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ON-SITE CHILD SAFETY SEAT INVESTIGATION

CASE NUMBER - IN08020
LOCATION - TEXAS
VEHICLE - 2004 GMC ENVOY
CRASH DATE - March 2008

Submitted:

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Contract Number: DTNH22-07-C-00044

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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.

Technical Report Documentation Page

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15. *Supplementary Notes* On-site Child Safety Seat (CSS) investigation involving a 2004 GMC Envoy.			
16. *Abstract* This report covers an on-site CSS investigation that involved a 2004 GMC Envoy, which departed the roadway and rolled over. The focus of this on-site investigation was the second row center passenger (2-year-old, male), who was restrained in a Cosco/Dorel Touriva convertible CSS. The GMC was traveling northeast on a 3-lane service leading to an interstate highway. The driver fell asleep and the vehicle traveled off the roadway and rolled over, left side leading, an unknown number of quarter turns. The second row center passenger remained restrained in the CSS throughout the crash sequence and was not injured. The second row left and right unrestrained child passengers were ejected through the right rear window opening and sustained skull fractures. The restrained driver sustained minor injuries. The driver, second row left passenger, and second row right passenger were transported by ambulance to a hospital. The second row left and right passengers were hospitalized and the driver was treated in the emergency room and released.			
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IN08020

This crash was brought to the National Highway Traffic Safety Administration's (NHTSA) attention on March 27, 2008 by a news article in a Texas newspaper. This on-site investigation was assigned on May 13, 2008. The crash involved a 2004 GMC Envoy that departed the roadway and rolled over. The crash occurred in March, 2008 at 2117 hours, in Texas and was investigated by the applicable city police department. The focus of this on-site investigation was the second row center passenger (2-year-old, male), who was restrained in a Cosco/Dorel Touriva convertible Child Safety Seat (CSS). This contractor inspected the Chevrolet, CSS, the crash scene, and interviewed the driver on May 14, 2008. This report is based on the police crash report, crash scene inspection, GMC, CSS, and exemplar vehicle inspections, driver interview, occupant medical records, occupant kinematic principles, and this contractor's evaluation of the evidence.

Figure 1: The damaged 2004 GMC Envoy

CRASH CIRCUMSTANCES

Crash Environment: The trafficway on which the GMC was traveling was a 3-lane, one-way, service road leading to an interstate highway. The roadway had two through lanes and an entrance lane to the interstate highway. The widths of the right lane, left lane, and entrance ramp lane were 3.8 m (12.5 ft), 4.4 m (14.4 ft), and 3.9 m (12.8 ft), respectively. The roadway was bordered by gravel shoulders that were nominally 1 m (3.2 ft) in width. The roadway pavement markings consisted of a white outside edge line, a broken white lane line, solid white entrance ramp lane line, and a yellow inside edge line. There was no posted speed limit sign near the crash site, but the police crash report indicated that the speed limit was 89 km/h (55 mph). At the time of the crash, it was dark but illuminated by street lights, the atmospheric condition was clear, and the roadway was dry, level bituminous. Traffic density was light and the site of the crash was urban commercial. See the Crash Diagram on page 11 of this report.

Figure 2: GMC drifted into the entrance ramp lane after driver fell asleep

Pre-Crash: The GMC was occupied by a restrained 24-year-old female driver, an unrestrained 7-year-old female second row left passenger, a 2-year-old male second row center passenger, who was restrained in a CSS, and an unrestrained 6-year-old male second row right passenger. The driver stated during the interview that she was traveling northeast in the center lane at 72 to 80 km/h (45 to 50 mph) and intended to

enter the interstate. She fell asleep and the vehicle drifted to the left into the entrance ramp lane (**Figure 2**). The driver was awakened and initiated a right steering maneuver. The vehicle traveled through the gore and reentered the roadway (**Figure 3**). The driver steered left and the vehicle departed the north side of the roadway (**Figure 4**). As the GMC entered the gravel on the north roadside, the driver initiated a right steering maneuver and the vehicle began to rotate clockwise.

