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ON-SITE CHILD SAFETY SEAT INVESTIGATION

CASE NUMBER - IN-06-035
LOCATION - INDIANA
VEHICLE - 2000 PONTIAC MONTANA
CRASH DATE - November 2006

Submitted:

May 14, 2007
Revised August 23, 2007

Contract Number: DTNH22-01-C-07002

Prepared for:

U.S. Department of Transportation
National Highway Traffic Safety Administration
National Center for Statistics and Analysis
Washington, D.C. 20590-0003

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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

1. *Report No.* IN-06-035	2. *Government Accession No.*	3. *Recipient's Catalog No.*	
4. *Title and Subtitle* On-Site Child Safety Seat Investigation Vehicle - 2000 Pontiac Montana Location - November		5. *Report Date:* May 14, 2007 6. *Performing Organization Code*	
7. *Author(s)* Special Crash Investigations Team #2		8. *Performing Organization Report No.*	
9. *Performing Organization Name and Address* Transportation Research Center Indiana University 222 West Second Street Bloomington, Indiana 47403-1501		10. *Work Unit No. (TRAIS)* 11. *Contract or Grant No.* DTNH22-01-C-07002	
12. *Sponsoring Agency Name and Address* U.S. Department of Transportation (NPO-122) National Highway Traffic Safety Administration National Center for Statistics and Analysis Washington, D.C. 20590-0003		13. *Type of Report and Period Covered* Technical Report Crash Date: November 2006 14. *Sponsoring Agency Code*	
15. *Supplementary Notes* On-site child safety seat investigation involving a 2000 Pontiac Montana mini van equipped with manual safety belts, dual front air bag system and child safety seats installed in the second seat left and seconds seat center seat positions.			
16. *Abstract* This report covers an on-site child safety seat investigation that involved a 2000 Pontiac Montana mini van (case vehicle) and a 2006 Freightliner tractor semi-trailer (other vehicle), which were involved in an intersection crash on a two-lane county highway. This crash is of special interest because the case vehicle's second seat left passenger (2-year-old, male) and second seat middle passenger (7-month-old, male) were restrained in child safety seats and sustained police-reported "B" (non-incapacitating-evident) injuries as a result of the crash. In addition, there was an 8-year-old male seated in the second row right seat using the lap-and-shoulder safety belt who sustained fatal injuries. The case vehicle was traveling west on a two-lane county roadway approaching a four leg intersection. The Freightliner was traveling south on a two-lane county roadway approaching the stop sign at the intersection. The Freightliner entered the intersection and its front impacted the right side of the case vehicle. The case vehicle rotated clockwise and traveled off the southwest corner of the intersection and rolled over four quarter rolls (i.e., 1 full roll) onto its wheels and came to rest heading northwest. The Freightliner came to final rest in the intersection heading south. The case vehicle's second seat left passenger and second seat middle passenger were transported to a hospital and treated and released. The second seat left passenger sustained only minor injury. The second seat middle passenger sustained no injuries. The second seat right passenger was transported to a hospital and admitted. He sustained fatal injuries. The driver and front right passenger were transported to a hospital and treated and released.			
17. *Key Words* Child Safety Seat Air Bag Deployment Motor Vehicle Traffic Crash Injury Severity		18. *Distribution Statement* General Public	
19 *Security Classif. (of this report)* Unclassified	20. *Security Classif. (of this page)* Unclassified	21. *No. of Pages* 19	22. *Price* $10,500

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This investigation was brought to NHTSA's attention on or before November 13, 2006 by an article in an Indiana newspaper. This crash involved a 2000 Pontiac Montana mini van (case vehicle) and a 2006 Freightliner Columbia 120 tractor-semitrailer (other vehicle). The crash occurred in November 2006, at 3:35 p.m., in Indiana and was investigated by the applicable county sheriff department. This crash is of special interest because the case vehicle's second row left passenger [2-year-old, (unknown race and ethnic origin) male] and second row center passenger [7-month-old, (unknown race and ethnic origin) male] were restrained in child safety seats and sustained police-reported "B" (non-incapacitating-evident) injuries as a result of the crash. In addition, there was an 8-year-old male seated in the second row right seat using the lap-and-shoulder safety belt who sustained fatal injuries. This contractor inspected the case vehicle and downloaded the data from the Event Data Recorder (EDR) on December 19, 2006. The scene was inspected on December 20, 2006. The case vehicle's driver did not consent to an interview. This report is based on the sheriff department's crash report and on-scene photographs, interview with the sheriff, interview with medical personnel, scene and vehicle inspections, case vehicle EDR data, occupant medical records, occupant kinematic principles, and this contractor's evaluation of the evidence.

SUMMARY

The case vehicle was traveling west on a two-lane county roadway approaching a four leg intersection. The Freightliner was traveling south on a two-lane county roadway approaching the stop sign at the intersection. The Freightliner entered the intersection. The case vehicle's driver steered left and applied the brakes. The front of the Freightliner impacted the right side of the case vehicle. The case vehicle rotated clockwise, traveled off the southwest corner of the intersection and rolled over four quarter rolls (i.e., 1 full roll) onto its wheels and came to rest heading northwest. The Freightliner came to final rest in the intersection heading south. At the time of the crash the light condition was daylight, the atmospheric condition was clear, and the roadway pavement was dry.

The CDC for the case vehicle's right side impact with the Freightliner was determined to be: **02-RDAW-3** (**60** degrees). The rollover CDC was estimated to be: **00-RDAO-2**. The WinSMASH reconstruction program, barrier algorithm, was used to determine a Barrier Equivalent Speed (BES) for the case vehicle based on the crush to the right side. The WinSMASH program calculated the BES as: 26.6 km.p.h. (16.5 m.p.h.). The case vehicle's EDR recorded a maximum longitudinal Delta V of 14.5 km.p.h. (9 m.p.h.). Using the assigned 60 degree direction of principal force angle, the Total and Lateral Delta Vs at the time of the peak longitudinal Delta V were calculated respectively as 29.9 km.p.h. (18.6 m.p.h.) and -25.9 km.p.h. (-16.1 m.p.h.). The case vehicle was towed due to damage.

A no-back belt-positioning booster seat was used to restrain the 2-year-old male seated in the case vehicle's second seat left position. The booster seat was made in France and imported by Car Seat Specialty, Inc., of Rock Hill, South Carolina. Information from a company representative indicated that the child seat was a Polo Booster Seat, model number 204188, and

was manufactured in late 2002 or 2003. The booster seat sustained no damage in the crash and was unremarkable.

