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ON-SITE CHILD SAFETY SEAT INVESTIGATION

CASE NUMBER - IN07033
LOCATION - ILLINOIS
VEHICLE - 1999 PONTIAC GRAND AM SE
CRASH DATE - October 2007

Submitted:

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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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16. <i>Abstract</i> The focus of this case was on a child passenger who was seated within a forward-facing child safety seat that was in the second row right position of a 1999 Pontiac Grand Am SE. This report covers an on-site investigation of a roadway departure crash that involved the Pontiac. The driver lost control and departed the right-hand side of the roadway in a clockwise yaw. The Pontiac's left front wheel impacted a culvert, shearing the wheel off. The Pontiac overturned, both rolling and flipping, before come to rest on its wheels along the right roadside. The second row right passenger (3-year-old, male) was seated in his Cosco/Dorel Eddie Bauer High Back Booster child safety seat. He was restrained by his child seat's 5-point internal harness system, and the child seat was secured by the lap-and-shoulder, safety belt system. The Pontiac's driver (23-year-old, female) was seated and restrained by her lap-and-shoulder, safety belt system. The driver sustained a minor cervical strain, and the child did not sustain any injuries as a result of this crash.					
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This crash was brought to National Highway Traffic Safety Administration's attention on October 17, 2007 by an article in an Illinois newspaper. This crash involved a 1999 Pontiac Grand Am SE that departed the roadway, impacted a fixed object, and overturned. The crash occurred in October 2007, at 18:59, in Illinois and was investigated by the applicable county sheriff department. This crash is of special interest because the Pontiac's second row right passenger was restrained in a child safety seat. This contractor inspected the scene and vehicle on October 18, 2007, and also downloaded the data from the onboard Event Data Recorder. This contractor also interviewed the driver on October 18, 2007. This report is based on the Police Crash Report, an interview with the Pontiac's driver, scene and vehicle inspections, occupant kinematic principles, and this contractor's evaluation of the evidence.

CRASH CIRCUMSTANCES

Crash Environment: The trafficway on which the Pontiac was traveling was a 2-lane, undivided, county roadway, traversing in a north-south direction. The north-south roadway had 1 through lane in each direction. There was a slight hill crest well before the crash area where the trafficway also curved slightly to the left for southbound traffic before straightening (**Figure 1**). At the crash area, there was a residential street that connected to the aforementioned trafficway at a 90 degree angle (**Figure 2**). The county road was straight and had a 3.2% grade negative to the south at the area of initial impact (i.e., a downgrade in the Pontiac's direction of travel). The pavement was a traveled bituminous surface, and the width of both the north and southbound lanes was 3.5 meters (11.5 feet). The shoulders were improved (bituminous), with a 0.3 meter (1.0 foot) wide paved shoulder adjacent to both the east and west sides of the roadway. Grassy areas were adjacent to the paved shoulders and specifically on the western roadside there was a grassy drainage ditch which was 1.0 meter (3.3 feet) deep relative to the roadway. In the immediate area of the crash, pavement markings consisted of a single broken yellow centerline for both north and southbound traffic, augmented by a single solid yellow no passing line for northbound traffic. In addition, solid white edge lines were present. There were no visible traffic controls in the immediate area of the crash. No regulatory speed limit sign was posted near the crash site. At the time of the crash the light



Figure 1: Pontiac's southbound travel path in slight left-hand curve; Pontiac drifted onto right shoulder before driver oversteered leftward, returning vehicle to roadway

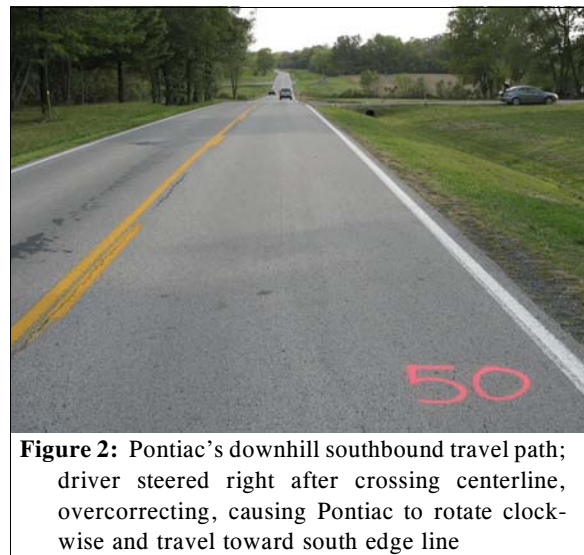


Figure 2: Pontiac's downhill southbound travel path; driver steered right after crossing centerline, overcorrecting, causing Pontiac to rotate clockwise and travel toward south edge line

condition was daylight, the atmospheric condition was clear, and the roadway pavement was dry. There was no other traffic present, and the site of the crash was rural residential. See the Crash Diagram at the end of this report.