Figure 3: Driver steered right and the GMC traveled through the gore and reentered the roadway

Crash: As the rotation increased, the vehicle tripped and rolled over (**Figures 5** and **6**), left side leading, an unknown number of quarter turns. The vehicle came to final rest on its left side partially on the shoulder and the left lane heading west. The right rear window glazing disintegrated during the rollover and the second row left and right passengers were fully ejected through the right rear window opening (**Figure 5**). Both occupants came to final rest on the roadway, but their location relative to the vehicle is not known.

Figure 4: Driver steered left (arrow on left shows right front yaw mark; arrow on right shows right rear yaw mark) and GMC departed north side of roadway

Post-Crash: The driver removed the uninjured back center passenger from his CSS and they exited the vehicle through the backlight opening. She attended to the two injured child occupants on the roadway and a passer-by reported the crash to authorities. The police arrived at the crash scene at 2137 hours followed by other emergency responders. The driver, second row left passenger and second row right passenger were transported by ambulance to a hospital. The vehicle was towed from the scene due to damage.

Figure 5: Damage from the rollover on the right side of the GMC; second row left and right passengers ejected through right rear window opening

CASE VEHICLE

The 2004 GMC Envoy was a rear-wheel drive, 4-door sport utility vehicle (VIN: 1GKDS13S842------) equipped with a 4.2 L, L6 engine, automatic transmission, four wheel anti-lock brakes, and an Event Data Recorder (EDR). The vehicle was not equipped with electronic stability control. The front row was equipped with bucket seats, adjustable head restraints, dual stage driver and front right passenger frontal air bags, and integral lap-and-shoulder belts. The second row was equipped with a split bench seat with folding backs, adjustable head restraints, lap-and-shoulder belts in the outboard positions, an

integral lap-and-shoulder belt in the center position, and Lower Anchors and Tethers for Children (LATCH) in the outboard seating positions.

Figure 6: Damage from the rollover on the left side of the GMC

CASE VEHICLE DAMAGE

Exterior Damage: The damage from the rollover (**Figures 1**, **5** and **6**) involved the top plane, both side planes, and portions of the front and back bumpers. The direct damage on the left side plane began on the left fender and extended rearward to the back bumper. The direct damage on the right side began at the front bumper corner and extended rearward along the fender and roof side rail to the D-pillar. The right side of the back bumper fascia was also scratched. The direct damage to the top plane began at the front right bumper corner and extended to the back of the vehicle. Scratches along both roof side rails and across the rear hatch also involved the full width of the roof, which was 123 cm (48.4 in). The maximum vertical crush was 8 cm (3.1 in) and occurred on the roof at the second row right seat position. The maximum lateral crush was 5 cm (2 in) and occurred on the right A-pillar.

The GMC's wheelbase was unchanged and the induced damage involved the hood, roof, front bumper, right front door, left front door, and the back bumper. There was also damage to the center portion of the front bumper that was not related to this crash. The driver stated that the damage occurred when another vehicle backed into the front bumper.

Damage Classification: The GMC's Collision Deformation Classification was **00-TDDO-2.** The severity of the rollover damage was minor based on the extent of the crush on the roof.

The manufacturer's recommended tire size was P245/65R17. The vehicle was equipped with a P235/65R17 size tire on the left front, P255/65R17 on the left rear, P245/70R17 on the right rear, and a P265/65R17 on the right front. The vehicle's tire data are shown in the table below.

Tire	*Measured Pressure*		*Vehicle Manufacturer's Recommended Cold Tire Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kPa	psi	kPa	psi	milli-meters	32nd of an inch			
LF	Flat	Flat	221	32	2	3	Hole in sidewall	No	Yes
LR	Flat	Flat	221	32	6	8	None	No	Yes
RR	193	28	221	32	5	6	None	No	No
RF	103	15	221	32	5	6	None	No	No

Vehicle Interior: Inspection of the GMC's interior revealed scratches on the left C-pillar and scuff marks on the left D-pillar from possible occupant contact. The second row right window frame was also bent outward and displaced, probably due to contact by either the second row right or left passenger, or possibly both passengers at the time of their ejection. Blood transfers were located on the front row roof, sunroof, left B-pillar, second row roof, and cargo area roof. The source of the blood transfers was probably a laceration on the driver's left elbow, and was deposited at the locations indicated when the driver moved from the front row to the cargo area to exit the vehicle through the backlight opening.