The second seat left passenger sustained only minor injury in this crash. His use of the no-back belt-positioning booster seat retained him in his seat position, mitigated his interaction with the case vehicle's interior during the crash and reduced his injury potential.

The type, make and model of the child safety seat used to restrain the 8-month-old male seated in the second seat middle position is unknown. The child safety seat could not be located.

The second seat middle passenger sustained no injury in this crash. His use of a child safety seat retained him in his seat position, mitigated his interaction with the case vehicle's interior during the crash and reduced his injury potential.

The second seat right passenger (8-year-old, male) was restrained by his three-point, lap-and-shoulder, safety belt system. He was seated adjacent to the impact area and sustained fatal head injuries due to contact with the grille of the striking vehicle.

The case vehicle's driver (32-year-old, female) and front right passenger (17-year-old, female) were both restrained by their manual, three-point, lap-and-shoulder, safety belt systems. The driver sustained police reported "C" (possible) injuries and was transported to a hospital and treated and released. The front right passenger sustained police reported "B" (non-incapacitating-evident) injuries and was transported to a hospital and treated and released.

CRASH CIRCUMSTANCES

Crash Environment: The trafficway on which the case vehicle was traveling was a straight, level two-lane, bituminous, major county roadway, traversing in an east-west direction and intersected a north-south county road. There was one travel lane in each direction and the roadway was bordered by bituminous shoulders. Each travel lane was 3.4 meters (11.2 feet) in width. Each shoulder was 1 meter (3.3 feet) in width. Roadway pavement markings consisted of a broken yellow centerline. The case vehicle's speed limit was 72 km.p.h. (45 m.p.h.). The trafficway on which the Freightliner was traveling was a straight, two-lane, bituminous, county roadway traversing in a north-south direction. It formed a four leg intersection with the case vehicle's roadway. There was one travel lane in each direction. Each travel lane was approximately 3.6 meters (11.8 feet) in width. On the approach to the intersection, the roadway grade was 2% positive. The roadway was bordered by a grass shoulder on the west side and a gravel parking lot on the east side. There was no posted speed limit sign for the Freightliner. The statutory speed limit on the county roadway is 89 km.p.h. (55 m.p.h). The case vehicle's roadway was uncontrolled at the intersection. The Freightliner's roadway was controlled by a stop sign at the intersection. At the time of the crash the light condition was daylight, the atmospheric condition was clear, and the roadway pavement was dry with an estimated coefficient of friction of 0.72. Traffic density was light and the site of the crash was rural. See the Crash Diagram at the end of this report.

Pre-Crash: The case vehicle was traveling west in the westbound lane (**Figure 1**) approaching the intersection. The Freightliner was traveling south in the southbound lane approaching the stop sign at the intersection (**Figure 2**). The Freightliner entered the intersection. The case vehicle's driver steered left to avoid the crash. The case vehicle's EDR data also indicated that the case vehicle's driver applied the brakes. The driver of the Freightliner also applied his brakes. The crash occurred in the intersection of the two roadways (**Figure 3**).

Figure 1: Approach of case vehicle westbound to area of impact (arrow), number on roadway shows meters to impact area

Crash: The front of the Freightliner (**Figure 4** below) impacted the right side of the case vehicle (**Figure 5** below) causing the case vehicle's driver air bag to deploy and the front right passenger's seat back-mounted side impact air bag and front air bag to deploy. The impact caused the case vehicle to rotate clockwise and it traveled off the southwest corner of the intersection (**Figure 6** below). The case vehicle's left side wheels furrowed into the ground and tripped the vehicle causing it to roll over driver side leading four quarter rolls (i.e., 1 full roll).

Figure 2: Approach of Freightliner southbound to intersection, number on roadway shows meters to impact area

Post-Crash: The case vehicle came to final rest on its wheels in the ditch on the southwest corner of the intersection heading northwest **(Figure 6** below). The Freightliner came to final rest in the intersection heading south.

Figure 3: Overview of impact area (green arrow) from case vehicle's approach, and case vehicle's post-impact travel to rollover and final rest (red arrows)

CASE VEHICLE

The 2000 Pontiac Montana was a front wheel drive, four-door minivan (VIN: 1GMDX03E3YD------) equipped with a 3.4L, V6 engine; four-speed automatic transmission and four-wheel, anti-lock brakes. The front seating row was equipped with driver and front right passenger next generation air bags, seat back-mounted side impact air bags, bucket seats with adjustable head restraints; manual, three-point, lap-and-shoulder safety belt systems with buckle mounted pretensioners and a front

right passenger air bag suppression switch. The second seating row was equipped with three bucket seats with folding backs, integral head restraints and three-point, lap-and-shoulder safety belts in the outboard seating positions and a two-point lap belt in the middle seating position. The third seating row was equipped with a split bench seat with integral head restraints and three-point, lap-and-shoulder safety belt systems. There was no third row middle seat position. Lastly, there were child safety seat tether anchors in all second and third row seat positions. The case vehicle's specification wheelbase was 305 centimeters (120 inches). The case vehicle's odometer reading at the time of the inspection is unknown. The case vehicle was equipped with an electronic odometer.

Figure 4: Sheriff department's on-scene photo of damage to front of Freightliner from impact with case vehicle

CASE VEHICLE DAMAGE

Exterior Damage: The case vehicle's contact with the Freightliner involved the right side of the vehicle. The right fender, right side doors, and the front portion of the right quarter panel were directly contacted and crushed inward. The direct damage began 16 centimeters (6.3 inches) forward of the right front axle and extended 353 centimeters (140 inches) rearward along the right side of the vehicle. Residual maximum crush was measured as 34 centimeters (13.4 inches) occurring at C_3 (**Figure 7** below). The table below shows the case vehicle's right side crush profile.

Figure 5: Damage to right side of case vehicle from impact by front of Freightliner, vertical scale increments in tenths of meter

The direct damage due to the rollover involved the left quarter panel, right quarter panel, upper right corner of the tailgate, the right roof side rail and the right fender. It also overlapped the direct damage from the Freightliner impact to the right side in several places. In addition, the bead was broken on all the tires and grass was jammed in the bead of all the tires. No direct damage was observed to the roof indicating the roof cleared the ground or only contacted very lightly during the rollover.

