

**TRANSPORTATION SCIENCES  
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**REMOTE NASS/SCI COMBINATION  
SIDE IMPACT INFLATABLE OCCUPANT PROTECTION INVESTIGATION**

**VERIDIAN CASE NO. 2000-12-177J**

**VEHICLE - 2000 CHEVROLET VENTURE**

**LOCATION - MICHIGAN**

**CRASH DATE - OCTOBER 2000**

**Contract No. DTNH22-94-07058**

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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 of the involved vehicle(s) or their safety systems.

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<p>16. <i>Supplementary Notes:</i> Combined NASS/SCI investigation of a 2000 Chevrolet Venture equipped with side impact occupant protection.</p>			
<p>17. <i>Abstract</i></p> <p>This on-site investigation focused on the injury mechanisms of a 14 year old male seated in the front right of a 2000 Chevrolet Venture. The Chevrolet was involved in an intersection collision with a 1992 Pontiac Bonneville. The Chevrolet Venture was equipped with a Supplemental Restraint System (SRS) that consisted of redesigned frontal and side impact air bags for the front seated occupants. The manual front seat belts were equipped with buckle pretensioners. The front right side impact air bag deployed as a result of the crash. The 14 year old child was restrained at the time of the crash by the vehicle's 3-point lap and shoulder belt system. He reportedly sustained a lacerated spleen and liver as a result of contact with arm rest of the intruding door panel.</p> <p>The crash was selected for investigation by PSU 12 of the National Automotive Sampling System (NASS). The Zone Center in-turn notified the Crash Investigations Division of the National Highway Traffic Safety Administration (NHTSA) of the crash. NHTSA subsequently assigned a remote level investigation to the Special Crash Investigations team at Veridian Engineering. A combined NASS/SCI analysis of the crash was conducted due to the interest in and potential benefits of side impact air bags.</p>			
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**REMOTE NASS/SCI COMBINATION  
SIDE IMPACT INFLATABLE OCCUPANT PROTECTION INVESTIGATION  
VERIDIAN CASE NO: 2000-12-177J**

**VEHICLE: 2000 CHEVROLET VENTURE  
LOCATION: MICHIGAN  
CRASH DATE: OCTOBER, 2000**

***BACKGROUND***

This on-site investigation focused on the injury mechanisms of a 14 year old male seated in the front right of a 2000 Chevrolet Venture. The Chevrolet was involved in an intersection collision with a 1992 Pontiac Bonneville. The Chevrolet Venture was equipped with a Supplemental Restraint System (SRS) that consisted of redesigned frontal and side impact air bags for the front seated occupants. The manual front seat belts were equipped with buckle pretensioners. The front right side impact air bag deployed as a result of the crash. The 14 year old child was restrained at the time of the crash by the vehicle's 3-point lap and shoulder belt system. He reportedly sustained a lacerated spleen and liver as a result of contact with arm rest of the intruding door panel.

The crash was selected for investigation by PSU 12 of the National Automotive Sampling System (NASS). The Zone Center in-turn notified the Crash Investigations Division of the National Highway Traffic Safety Administration (NHTSA) of the crash. NHTSA subsequently assigned a remote level investigation to the Special Crash Investigations team at Veridian Engineering. A combined NASS/SCI analysis of the crash was conducted due to the interest in and potential benefits of side impact air bags.

***SUMMARY***

***Crash Site***

This two-vehicle crash occurred during the afternoon hours of October, 2000. At the time of the crash, it was daylight and the weather was not a factor. The road surface was dry. The crash occurred at the four-leg intersection of a two-lane north/south road and a two-lane east/west road in a rural area of the county. The intersection was controlled by stop signs for traffic traveling in the north/south direction. There were no obstructions in the intersection quadrants that would have impaired the line of sight for the respective drivers. The speed limit in the area of the crash was 89 km/h (55 mph). **Figure 1** is a westbound view on the approach to the intersection.