All of the vehicle's window glazing was either fixed or closed. The windshield was in place and cracked from impact forces while the left front, third left rear, right rear, second right rear, and the backlight window glazings were disintegrated from impact forces. The left front and left rear doors were jammed shut while the right front door, right rear door, and the tailgate remained closed and operational.

The vehicle sustained two passenger compartment intrusions. The right A-pillar intruded 5 cm (2 in) laterally into the front row right position, and the roof intruded 8 cm (3.1 in) vertically into the second row right position. There was no evidence of steering rim deformation or compression of the energy absorbing steering column.

EVENT DATA RECORDER

It was not possible to image the vehicle's EDR because the Sensing and Diagnostic Module (SDM) had been removed from the vehicle and could not be located.

AUTOMATIC RESTRAINT SYSTEM

The GMC was equipped with dual stage driver and front right passenger frontal air bags. The driver's air bag was located within the steering wheel hub and the front right passenger air bag was located within the middle of the right instrument panel. Neither air bag deployed in this crash because the front air bag system is not designed to deploy in rollover crashes.

MANUAL RESTRAINT SYSTEM

The GMC was equipped with integral lap-and-shoulder belts for the front row seating positions and the second row center seating position. The second row left and right seating positions were equipped with lap-and-shoulder belts with fixed upper anchors. The driver's seat belt consisted of continuous loop belt webbing, an Emergency Locking Retractor (ELR), and a sliding latch plate. The front right seat belt consisted of continuous loop belt webbing, a switchable ELR/Automatic Locking Retractor (ALR) and a sliding latch plate. The second row seat belts consisted of continuous loop belt webbing, switchable ELR/ALRs, and sliding latch plates.

The inspection of the driver's seat belt assembly revealed significant historic usage scratches on the latch plate, but there was no evidence of loading on the belt webbing, latch plate belt guide,

or the D-ring. The driver stated she was restrained in this crash.

The inspection of the second row left and right passenger seat belts revealed moderate usage scratches on the latch plates, but no evidence of loading. The second row center seat belt had historic usage scratches on the latch plate and the webbing was slightly stiff and wavy indicating it had probably been loaded during the crash. The evidence was consistent with the driver's statement that the second row center passenger was restrained in the CSS and the seat belt was used to secure the CSS. The driver also stated that the second row left and right passengers were not restrained in this crash.

Figure 7: Second row center passenger's CSS

CHILD SAFETY SEAT

The GMC's back center passenger [2-year-old, male; 86 cm and 12 kg (34 in, 27 lbs)] was seated in a convertible CSS (**Figure 7**). The CSS was a Cosco brand manufactured by the Dorel Juvenile Group. The CSS model, model number, date of manufacturer, and weight and height limitations could not be determined because the manufacturer's labels had been removed or worn. Consultation with a NHTSA CSS consultant indicated that the CSS was probably a 1999 Cosco/Dorel Touriva model. The CSS was designed with a 5-point harness and three sets of harness strap adjustment slots. The harness straps were threaded through the top set of slots and a harness retainer clip was attached to the harness straps. The driver stated that the CSS was installed in the forward facing position and the harness retainer clip was positioned at the child's armpit level. The CSS was secured in the vehicle by the lap-and-shoulder belt. The driver stated that she spooled the belt webbing out of the retractor and switched it to the ALR mode. She further stated that she routed the seat belt through the forward facing belt paths.

The CSS was constructed of a one piece plastic shell and the seat back and seat cushion were fitted with a cloth pad. Inspection of the CSS revealed a few light discolorations in the plastic on the left and right sides; otherwise, the CSS was undamaged and unremarkable.