Figure 6: View southwest to case vehicle's rest position and tire furrows leading to rollover

Units	Event	Direct Damage		Field L	C_1	C_2	C_3	C_4	C_5	C_6	Direct	Field L
		Width CDC	Max Crush								±D	±D
cm	1	353	34	423	3	23	34	26	12	0	-11	-15
in		139.0	13.4	166.5	1.2	9.1	13.4	10.2	4.7	0.0	-4.3	-5.9

The case vehicle's right side wheelbase was reduced 1 centimeter (0.4 inches) as a result of the impact with the Freightliner while the left side wheelbase was unchanged. Induced damage from the impact with the Freightliner and the rollover involved the hood, roof, tailgate, left quarter panel and left fender. In addition, the backlite was broken out and the windshield was cracked due to the deployment of the front right passenger air bag.

Figure 7: Top view of crush to right side of case vehicle's passenger compartment due to Freightliner's front impact, each increment on rods is 5 cm (2 in)

The case vehicle's recommended tire size was P215/70R15, and the case vehicle was equipped with tires of this size. The case vehicle's tire data are shown in the table below.

Tire	*Measured Pressure*		*Recommend Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kpa	psi	kpa	psi	milli-meters	32nd of an inch			
LF	0	0	241	35	5	6	Bead separated, some grass in bead	No	Yes
RF	0	0	241	35	2	3	Bead separated, grass in bead	No	Yes
LR	0	0	241	35	4	5	Bead separated, grass in bead	No	Yes
RR	193	28	241	35	4	5	Bead not separated, but grass in bead	No	No

Vehicle Interior: Inspection of the case vehicle's interior (**Figures 8**, **9**, and **10** below) revealed evidence of occupant contact to the right front door. The arm rest was dented and the plastic below the arm rest was broken. Load marks were observed on the driver's shoulder belt. The safety belt in the second row right seat had been cut by rescue. There were numerous intrusions to the case vehicle's right side. The most severe intrusions were 27 centimeters (10.6 inches) of

lateral door intrusion into the second row right seat position, 23 centimeters (9.1 inches) of lateral "B"-pillar intrusion into the front right seat position and 15 centimeters (5.9 inches) of lateral door intrusion into the front right seat position. There was no deformation of the steering wheel or compression of the energy absorbing steering column.

Figure 8: Overview of case vehicle's instrument panel, windshield and steering wheel

Damage Classification: Based on the vehicle inspection, the CDC for the case vehicle's right side impact with the Freightliner was determined to be: **02-RDAW-3** (**60** degrees). The primary contact area due to the rollover involved the right side of the case vehicle. The rollover damage partly overlapped the damage from the Freightliner impact. The rollover CDC was estimated to be: **00-RDAO-2**. Collisions between heavy trucks and light vehicles are out-of-scope for the WinSMASH reconstruction program. However, the WinSMASH reconstruction program, barrier algorithm, was used to determine a Barrier Equivalent Speed (BES) for the case vehicle based on the crush to the right side. The WinSMASH program calculated the BES as: 26.6 km.p.h. (16.5 m.p.h.). The case vehicle's EDR recorded a maximum longitudinal Delta V of 14.5 km.p.h. (9 m.p.h.). Using the assigned 60 degree direction of principal force angle, the Total and Lateral Delta Vs at the time of the peak longitudinal Delta V were calculated respectively as 29.9 km.p.h. (18.6 m.p.h.) and -25.9 km.p.h. (-16.1 m.p.h.). The case vehicle was towed due to damage.

Figure 9: Overview case vehicle's right front door and front right seat

Figure 10: View from left side of case vehicle's second seat row

AUTOMATIC RESTRAINT SYSTEM

The case vehicle was equipped with a next generation driver and front right passenger front air bag system as well as front seat back-mounted side impact air bags. Both front air bags and the front right passenger seat back mounted side impact air bag deployed in this crash due to the right side impact.

The case vehicle driver's air bag was located in the steering wheel hub. An inspection of the air bag module cover flaps and the air bag fabric revealed that the cover flaps opened at the designated tear points. There was no evidence of damage to the air bag or the cover flaps due to the deployment. The deployed driver's air bag (**Figure 11**) was round with a diameter of approximately 65 centimeters (25.6 inches), and was designed without tethers or vent ports. Inspection of the air bag revealed no evidence of occupant contact. There were several parallel black marks on the top and bottom, which appeared to be related to the back of the cover flaps. In addition, a few blood stains were observed on the air bag, which were most likely blood splatter and not direct contact.

Figure 11: Case vehicle driver's air bag

The front right passenger's air bag was located in the top of the instrument panel. An inspection of the air bag module cover flap revealed that the cover flap opened at the designated tear points. The cover flap was bent during the deployment. There were numerous small holes in the air bag due to contact by flying glass during the crash. In addition, there was a small tear in the top of the air bag, which was most likely due to contact with the broken windshield glass. The windshield was fractured due to the right side impact as well as contact by the air bag as it deployed. The deployed front right passenger air bag (**Figure 12**) was rectangular in shape and was approximately 66 centimeters (26 inches) in height and 54 centimeters (21.3 inches) in width. The air bag was designed with four tethers, each 8 centimeters (3.1 inches) in width. There were two vent ports, each 3 centimeters in diameter located on each side of the air bag at the approximate 10 and 2 o'clock positions. Inspection of the air bag revealed a few blood stains due to blood splatter but no obvious occupant contact marks. In addition, there was a black scuff on the front and right side of the air bag, which appeared to be due to the deployment.

Figure 12: Overview of case vehicle's front right passenger air bag

Figure 13: Case vehicle front right passenger's seat back-mounted side impact air bag

The front right passenger's seat back-mounted side impact air bag was located in the outboard side of the passenger's seat back. The deployed air bag (**Figure 13** above) was approximately rectangular in shape and was approximately 36 centimeters (14.2 inches) in width and 28 centimeters (11 inches) in height. The air bag was designed without tethers or vent ports. There was no damage due to deployment. The front right passenger loaded into the air bag during the side impact; however, there was no residual contact evidence noted on the air bag.