**Figure 1:** Westbound trajectory view of the 2000 Chevrolet Venture into the intersection.

### *Pre-Crash*

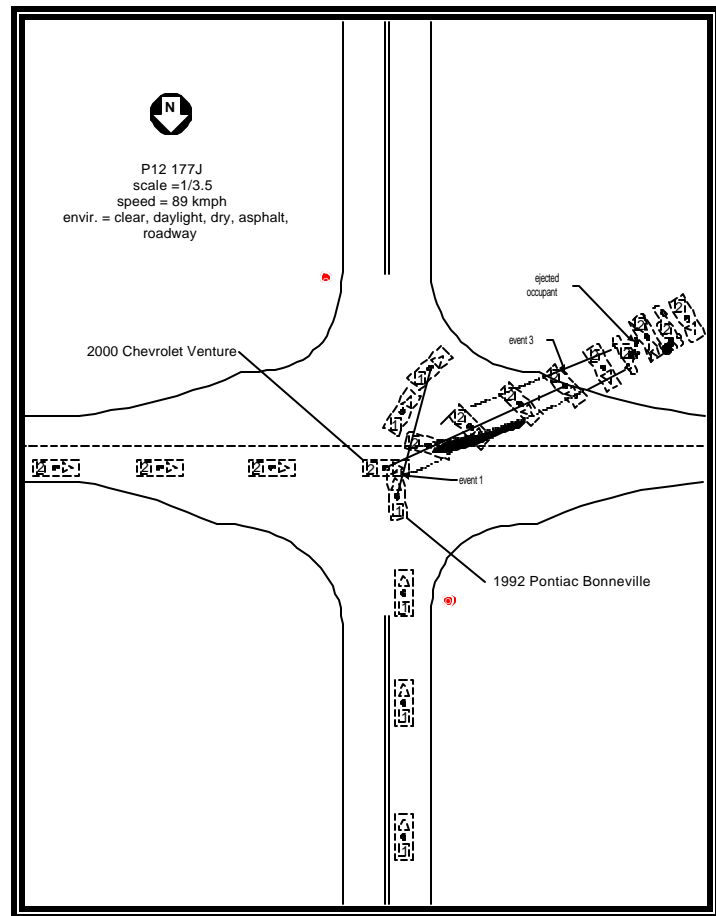
The 2000 Chevrolet Venture was westbound on the approach to the intersection and was driven by a 42 year old female. She was restrained by the vehicle's 3-point lap and shoulder belt. The front right seat was occupied by a 14 year old restrained male. The Chevrolet's second row seat system consisted of three modular bucket seats. The second row left and second row center positions were occupied by a restrained 11 year old male and an unrestrained 10 year old female, respectively. The 1992 Pontiac Bonneville was southbound driven by a 16 year old female. She was restrained by the vehicle's 3-point lap and shoulder belt and was the vehicle's sole occupant. As the Pontiac approached the intersection, the driver failed to stop and entered the intersection coincident with the Chevrolet Venture. Both drivers estimated their respective travel speed was approximately 89 km/h (55 mph). No pre-crash braking evidence was documented.

### *Crash*

The crash occurred with the front plane of the Pontiac striking the right side plane of the Chevrolet in a 12/3 o'clock impact configuration. The direct vehicular contact occurred in the area of the Chevrolet's right front door. Refer to the crash scene schematic, **Figure 2**. The force of the impact caused the front right side impact air bag in the Chevrolet Venture to deploy from the seat back. The Venture's frontal air bags did not deploy. The delta V calculated by the Damage algorithm of the WINSMASH model was 23.4 km/h (14.5 mph). The longitudinal and lateral components were -11.7 km/h (-7.3 mph) and -20.3 km/h (-12.6 mph), respectively. The barrier equivalent speed was 35.6 km/h (22.1 mph). The Collision Deformation Classification (CDC) coded by the researcher was 02-RYEW-4.

The impact force also commanded the deployment of the frontal air bag system in the Pontiac Bonneville. The Pontiac was not available for post-crash inspection. The delta V calculated by the Missing Vehicle algorithm of the WINSMASH model was 28.6 km/h (17.8 mph).

The southbound momentum of the Pontiac altered the trajectory of the Chevrolet to the southwest. The area of impact was identified by a tire mark attributed to the



**Figure 2:** Crash schematic.

right front of the Chevrolet. Additional evidence documented during the NASS investigation included a large fluid spill and a series of tire marks along the Chevrolet's southwest trajectory. The Chevrolet slid laterally across the center line, through the eastbound traffic lane and into the southwest quadrant of the intersection over a 22 m (72 ft) distance. The Chevrolet had also rotated clockwise approximately 45 degrees. Upon leaving the pavement, the vehicle began to furrow on the sloping earthen shoulder with its left side tires. The vehicle tripped and initiated a left side leading roll. The Chevrolet rolled 4 quarter turns, coming to rest on its wheels. The roll sequence was evidenced by the furrow and the fractured left side window glazing. During the roll sequence, the unrestrained 10 year old female passenger was ejected through the left side window. **Figure 3** is a look back view from the area of the Chevrolet's final rest toward the intersection.