CASE VEHICLE DRIVER KINEMATICS

The driver [24-year-old, female; 160 cm and 61 kg (63 in, 135 lbs)] was seated in an upright posture with both hands on the steering wheel. Her left foot was on the floor and her right foot

was on the accelerator. The seat track was adjusted to between the forward and middle position and the seat back was slightly reclined. The tilt steering wheel was located in the center position. The driver was not wearing glasses at the time of the crash.

As the vehicle rolled over, left side leading, the driver was displaced to the left and toward the roof within her seat belt. During the rollover she sustained abrasions and a laceration on the left elbow from flying glass. She also sustained a contusion on the left shoulder and left elbow due to loading the left front window sill and left front door, respectively. She remained restrained within her seat position throughout the rollover.

CASE VEHICLE DRIVER INJURIES

The driver was treated in a hospital emergency room and released. Her medical records indicated that she was not examined until approximately seven hours post-crash. She was released from the emergency room 10.5 hours following her arrival at the hospital. She had one follow up visit to her doctor to have stitches removed, and missed five work days as a result of the crash. The table below shows the driver's injuries and injury sources.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source	Source Confidence	Source of Injury Data
1	Contusion left shoulder, not further specified	minor 790402.1,2	Left front window sill	Possible	Emergency room records
2	Laceration, 3 cm (1.2 in) left elbow, not further specified	minor 790602.1,2	Noncontact injury: flying glass, left front glazing	Probable	Emergency room records
3	Abrasion left elbow, not further specified	minor 790202.1,2	Noncontact injury: flying glass, left front glazing	Probable	Interviewee (same person)
4	Contusion left elbow, not further specified	790402.1,2	Left front door panel, rear upper quadrant	Possible	Emergency room records

CASE VEHICLE SECOND ROW LEFT PASSENGER KINEMATICS

The second row left passenger [7-year-old, female; 137 cm and 16 kg (54 in, 35 lbs)] was seated in an unknown posture. She was not restrained.

As the vehicle rolled over, the back left passenger was displaced to the left and toward the roof. During the rollover the right rear window glazing disintegrated and the passenger was redirected toward the right rear window. She was fully ejected through the right rear window (**Figure 5**) opening and landed on the roadway, which caused multiple skull fractures and brain injuries.

The second row left passenger was admitted to the hospital for treatment of her injuries. Based on her medical records, she had a Glasgow Coma Scale (GCS) score of 4 and received five units of blood. She was hospitalized for 13 days and then treated for seven days at a rehabilitation facility following her release from the hospital. The table below shows the passengers injuries and injury sources.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source	Source Confidence	Source of Injury Data
	Nonanatomic brain injury with loss of conscious, GCS = 4 initially, then 6 or 7; pupils reactive	Not coded	Ground	Certain	Hospitalization records
1	Hemorrhage, subarachnoid, not further specified	serious 140684.3,9	Ground	Certain	Hospitalization records
2	Edema, cerebral, mild with persistent effacement of cortical sulci, cisterns fully visualized, 4th ventricle patent; intracranial pressure monitor placed[1]	serious 140662.3,9	Ground	Certain	Emergency room records
3	Fracture, compound, left occipital skull with stellate, 4 cm (1.6 in) laceration over posterior scalp	serious 150404.3,6	Ground	Certain	Hospitalization records
4 5	Fracture, linear, oblique, non-displaced, involving superior orbital roof and anterior cranial fossa of frontal bone with associated pneumocephalus	serious 140682.3,1 150202.3,8	Ground	Certain	Hospitalization records
6	Fracture, linear, non-displaced, right parietal bone, not further specified	moderate 150402.2,1	Ground	Certain	Hospitalization records
7	Fracture, linear, non-displaced, left parietal bone, not further specified	moderate 150402.2,2	Ground	Certain	Hospitalization records
8	Fracture right orbit involving superior and inferior orbital rims, not further specified	moderate 251202.2,1	Ground	Certain	Hospitalization records