CHILD SAFETY SEAT

A no-back belt-positioning booster seat (**Figures 14** and **15**) was used to restrain the 2-year-old male seated in the second row left seat position. The booster seat was made in France and imported by Car Seat Specialty, Inc., of Rock Hill, South Carolina. The make/model and manufacture date label had faded and the information could not be read. Subsequent information was obtained that indicated the child safety seat was an "Uno/Polo booster seat, Model 204188, and was manufactured in late 2002 or 2003. The booster seat consisted of a single molded plastic shell with two padded arm rests. The booster seat sustained no damage in the crash and was unremarkable.

Figure 14: Front view of second seat left passenger's no-back belt-positioning booster seat

Figure 15: Left side view of no-back belt-positioning booster seat

The type, make and model of the child safety seat used to restrain the second seat middle passenger is unknown. The child safety seat was not in the case vehicle at the time of the inspection and the tow facility personnel had no knowledge of its location. The sheriff and staff at the treating hospital were interviewed but no information regarding the type, make, model or location of the child safety seat could be determined.

CRASH DATA RECORDING

The case vehicle's EDR was downloaded via the case vehicle's diagnostic link connector. The EDR recorded a deployment event. The EDR reports are presented at the end of this report in **Figures 16-19**. The system status report showed that the SIR warning lamp was recorded as off, the driver safety belt switch circuit status was recorded a buckled and the front right passenger air bag suppression switch circuit was recorded as air bag not suppressed. The EDR recorded an adjusted algorithm maximum longitudinal velocity change of 14.5 kilometers (9 m.p.h.) occurring at 110 milliseconds after algorithm enable (AE). The pre-crash data indicated that the case vehicle was traveling at 92 km.p.h. (57 m.p.h) at 18 % throttle five seconds prior to AE. The brake

switch circuit was recorded as on one second prior to AE and vehicle speed at this point was recorded at 76 km.p.h. (47 m.p.h.).

CASE VEHICLE SECOND SEAT LEFT PASSENGER KINEMATICS

Immediately prior to the crash, the case vehicle's second seat left passenger [2-year-old, (unknown race and ethnic origin) male; unknown height and 11.8 kilograms (26 pounds)] was seated in his no-back belt-positioning booster seat. His seated posture is not known. The case vehicle's seat was positioned one click forward of the rear-most track position.

Based on this contractor's vehicle inspection and the police crash report, the case vehicle's second seat left passenger was restrained in his booster seat by the three-point, lap-and-shoulder, safety belt system.

The case vehicle driver's pre-crash braking most likely caused the passenger's safety belt retractor to lock and he moved forward within his booster seat and loaded the safety belt. The Freightliner's impact to the right side of the case vehicle caused his safety belt retractor to remain locked and the passenger to move to the right and forward within his safety belt along a path opposite the case vehicle's 60 degree direction of principal force as the case vehicle decelerated longitudinally and accelerated laterally to the left. As the case vehicle rotated clockwise, the passenger moved to the left and then toward the roof within his booster seat as the case vehicle rolled over. He continued to load his safety belt system and remained restrained in his booster seat as the case vehicle rolled over four quarter rolls and came to final rest of its wheels. It is not known how the passenger exited the case vehicle. The second seat left passenger's use of the no-back belt-positioning booster seat retained him in his seat position, mitigated his interaction with the case vehicle's interior and reduced his injury potential in this crash.

CASE VEHICLE SECOND SEAT LEFT PASSENGER INJURIES

The second seat left passenger sustained a police reported "B" (non-incapacitating-evident) injury and was transported by ambulance to a hospital and treated and released. The table below shows the passenger's injury and injury mechanism.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
	Pain, redness mid to lower back, not further specified; glass noted in diaper and shirt	not coded	Child safety seat's back surface	Probable	Emergency room records
1	Laceration, 1-2 millimeters (<0.1 in), back of head, not further specified; auto glass overlying C-collar applied by EMS on arrival ER	minor 190602.1,6	Noncontact injury: flying glass, right rear glazing	Probable	Emergency room records

Immediately prior to the crash, the case vehicle's second seat middle passenger [8-month-old, (unknown race and ethnic origin) male; unknown height and weight] was seated in an unknown type child safety seat. His seated posture is not known. The case vehicle's seat was positioned one click forward of the rear-most track position.

Based on the police crash report, the case vehicle's second seat middle passenger was restrained in his child safety seat. The child safety seat was secured in the case vehicle by the two-point lap belt. It is unknown how the child was secured in the child safety seat.

The case vehicle driver's pre-crash braking most likely caused the second seat middle passenger to move forward within his child safety seat. The Freightliner's impact to the right side of the case vehicle then caused the passenger to move to the right and forward within his child safety seat along a path opposite the case vehicle's 60 degree direction of principal force as the case vehicle decelerated longitudinally and accelerated laterally to the left. As the case vehicle rotated clockwise, the passenger moved to the left and then toward the roof within his child safety seat as the case vehicle rolled over. He remained restrained in his child safety seat as the case vehicle rolled over four quarter rolls and came to final rest of its wheels. It is not known how the passenger exited the case vehicle. The second seat middle passenger's use of a child safety seat retained him in his seat position, mitigated his interaction with the case vehicle's interior and reduced his injury potential in this crash.

CASE VEHICLE SECOND SEAT MIDDLE PASSENGER INJURIES

The second seat middle passenger sustained a police reported "B" (non-incapacitating-evident) injury and was transported by ambulance to a hospital and treated and released. This passenger's emergency room record indicated he was not injured.

CASE VEHICLE SECOND SEAT RIGHT PASSENGER KINEMATICS

Immediately prior to the crash, the case vehicle's second seat right passenger [8-year-old, White (non-Hispanic) male; unknown height and 28 kilograms (62 pounds)] was seated in an upright position. His seat track was adjusted to the rear-most position and his seat back was slightly reclined.

Based on this contractor's vehicle inspection, the case vehicle's second row right passenger was restrained by his three-point, lap-and-shoulder, safety belt system. Inspection of the safety belt system revealed that the webbing had a slight wavy appearance to it indicating possible loading during the crash. In addition, the safety belt had been cut by rescue in order to extricate the passenger.