**Figure 3:** Look back view from the Chevrolet's final rest toward the intersection.

The Pontiac Bonneville came to rest on the roadway approximately 15 m (50 ft) from the point of impact. The vehicle rotated clockwise during its post-impact travel, due to the lateral momentum of the Chevrolet, and was facing southwest as referenced in the police report. The exact final rest position of the vehicle was not identified. The Pontiac was sold for salvage by its insurance company after the crash and was not available for inspection.

### ***Post-Crash***

The police and EMS personnel responded to the scene. Upon arrival, the 14 year old front right occupant of the Chevrolet was unconscious. He was immediately transported to a regional trauma center. At the time of his admission, he was alert with a Glasgow Coma Score of 15. He reportedly was admitted for a period of 5 days. The medical record indicated he sustained a minor liver laceration (AIS 2) and a major spleen laceration (AIS 4) (both related to the intruding right front door), as well as multiple abrasions and contusions.

The driver was assisted from the vehicle due to police reported non-incapacitating injuries. Reportedly, she was diagnosed with two right rib fractures, multiple abrasions and contusion and strain to the cervical,

thoracic and lumbar regions of her spine. The driver was hospitalized for two days and released. The restrained 11 year old male, seated on the left side of row 2, was initially unconscious at the scene. However, upon his arrival at the trauma center, he was awake with a GSC of 15. He sustained a bladder laceration(AIS 3) and multiple minor abrasions and lacerations. He was hospitalized for two days and released. The unrestrained 10 year old female occupant suffered a fracture of the right clavicle (related to right side intrusion) and facial abrasions. During the first quarter roll, this unrestrained occupant was displaced to the area of the left side window. Upon ground contact, the window glazing fractured and the occupant was deposited on the ground. The vehicle then rolled away from her. She was found unconscious outside the vehicle.

The 16 year old female driver of the Pontiac reportedly exited the vehicle under her own power, sat down outside the vehicle and waited for the emergency responders. She was transported to a local hospital and admitted for overnight observation. She sustained a 2 cm (1 in) posterior occiput laceration from an unknown rebound contact. Additionally, the medical record indicated she sustained minor seat belt related abrasions to her neck and chest.

### ***2000 CHEVROLET VENTURE***

The 2000 Chevrolet Venture was identified by the Vehicle Identification Number (VIN): 1GNDX03E5YD (production sequence deleted). The minivan was the extended wheelbase (305 cm (120 in)) model and had a gross vehicle weight rating of 2,430 kg (5,357 lb). The power train consisted of 3.4 liter V-6 engine linked to a 4-speed automatic transmission. A four-wheel anti-lock braking system (ABS) was standard equipment. The electronic odometer could not be read during the inspection.

The vehicle was configured to seat seven (7) occupants. The seats were all forward facing modular bucket seats and were arranged in a 2/3/2 configuration. The manual restraint system consisted of 3-point lap and shoulder belts in the six (6) outboard positions. The front row seat belt systems were equipped with buckle pretensioners. The center seat in row 2 was equipped with a lap belt. The Supplemental Restraint System (SRS) consisted of redesigned frontal air bags for the driver and front right passenger and seat mounted side impact air bags for the front occupants. The driver's seat belt pretensioner and right side impact air bag deployed as a result of the crash.