[1] The following terms are defined in DORLAND'S ILLUSTRATED MEDICAL DICTIONARY as follows:
cistern (sis'tern): a closed space serving as a reservoir for fluid; see also *cisterna*.
cisterna (sis-ter'na) **pl.** ***cister'nae***: a cistern -- a closed space serving as a reservoir for lymph or other body fluid, especially one of the enlarged subarachnoid spaces containing cerebrospinal fluid.
patent (pa'tent): open, unobstructed, or not closed.
sulcus (sul'kas) pl. ***sul'ci (sul'si)***: a groove, trench, or furrow; a general term for such a depression, especially one of those on the surface of the brain, separating the gyri. Compare *fissure*.
The initial reading on the ICP was 30 mmHg, decreasing to 20-21 mmHg after five minutes.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source	Source Confidence	Source of Injury Data
9	Contusion {ecchymosis, hematoma} right orbital area with some ptosis[2]	minor 297402.1,1	Ground	Certain	Hospitalization records
10	Abrasions scattered over bilateral upper extremities, not further specified	minor 790202.1,3	Ground	Probable	Hospitalization records
11	Abrasions scattered over bilateral lower extremities, not further specified	minor 890202.1,3	Ground	Probable	Hospitalization records

CASE VEHICLE SECOND ROW CENTER PASSENGER KINEMATICS

The second row center passenger [2-year-old, male; 86 cm and 12 kg (34 in, 27 lbs)] was seated in the CSS in an upright posture. His back was against the CSS back and his feet were dangling over the end of the CSS cushion.

As the vehicle rolled over, the second row center passenger was displaced to the left and toward the roof within the CSS harness. He remained restrained in the CSS throughout the crash sequence.

CASE VEHICLE SECOND ROW CENTER PASSENGER INJURIES

The second row center passenger sustained no injuries as a result of the crash.

CASE VEHICLE SECOND ROW RIGHT PASSENGER KINEMATICS

The second row right passenger [6-year-old, male; 122 cm and 18 kg (48 in, 40 lbs)] was seated in an unknown posture. The passenger was not restrained.

As the vehicle rolled over, the second row right passenger was displaced to the left. Based on occupant kinematics principles, he probably contacted the back center passenger's CSS and was also displaced toward the roof. During the rollover the right rear window glazing disintegrated and the passenger was redirected toward the right rear window. He was fully ejected through the right rear window opening and landed on the roadway, which caused multiple skull fractures and

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[2] The following terms are defined in DORLAND'S ILLUSTRATED MEDICAL DICTIONARY as follows:
prolapse (pro-laps′)* [L. prolapsus]**: 1. the falling down, or sinking, of a part or viscus; called also *procidentia* and ***ptosis. 2. to undergo such displacement.
***ptosis (to′sis)* [Gr pt oo sis fall]**: 1. *prolapse*. 2. drooping of the upper eyelid from paralysis of the third nerve or from sympathetic innervation; called also *blepharoptosis*.
It should also be noted that a visual field deficit and/or dipolia (i.e., double vision) was observed with this patient, but this result was believed to be related to the contusion and swelling.

brain injuries, as well as a fractured left clavicle, pubic ramus, left lung contusion, and multiple lacerations, contusions, and abrasions.

CASE VEHICLE SECOND ROW RIGHT PASSENGER INJURIES

The second row right passenger was admitted to the hospital for treatment of his injuries. Based on the medical records, he had a GCS score of 6 and received two units of blood. He was hospitalized for 14 days and transferred directly to a rehabilitation facility following his release from the hospital. The driver did not know the number of days involved in the rehabilitation. The passenger was expected to return to the hospital for additional surgery to replace a cranial bone segment, which had been removed as part of his treatment for elevated intracranial pressure (see footnote 3). The table below shows the passenger's injuries and injury sources.