The case vehicle driver's pre-crash braking most likely caused the passenger's safety belt retractor to lock and he moved forward and loaded his safety belt. The Freightliner's impact to the right side of the case vehicle caused the passenger's safety belt retractor to remain locked and he moved to the right and forward opposite the case vehicle's 60 degree direction of principal

force as the case vehicle decelerated longitudinally and accelerated laterally to the left. The right side of the passenger's body impacted the right rear door and his head passed through the broken side window and impacted the grille of the Freightliner causing multiple facial and skull fractures and traumatic brain injury. As the case vehicle rotated clockwise, the passenger moved to the left and then toward the roof within his safety belt as the case vehicle rolled over. He remained restrained in his seat as the case vehicle rolled over four quarter rolls and came to final rest of its wheels. Rescue personnel cut his safety belt and removed him from the case vehicle.

CASE VEHICLE SECOND SEAT RIGHT PASSENGER INJURIES

The second seat right passenger was transported by ambulance to a hospital. He was hospitalized for one day. His death was reported as occurring 24 hours and 55 minutes following the crash. The table below shows the second seat right passenger's injury and injury mechanisms.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Nonanatomic brain injury with loss of consciousness, no response to painful stimulation, flaccid, pupils fixed and dilated, no cough or gag reflexes, and GCS=3; no cerebral blood flow or discernable cortical activity	critical 160824.5,0	Exterior of other motor vehicle: grille	Certain	Hospitalization records
2	Edema, cerebral, massive with slit ventricles, and no gray-white matter differentiation	critical 140666.5,9	Exterior of other motor vehicle: grille	Certain	Hospitalization records
3	Diffuse axonal {white matter shearing} injury, not further specified	critical 140628.5,9	Exterior of other motor vehicle: grille	Certain	Hospitalization records
4	Hematoma, subdural, small, left cerebrum, not further specified	severe 140652.4,2	Exterior of other motor vehicle: grille	Certain	Hospitalization records
5	Pneumocephalus, not further specified	serious 140682.3,9	Exterior of other motor vehicle: grille	Certain	Hospitalization records
6	Contusion posterior upper lobe of right lung	serious 441406.3,1	Right rear window sill	Probable	Hospitalization records
7	Fracture, open, right temporal bone, with extrusion and/or exposure of brain tissue	severe 150406.4,1	Exterior of other motor vehicle: grille	Certain	Hospitalization records

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
8	Fracture, basilar, complex, including left anterior cranial fossa (i.e., left orbital roof) and right clivis[1] portion of posterior cranial fossa	severe 150206.4,8	Exterior of other motor vehicle: grille	Certain	Hospitalization records
9	Fracture, non-displaced, frontal bone underlying forehead laceration	moderate 150402.2,5	Exterior of other motor vehicle: grille	Certain	Hospitalization records
10	Fracture right lateral orbital wall, not further specified	moderate 251200.2,1	Exterior of other motor vehicle: grille	Certain	Hospitalization records
11	Laceration, stellate, 20-25 cm (7.9 - 9.8 in), multiangulated, pulverizing laceration across central forehead from right eyebrow to left hairline with active bleeding that resulting in massive blood loss anemia and five units of blood replacement products, honeycombed skin tissue with multiple imbedded glass fragments, and surgical repair	serious 290606.3,7	Noncontact injury: flying glass, right rear glazing	Probable	Hospitalization records
12 13	Contusions {bruising} bilateral eyes with both eyes swollen shut; globes appear intact	minor 297402.1,1 297402.1,2	Exterior of other motor vehicle: grille	Certain	Hospitalization records

CASE VEHICLE DRIVER KINEMATICS

Immediately prior to the crash, the case vehicle's driver [32-year-old, (unknown race and ethnic origin) female; unknown height and weight] was most likely seated in an upright position with both hands bracing on the steering wheel and her right foot on the brake. Her seat track was positioned between the middle and forward most position and her seat back was slightly reclined. The tilt steering column was in the center position.

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[1] The following terms are defined in DORLAND'S ILLUSTRATED MEDICAL DICTIONARY as follows:

clivus (klī′vas) [L. "slope"]: a bony surface in the posterior cranial fossa, sloping superiorly from the foramen magnum to the dorsum sellae, the inferior part being formed by a portion of the basilar part of the occipital bone (*c. ossis occipitalis*) and the superior part by a surface of the body of the sphenoid bone (*c. ossis sphenoidalis*).

basilar c., c. basila′ris: c. ossis occipitalis.

c. os′sis occipita′lis: the lower part of the clivus, formed by the basilar portion of the occipital bone; called also *basilar c.* or *c. basilaris*, and *basilar groove of occipital bone*.

c. os′sis sphenoida′lis: the upper part of the clivus, formed by a surface of the body of the sphenoid bone; called also *basilar groove of sphenoid bone*.

Based on this contractor's vehicle inspection and supported by the EDR data, the case vehicle's driver was restrained by her manual, three-point, lap-and-shoulder, safety belt system. Inspection of the driver's safety belt webbing, "D"-ring, and latch plate showed plastic transfer from the "D"-ring on the shoulder belt. In addition, the buckle mounted pretensioner actuated during the crash.

The case vehicle driver's pre-crash braking most likely caused the driver' safety belt retractor to lock and the driver moved forward and loaded her safety belt. The Freightliner's impact to the right side of the case vehicle caused the driver's safety belt retractor to remain locked and the pretensioner to actuate. The impact caused the driver to move to the right and forward along a path opposite the case vehicle's 60 degree direction of principal force as the case vehicle decelerated longitudinally and accelerated laterally to the left. The driver loaded her safety belt and her chest and face most likely impacted her deployed air bag. The driver rebounded off her air bag and moved to the left as the vehicle rotated clockwise. As the case vehicle rolled over driver side leading, the driver most likely loaded the left front door and moved toward the roof within her safety belt. She continued to load her safety belt and most likely remained restrained in her seat as the case vehicle rolled over four quarter rolls and came to rest on its wheels. The driver likely impacted her right arm rest during the rollover causing a possible fracture to her right 11th rib. It is unknown how the driver exited the case vehicle.

CASE VEHICLE DRIVER INJURIES

The case vehicle's driver sustained a police reported "B" (non-incapacitating) injury and was transported from the scene by ambulance to a hospital and treated and released. The table below shows the driver's reported possible injury and the contact mechanism.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
	Fracture, possible, with deformity posterolateral right 11th rib	not coded	Seat position's right side armrest	Possible	Emergency room records

CASE VEHICLE FRONT RIGHT PASSENGER KINEMATICS

Immediately prior to the crash, the case vehicle's front right passenger [17-year-old, White (non-Hispanic) female; unknown height and 80 kilograms (176 pounds)] was seated in an unknown posture. It is likely that both of her feet were on the floor, but the position of her hands and arms is not known. The passenger's seat track was adjusted to its middle position and the seat back was most likely slightly reclined.