#### ***Exterior Damage***

The right side of the Chevrolet Venture, **Figure 4**, sustained 320 cm (126 in) of direct contact damage that began at the right corner of the front bumper and ended 77 cm (30 in) forward of the left rear axle. The width of the direct and induced damage (Field L) measured 385 cm (152 in). The Field L began at the



**Figure 4:** View of the right side damage to the Chevrolet Venture.



right corner of the front bumper and extended rearward to a point 12 cm (5 in) forward of the left rear axle. The maximum crush occurred at C4, approximately at the location of the B-pillar. The crush profile recorded at the mid-door location was as follows: C1=0, C2=8 cm (3 in), C3=44 cm (17 in), C4=62 cm (24 in), C5=14 cm (5.5 in), C6=1 cm (2.5 in). The Principle Direction of Force was in the 2 o'clock sector. The windshield was fractured in the impact and the right side glazings disintegrated. The right side wheelbase was foreshortened 39 cm (15 in). The delta V calculated by the Damage algorithm of the WINSMASH model was 23.4 km/h (14.5 mph). The longitudinal and lateral components were -11.7 km/h (-7.3 mph) and -20.3 km/h (-12.6 mph), respectively. The barrier equivalent speed was 35.6 km/h (22.1 mph). The Collision Deformation Classification (CDC) coded by the researcher was 02-RYEW-4.

The balance of the Chevrolet's exterior damage was consistent with a 4-quarter turn rollover. **Figure 5** is a front view of the vehicle. The vehicle's front and back planes sustained minor damage indicative that the roll was primarily lateral in direction. The longitudinal dimensions of the vehicle were unchanged. The side and top planes of the vehicle were abraded from the ground contact. There was no vertical roof deformation. The left side glazings disintegrated due to ground contact during the first quarter roll. The CDC of the rollover damage was 00-TDDO-1.



**Figure 5:** Front view of the Chevrolet Venture.

### ***Interior Damage***

The right side interior compartment of the Chevrolet Venture sustained moderate damage and intrusion as a direct result of the impact. **Figure 6** is a view of the front right occupant position. The lateral intrusion of the mid-door and floor pan measured 37 cm (14.6 in) and 35 cm (13.8 in), respectively. The front right seat moved laterally 12 cm (4.7 in) and rolled to the left due to the floor pan deformation. The right side impact air bag had deployed from the seat back.



**Figure 6:** Front right interior view.

The intrusion of the right rear door panel into the second row measured 34 cm (13.4 in). The floor pan intrusion in this region measured 32 cm (12.6 in). The intruded door panel was in contact with the middle row right seat.

Several minor interior occupant contacts were identified during the NASS inspection consistent with the lateral impact. There was no significant interior damage directly related to the rollover.

### ***Manual Restraint System***

The manual restraint system consisted of 3-point lap and shoulder belts for the 6 outboard seat positions. The front seat belts were equipped with pretensioners attached to the inboard buckle anchors. A lap belt was available for the center occupant in row 2.

The driver's belt was stowed in the retractor at inspection and exhibited signs of historical use. The adjustable upper anchorage(D-ring) was in the full down position. The pretensioner attached to the inboard buckle was reported as fired, **Figure 7**. There was no evidence of direct loading to the webbing identified by the inspection. The occupant kinematics and minor nature of the driver's injuries are consistent with the driver being restrained at the time of the crash.

The front right seat belt webbing was extended from its retractor and lying on the seat at inspection. The retractor was probably locked due to the deformation. **Figure 8** is a view of the right seat belt buckle. The pretensioner, incorporated into the buckle, reportedly did not fire. The adjustable upper anchorage (D-ring) was in the full down position. Evidence of historical use was identified on the latch plate. The 14 year old passenger was reportedly restrained at the time of crash. He sustained a lacerated spleen (AIS 4) as a result of his interaction with the seat belt during the impact.



**Figure 7:** Left buckle and reportedly fired pretensioner.



**Figure 8:** Right buckle and reportedly non-fired pretensioner.

Although the NASS researcher coded a split-deployment of the front pretensioners, it was more likely the left pretensioner did not fire in this crash. The deployment logic of the Supplement Restraint System of the Chevrolet Venture fired both front pretensioners at the time of frontal air bag deployment. Given that the frontal air bags did not deploy in this crash, the pretensioners should not have fired.

The 3-point lap and shoulder belt for the left seat 2<sup>nd</sup> row was stowed upon initial inspection and was operational. Inspection of the latch plate and webbing identified evidence of historical use. A plastic transfer webbing as a result of frictional contact with left door panel during the rollover was also identified.

The evidence identified during the inspection supported this occupant as being restrained during the crash events.

