commanded	No
Second Row Left Pretensioner Deployment Loop Commanded	No
Third Row Left Roof Rail/Head Curtain Loop Commanded	No
Second Row Right Side Deployment Loop Commanded	No
Second Row Right Pretensioner Deployment Loop Commanded	No
Third Row Right Roof Rail/Head Curtain Loop Commanded	No
Second Row Center Pretensioner Deployment Loop Commanded	No
Crash Record Locked	No
Vehicle Event Data (Pre-Crash) Associated With This Event	No
Deployment Event Recorded in the Non-Deployment Record	No
Event Recording Complete	Yes



Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Longitudinal Axis Recorded Velocity	0.00	-0.68	-1.36	-2.03	-2.71	-4.07	-4.07	-4.07	-4.07	-4.07	-4.07	-4.07	0.00	0.00	0.00
Time (milliseconds)	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
Longitudinal Axis Recorded Velocity	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00



Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Lateral Axis Recorded Velocity Change (MPH)	0.00	-0.68	-2.03	-2.71	-4.74	-7.46	-8.81	-9.49	-10.17	-9.49	-9.49	-10.17	0.00	0.00	0.00
Time (milliseconds)	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
Lateral Axis Recorded Velocity Change (MPH)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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