Based on this contractor's vehicle inspection, the case vehicle's front right passenger was restrained by her manual, three-point, lap-and-shoulder, safety belt system. The safety belt pretensioner had actuated and the retractor was jammed with the belt extended out consistent with usage in the crash.

The case vehicle driver's pre-crash braking most likely caused the passenger's safety belt retractor to lock and the she moved forward and loaded her safety belt. The Freightliner's impact to the right side of the case vehicle caused the passenger's safety belt retractor to remain locked, the pretensioner to actuate and her front air bag and side impact air bag to deploy. She loaded the safety belt and moved forward and to the right along a path opposite the case vehicle's 60 degree direction of principal force as the case vehicle decelerated longitudinally and accelerated laterally to the left. Her right arm and thorax impacted the deployed side impact air bag and her face and chest impacted the deployed front air bag causing multiple abrasions. She also sustained several lacerations due to flying glass. She most likely rebounded off the air bags and moved to the left as the case vehicle rotated clockwise. As the case vehicle rolled over driver side leading, the passenger continued to load her safety belt and moved left and toward the roof. She most likely remained restrained in her seat as the case vehicle rolled over four quarter rolls and came to rest on it wheels. It is unknown how the front right passenger exited the case vehicle.

CASE VEHICLE FRONT RIGHT PASSENGER INJURIES

The case vehicle's front right passenger sustained a police reported "B" (non-incapacitating-evident) injury and was transported by ambulance to a hospital and treated and released. The table below shows the front right passenger's injuries and injury mechanisms.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Lacerations (x3), totaling 4 cm (1.6 in), right elbow–stitches required	minor 790602.1,1	Noncontact injury: flying glass, right front glazing	Probable	Emergency room records
2	Abrasions forehead, left and right, not further specified, with dried blood noted to face	minor 290202.1,7	Air bag, front right passenger's	Probable	Emergency room records
3	Laceration, small, superficial, along lateral left forehead	minor 290602.1,7	Noncontact injury: flying glass, right front glazing	Probable	Emergency room records
4	Abrasion neck, not further specified	minor 390202.1,9	Air bag, front right passenger's	Probable	Emergency room records
5	Abrasions central superior chest, including left anterior upper portion	minor 490202.1,4	Air bag, front right passenger's	Probable	Emergency room records
6	Abrasions left forearm and left hand–probably dorsum of hand, not further specified	minor 790202.1,2	Air bag, front right passenger's	Probable	Emergency room records
7	Abrasion right forearm and hand–probably dorsum of hand, not further specified	minor 790202.1,1	Air bag, front right passenger's side impact	Probable	Emergency room records

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
8	Contusion right elbow, not further specified	minor 790402.1,1	Right side interior surface, excluding hardware and/or armrest	Probable	Emergency room records

OTHER VEHICLE

The 2006 Freightliner CL120 Columbia was a 4x6 conventional cab truck tractor (VIN: 1FUJA6CK66L------) pulling a 2004 Great Dane van style semi-trailer.

Exterior Damage: The Freightliner's impact with the right side of the case vehicle involved the bumper and lower portion of the hood. There was direct contact across the full width of the front bumper.

Damage Classification: Based on the sheriff department's on-scene photographs and post-impact trajectory of the case vehicle, the TDC for the Freightliner was estimated to be: **11-FDEW-1** (**330** degrees).

Freightliner's Occupants: According to the police crash report, the Freightliner's driver [52-year-old, (unknown race and ethnic origin) male] was restrained by his manual, three-point, lap-and-shoulder, safety belt system. The police crash report indicated that the driver sustained no injury as a result of the crash.

CDR File Information

Vehicle Identification Number	1GMDX03E3YD******
Investigator	
Case Number	
Investigation Date	
Crash Date	
Filename	IN06035.CDR
Saved on	Tuesday, December 19 2006 at 11:46:44 AM
Collected with CDR version	Crash Data Retrieval Tool 2.800
Collecting program verification number	9238B95E
Reported with CDR version	Crash Data Retrieval Tool 2.800
Reporting program verification number	9238B95E
Interface used to collected data	Block number: 00 Interface version: 4A Date: 11-08-05 Checksum: 7500
Event(s) recovered	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 contains Pre-Crash and Crash data. The SDM can store up to one Non-Deployment Event. This event may be overwritten by another Non-Deployment Event. 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 contains 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, and then the Deployment Level Event will overwrite the Non-Deployment Event file.

SDM Data Limitations:
-SDM Adjusted Algorithm Forward Velocity Change:
Once the crash data is downloaded, the CDR tool mathematically adjusts the recorded algorithm forward velocity data to generate an adjusted algorithm forward velocity change that may more closely approximate the forward velocity change the sensing system experienced during the recorded portion of the event. The adjustment takes place within the downloading tool and does not affect the crash data, which remains stored in the SDM. The SDM Adjusted Algorithm Forward Velocity Change may not closely approximate what the sensing system experienced in all types of events. For example, if a crash is preceded by other common events, such as rough road, struck objects, or off-road travel, the SDM Adjusted Algorithm Forward Velocity Change may be less than and some times significantly less than the actual forward velocity change the sensing system experienced. 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 100 milliseconds of data after deployment criteria is met and up to 50 milliseconds before deployment criteria is met. The maximum value that can be recorded for SDM Adjusted Algorithm Forward Velocity Change is about 112 MPH.
-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.
-Some of the Pre-Crash data may be recorded after Algorithm Enable (AE). This may happen in situations involving relatively "soft" crash pulses or those that take place over a relatively longer period of time. If this occurs, it may affect the reported pre-crash data values, but does not affect other data such as SDM Adjusted Algorithm Forward Velocity Change.
-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 Belt Switch Circuit Status indicates the status of the driver's seat belt switch circuit. If the vehicle's electrical system is compromised during a crash, the state of the Driver's Belt Switch Circuit may be reported other than the actual state.
-Passenger Front Air Bag Suppression Switch Circuit Status indicates the status of the suppression switch circuit.
-The Time Between Events is displayed in seconds. If the time between the two events is greater than five seconds,