The lap belt in the center position 2<sup>nd</sup> row was lying on the seat at the inspection and available to the occupant. It was not behind the seat cushions. There were some routine use marks on the latch plate. However, the driver indicated this occupant was unrestrained. Additionally the fact that this occupant was ejected also supported the lack of restraint use by the 10 year old female. Proper use of this restraint would have mitigated the injuries suffered by this occupant.

### ***Supplemental Restraint System***

The Chevrolet Venture's Supplemental Restraint System (SRS) consisted of dual redesigned frontal air bags and seat-mounted side impact air bags for the front occupants. The driver air bag was located in the typical manner in the center hub of the steering wheel. The front right air bag was a top-mount design located in the right aspect of the instrument panel. Neither frontal air bag deployed in the lateral crash event.

The right side impact air bag, **Figure 9**, deployed as a result of the right side impact with the Pontiac. The side impact air bag was mounted in the upper outboard aspect of the seat back and was designed for thorax protection. The air bag was rectangular in shape and measured 45 cm x 25 cm (18 in x 10 in). It was not tethered and was vented by a single port. Considering the nature of the occupants injuries, the 14 year old occupant benefitted from the addition protection of the side impact air bag. His major injuries were abdominal (lacerated liver and spleen) and related to intrusion.



**Figure 9:** Right side impact air bag.

## ***OCCUPANT DEMOGRAPHICS***

### ***2000 Chevrolet Venture***

#### ***First Row***

	<b><i>Driver</i></b>	<b><i>Front Right Passenger</i></b>
Age/Sex:	42 year old/Female	14 year old/Male
Height:	160 cm (63in)	165 cm (65 in)
Weight:	48 kg (105 lb)	64 kg (140 lb)
Restraint Use:	3-point lap & shoulder	3-point lap & shoulder
Usage Source:	Inspection/interview	Inspection/interview
Medical Treatment:	Hospitalized 2 days	Hospitalized 5 days

#### ***Second Row***

	<b><i>Left Passenger</i></b>	<b><i>Center Passenger</i></b>
Age/Sex:	11 year old/Male	10 year old/Female
Height:	127 cm (50 in)	122 cm (48 in)
Weight:	39 kg (85 lb)	39 kg (85 lb)
Restraint Use:	3-point lap & shoulder	unrestrained
Usage Source:	inspection/interview	occupant kinematics/interview
Medical Treatment:	Hospitalized 2 days	Hospitalized 2 days

## ***OCCUPANT KINEMATICS & INJURY***

### ***Driver***

The 42 year old female driver was restrained and seated with a normal posture immediately prior to the crash. Upon impact, the emergency locking retractor of the driver's seat belt system locked. The driver initiated a rightward and forward trajectory in response to the 2 o'clock direction of the impact. She loaded the 3-point restraint with her pelvis and torso and probably contacted the center console with her right hip. As the vehicle left the roadway and began to rollover, the driver exhibited a leftward trajectory upon left side contact with the ground. She probably contacted the left door panel and shattered glazing. As the vehicle completed the roll sequence, the 3-point belt system effectively restrained the driver within her occupant space and prevented major contact with the vehicle's interior. Her injuries are summarized in the table below:

<i>Injury</i>	<i>Injury Severity (AIS 98 update)</i>	<i>Injury Source</i>
Multiple right rib fractures	Moderate (450220.2,2)	Inertial contact with seat belt
Multiple facial abrasions	Minor (290202.1,0)	Left door glazing
Chest abrasion, right side	Minor (490202.1,2)	Inertial contact with seat belt
Lower extremity contusions, bilateral	Minor (890402.1,1) Minor (890402.1,2)	Driver knee bolster
Back skin abrasion	Minor (690202.1,4)	Left seat back
Left upper extremity laceration	Minor (790602.1.1)	Left door glazing
Cervical spine strain	Minor (640278.1,6)	Inertial contact with seat belt
Thoracic spine strain	Minor (640478.1,6)	Inertial contact with seat belt
Lumbar spine strain	Minor (640678.1,6)	Inertial contact with seat belt