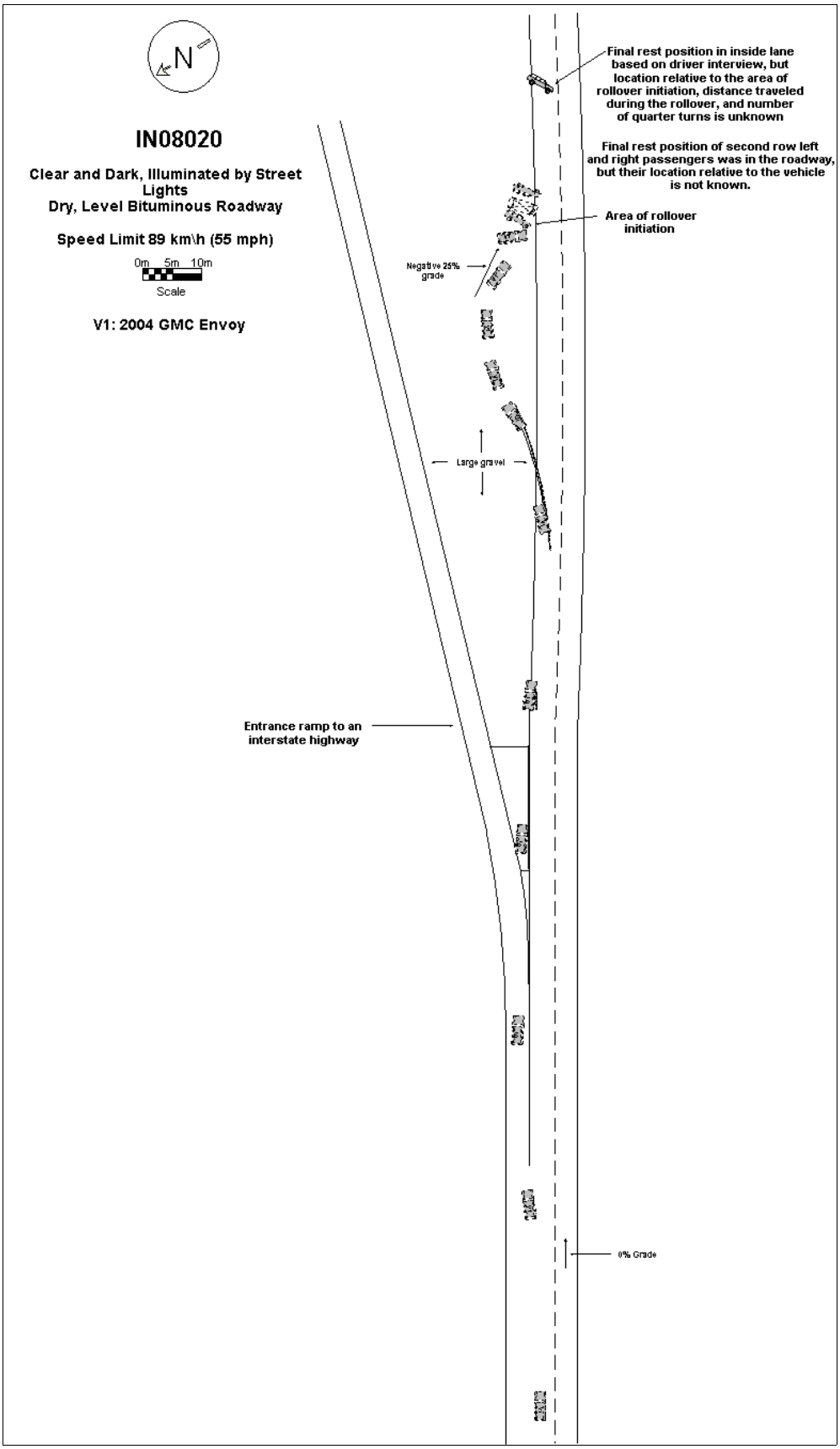
Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source	Source Confidence	Source of Injury Data
	Nonanatomic brain injury with loss of consciousness at scene and intermittent consciousness in emergency room; responsive to painful stimuli; pupils reactive; GCS=6	Not coded	Ground	Certain	Hospitalization records
1	Hemorrhage, intraventricular, occipital horn of left ventricle	severe 140678.4,2	Ground	Certain	Hospitalization records
2	Contusions, small, foci intraparenchymal right inferior parietal lobe and caudal aspect superior temporal gyrus	serious 140614.3,1	Ground	Certain	Hospitalization records
3	Edema, cerebral, mild, with persisting effacement of cortical sulci; intracranial pressure monitor placed[3] right frontal region	serious 140662.3,9	Ground	Certain	Hospitalization records
4	Pneumocephalus, not further specified	serious 140682.3,9	Ground	Certain	Hospitalization records
5	Hemorrhage, subarachnoid, right, not further specified	serious 140684.3,1	Ground	Certain	Hospitalization records
6	Contusion, left lung {pulmonary}, not further specified	serious 441406.3,2	Ground	Probable	Emergency room records