Figure 16 Case vehicle's CDR File Information and SDM Data Limitations

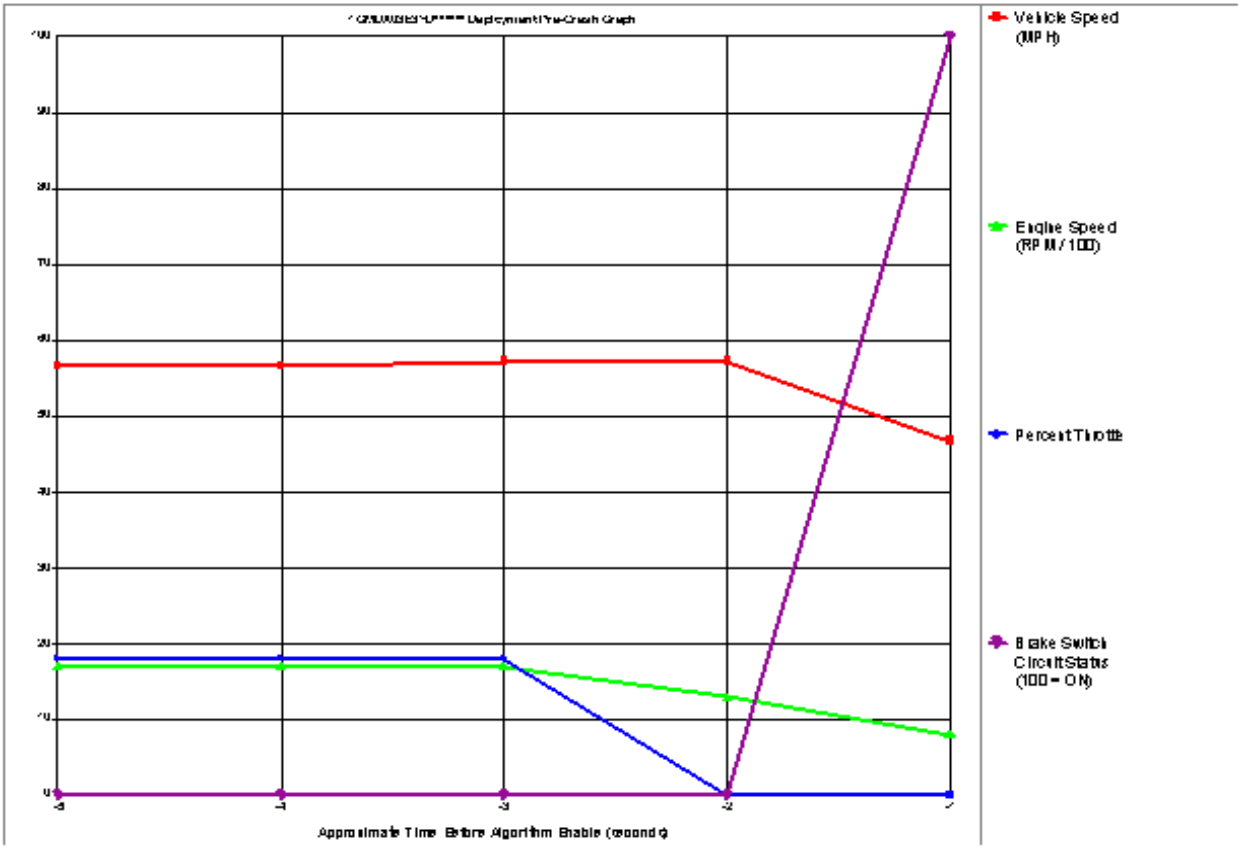
"N/A" is displayed in place of the time.
-If power to the SDM is lost during a crash event, all or part of the crash record may not be recorded.
-If the vehicle is a 2000 - 2002 Chevrolet Cavalier Z24 or a Pontiac Sunfire GT, with a manual transmission (RPO MM5) and a 2.4L engine (RPO LD9), the Brake Switch Circuit Status data will be reported in the opposite state than what actually occurred, e.g. an actual brake switch status of "ON" will be reported as "OFF".

SDM Data Source:
All SDM recorded data is measured, calculated, and stored internally, except for the following:
-Vehicle Speed, Engine Speed, and Percent Throttle data are transmitted once a second by the Powertrain Control Module (PCM), via the vehicle's communication network, to the SDM.
-Brake Switch Circuit Status data is transmitted once a second by either the ABS module or the PCM, via the vehicle's communication network, to the SDM.
-The SDM may obtain Belt Switch Circuit Status data a number of different ways, depending on the vehicle architecture. Some switches are wired directly to the SDM, while others may obtain the data from various vehicle control modules, via the vehicle's communication network.
-The Passenger Front Air Bag Suppression Switch Circuit is wired directly to the SDM.