### ***Front Right Passenger***

The 14 year old passenger was restrained at the time of the crash and seated with an upright normal posture. Upon impact with the Pontiac, the right side impact air bag deployed from the right aspect of the seat back and inflated. The right front door panel deformed laterally to the left due to the force of the impact. The passenger contacted the inflated side impact air bag with his right shoulder, right arm and torso. Given the occupant's age and probable seated height, his head may have also been protected. The arm rest of the intruding door panel, below the elevation of the side bag, contacted his abdominal region and his lower extremities. Contact with the hard surfaces of the arm rest caused a minor liver laceration (AIS 2) and (indirectly) a major spleen laceration (AIS 4). The intruding door panel then displaced the passenger into a rebound contact with the seat back. The passenger also sustained abrasions and contusions to his abdominal and thoracic regions as a result of inertial contact to the seat belt. Given the overall severity of the passenger's injuries relative to the magnitude of the intrusion, the passenger benefitted from the performance of the side impact air bag due to the lack of any rib and/or thoracic injuries. Additionally, the use of the manual 3-point belt system effectively protected the passenger from injury during the rollover crash event.

<i>Injury</i>	<i>Injury Severity (AIS 98 update)</i>	<i>Injury Source</i>
Major spleen laceration	Severe (544226.4,1)	Intruding right arm rest (Indirect contact injury)

Minor liver laceration	Moderate (541822.2,2)	Intruding right arm rest (Direct contact injury)
Left upper extremity contusion	Minor (790402.1,1)	Right front seat back
Abdominal skin abrasion	Minor (590202.1,8)	Inertial contact with seat belt
Abdominal skin contusion	Minor (590402.1,8)	Inertial contact with seat belt
Thorax abrasion	Minor (490202.1,1)	Inertial contact with seat belt
Thorax contusion	Minor (490402.1,1)	Inertial contact with seat belt
Amnesic to events of the crash, NFS, GSC=15	Moderate (160410.2,0)	Inertial forces of the crash

### ***Second Row Left Passenger***

The 11 year old passenger seated in the left seat of the second row was restrained at the time of the crash by the available manual 3-point lap and shoulder belt system. Upon impact, the passenger initiated a right and forward trajectory in response to the 2 o'clock impact force. The passenger contacted and loaded the belt system causing a bladder laceration (AIS 3). The passenger then began to rebound back into the seat. Coincident to the rebound, the vehicle began to rollover. At left side/ground contact, the passenger probably struck his head on the left side glazing and ground or the interior causing the loss of consciousness and the minor facial laceration and abrasions. The use of the 3-point restraint was effective in minimizing the injuries suffered by this passenger.

<b><i>Injury</i></b>	<b><i>Injury Severity (AIS 98 update)</i></b>	<b><i>Injury Source</i></b>
Bladder laceration	Serious (540622.3,8)	Inertial contact with seat belt
Left side scalp abrasion	Minor (190202.1,1)	Left side glazing
Right side scalp laceration	Minor (190602.1,2)	Left side glazing
Abdominal skin abrasion	Minor (590202.1,1)	Inertial contact with seat belt
Facial abrasion	Minor (290202.1,7)	Left side glazing
Loss of consciousness, length unknown, GSC=15	Moderate (160406.2,0)	Inertial contact with the ground

### ***Second Row Center Passenger***

The 10 year old male passenger was seated in the center seat of the second row. He was not restrained by the available lap belt. Upon impact, the right side door panels of Chevrolet began to deform and intrude laterally into the occupant space. Coincident to this intrusion, the passenger responded to the 2 o'clock direction of the impact by initiating a right and forward trajectory. The unrestrained passenger contacted the interior panel of the right second door causing a fracture of the right clavicle (AIS 2). The passenger also suffered a loss of consciousness during this impact sequence. The passenger then began to rebound to the left. At this time the vehicle probably was beginning to roll. The left side of the vehicle contacted the ground causing the left side glazing to disintegrate. The unrestrained occupant was displaced through this open portal and deposited on the ground. The vehicle then continued its roll sequence and moved away from the passenger. Fortunately passenger did not sustain further injury as a result of the ejection. The injuries sustained by this occupant were directly related to his unrestrained condition.

<b><i>Injury</i></b>	<b><i>Injury Severity (AIS 98 update)</i></b>	<b><i>Injury Source</i></b>
Right clavicle fracture	Moderate (752200.2,2)	Intruding right sliding door
Facial abrasions, NFS	Minor (290202.1,0)	Intruding right sliding door
Loss of consciousness, length unknown, GSC=15	Moderate (160406.2,0)	Inertial contact with the ground