[3] Patient developed elevated intracranial pressure resistant to all conservative measures. The initial ICP measurement was 40 mmHg; 18 to 55 mmHg on third day; decreasing to 18 to 30 mmHg on fourth day. The ICP was followed by an extensive frontal craniectomy with bone segment placed inside an surgically created abdominal pouch for preservation.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source	Source Confidence	Source of Injury Data
7 8	Fracture, linear, non-displaced right parietal bone extending to petrous apex of temporal bone through mastoid air cells with resulting hemomastoid; clinical basilar skull fracture[4]	moderate 150402.2,1 serious 150200.3,8	Ground	Certain	Hospitalization records
9	Fracture left clavicle, not further specified	moderate 752200.2,2	Ground	Probable	Emergency room records
10	Fracture, {open synchondroses[5]} left inferior pubic ramus {ischiopubic junction}	moderate 852602.2,5	Ground	Probable	Emergency room records
11	Laceration posterior scalp, not further specified	minor 190600.1,6	Ground	Certain	Emergency room records
12	Contusion {subgaleal hematoma} right parietal scalp	minor 190402.1,1	Ground	Certain	Hospitalization records
13	Laceration left frontal scalp, not further specified	minor 190600.1,5	Ground	Certain	Hospitalization records
14	Abrasion left hand, not further specified	minor 790202.1,2	Ground	Probable	Emergency room records
15	Lacerations bilateral hands, not further specified	minor 790600.1,3	Ground	Probable	Emergency room records
16	Abrasion proximal anterior right thigh, not further specified	minor 890202.1,1	Ground	Probable	Emergency room records
17	Contusion right knee area, not further specified	minor 890402.1,1	Ground	Probable	Emergency room records
18	Lacerations bilateral knee areas, right slightly at or below knee while left is at or above knee, not further specified	minor 890600.1,3	Ground	Probable	Emergency room records
19	Abrasion below right knee, not further specified	minor 890202.1,1	Ground	Probable	Hospitalization records

[4] Hemotympanium was observed in the right ear with possible cerebrospinal fluid leak from right ear.

[5] This lesion is like a diastatic fracture.
The following terms are defined in DORLAND'S ILLUSTRATED MEDICAL DICTIONARY as follows:
diastasis (di-as/te-sis): a form of dislocation in which there is separation of two bones normally attached to each other without the existence of a true joint; as in separation of the pubic symphysis. Also, separation beyond the normal between associated bones, as between the ribs, or the ulna and radius.
diastatic (di"e-stat/ik): pertaining to diastasis.
synchondrosis (sin"kon-dro/sis) **[Gr. synchondrosis a growing into one cartilage]**: a union between two bones formed by either hyaline cartilage or fibrocartilage; it is usually temporary, the intervening cartilage being converted into bone before adult life.


N
IN08020
Clear and Dark, Illuminated by Street Lights
Dry, Level Bituminous Roadway
Speed Limit 89 km\h (55 mph)
0m 5m 10m
Scale
V1: 2004 GMC Envoy
Final rest position in inside lane based on driver interview, but location relative to the area of rollover initiation, distance traveled during the rollover, and number of quarter turns is unknown
Final rest position of second row left and right passengers was in the roadway, but their location relative to the vehicle is not known.
Area of rollover initiation
Negative 25% grade
Large gravel
Entrance ramp to an interstate highway
0% Grade