Figure 17: Case vehicle's SDM Data Limitations continued

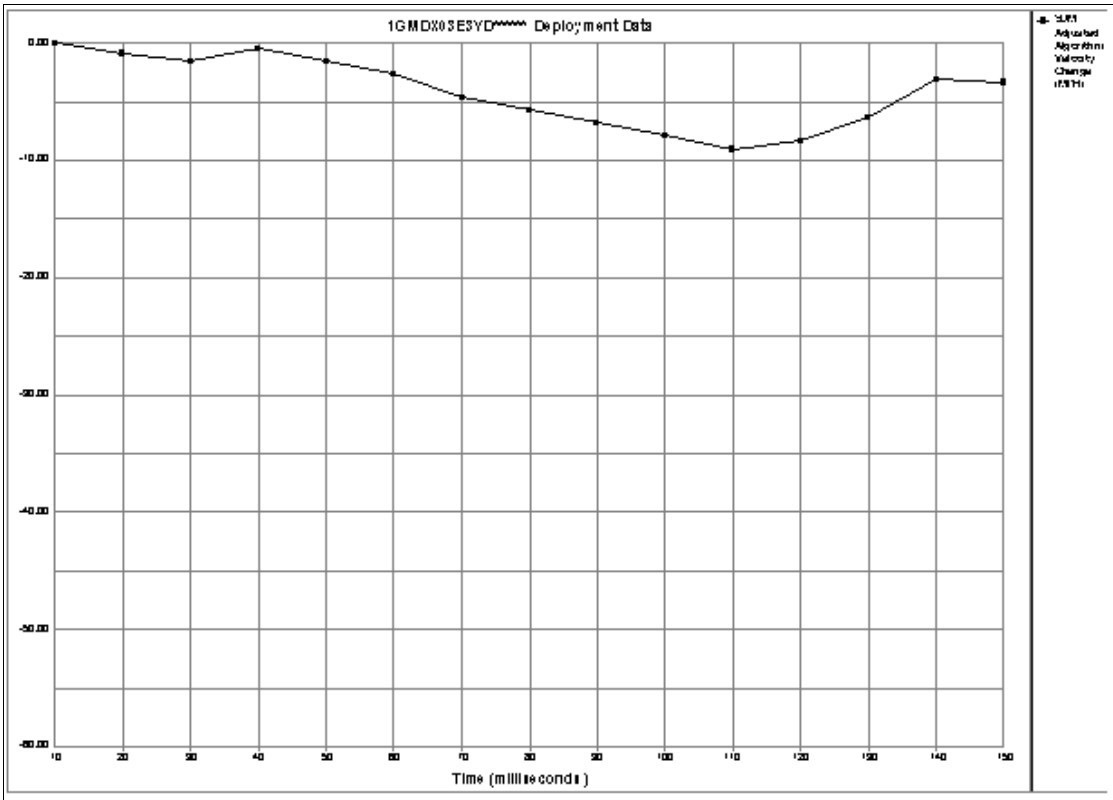
System Status At Deployment

SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	BUCKLED
Passenger Front Air Bag Suppression Switch Circuit Status	Air Bag Not Suppressed
Ignition Cycles At Deployment	24174
Time Between Non-Deployment And Deployment Events (sec)	N/A



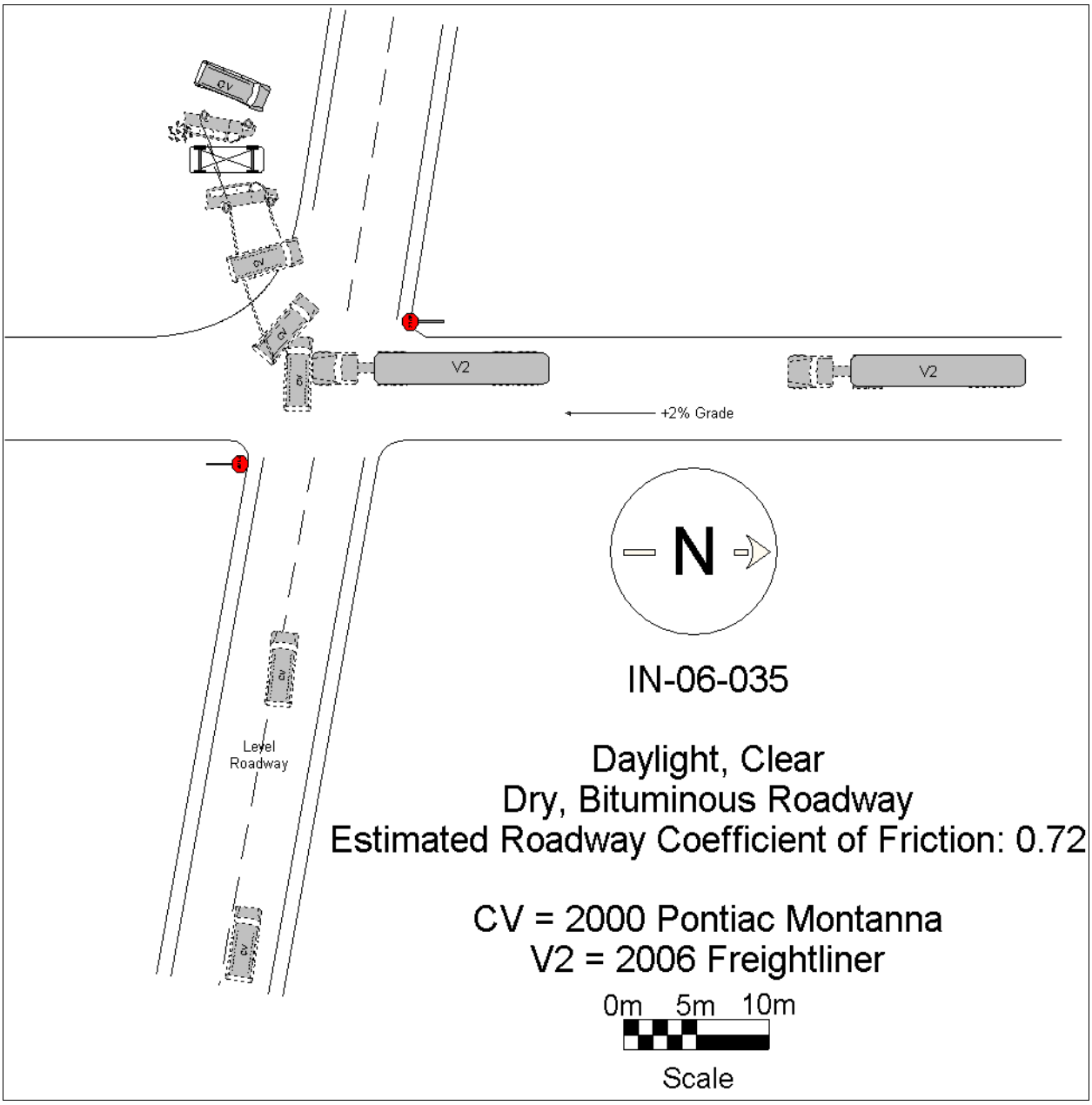
Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status
-5	57	1664	18	OFF
-4	57	1728	18	OFF
-3	57	1728	18	OFF
-2	57	1344	0	OFF
-1	47	832	0	ON

Figure 18: Case vehicle's System Status at Deployment report



Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Adjusted Algorithm Velocity Change	0.00	-0.88	-1.54	-0.44	-1.54	-2.64	-4.61	-5.71	-6.81	-7.90	-9.00	-8.34	-6.37	-3.08	-3.30

Figure 19: Case vehicle's deployment Algorithm Adjusted Velocity Change graph


CV
CV
CV
CV
V2
V2
+2% Grade
N
IN-06-035
Level
Roadway
Daylight, Clear
Dry, Bituminous Roadway
Estimated Roadway Coefficient of Friction: 0.72
CV = 2000 Pontiac Montanna
V2 = 2006 Freightliner
0m 5m 10m
Scale