Pre-Crash: According to the Police Crash Report and the Pontiac’s driver, the Pontiac was traveling south in the southbound through lane and the driver intended to continue straight ahead. According to the driver, she swerved slightly to the right and lost control of the vehicle. In this contractor’s experience it is more likely that the Pontiac’s driver simply allowed the vehicle to drift off the right (west) side of the roadway in the left-hand curve and onto the gravel, grass portion of the shoulder. The Pontiac’s driver steered leftward, and the vehicle reentered the roadway and traveled into the northbound lane (**Figure 1**). The Pontiac’s driver then steered back to the right, attempting to regain control (**Figure 2**). As a result, the Pontiac departed the right (western) side of the roadway in an approximate 80 degree clockwise yaw (**Figures 3 through 6**). The driver probably steered and braked, attempting to avoid the crash; however, the driver does not recall her exact maneuvers. The crash occurred on the western roadside of the trafficway. Based on available information, the Pontiac’s speed prior to crash is unknown; although, the driver stated she was traveling approximately 64-72 km/h (40-45 mph).



Figure 3: Pontiac’s travel path off roadway toward culvert while rotated approximately 80 degrees clockwise



Figure 4: Pontiac’s travel path on south roadside toward culvert; scuff mark on south edge line from left front tire; arrow marks path of right front tire; highlighted area shows rear tire marks



Figure 5: Convergent trajectories of Pontiac’s front tires on south roadside approaching culvert; right lines mark right front tire while left lines mark left front tire

Crash: As the Pontiac rotated clockwise and departed onto the right roadside, the left front wheel impacted a culvert (**Figure 7**), shearing it off (**Figure 8**). The Pontiac traveled airborne over the

connecting county road and began to roll leftward about its longitudinal axis while simultaneously continuing to rotate clockwise. No evidence of contact from the Pontiac was found on the intersecting county road or on either the street sign or stop sign posts or signs. After clearing the connecting roadway, the Pontiac's left side impacted and damaged a realty sign. Next, the Pontiac impacted the drainage ditch (**Figure 9**), initially along the Pontiac's left fender, A-pillar, and side (**Figure 8**). The vehicle inspection showed that the Pontiac's left fender and hood were crushed inward from a lateral force along these areas (**Figure 10**).



Figure 6: Convergent trajectories of Pontiac's rear tires near south edge line as it travels off road toward impact with culvert; front lines indicate right rear tire, rear lines indicate left rear tire



Figure 7: Pontiac's left front wheel impacts near culvert shearing wheel from vehicle and initiating vehicle's roll over

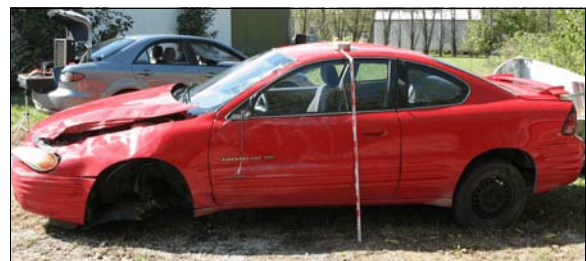


Figure 8: Pontiac's left side damage and sheared left front wheel



Figure 9: Pontiac's rollover touchdown location, south of intersecting roadway and west of Pontiac's roadway; left fender was initial impact point

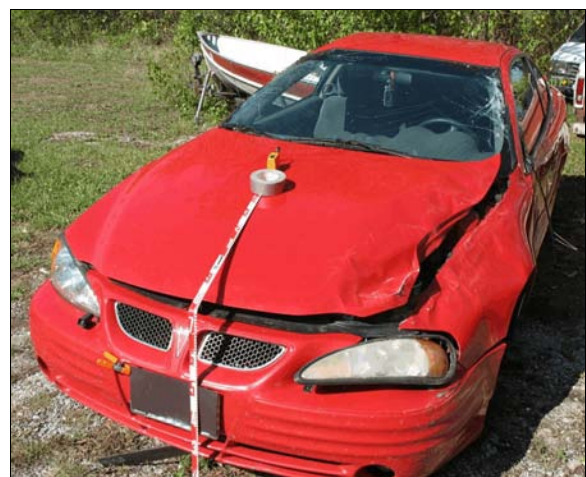


Figure 10: Elevated view of Pontiac's rollover damage showing lateral crush to top of left fender and left side of hood

The physical evidence indicated that the Pontiac's touchdown began approximately 4 meters (13 feet) south of the south edge of the intersecting roadway and 6 meters (20 feet) west of the main roadway (**Figure 9**). The Pontiac continued to roll about its longitudinal axis with the

Pontiac's right front wheel, A-pillar, and roof side rail contacting the drainage area (**Figure 11**). At the same time, the Pontiac continued to rotate clockwise in its upside-down position such that the vehicle was facing in a northwesterly direction. This contractor deduced that the Pontiac rebounded (i.e., bounced) from the drainage ditch, pivoting about its back right corner, and flipped in an end-over-end fashion (rotated counterclockwise about its lateral axis) along its southward travel path. According to the investigating police officer and the Pontiac's driver, the Pontiac came to rest on its wheels along the ditch line on the west side of the roadway, heading in a southerly direction. The Pontiac rolled and flipped a total of 4 quarter turns. The distance between the trip point and the estimated final rest position was 33 meters (108 feet). There was no physical evidence supporting the exact final rest location.



Figure 11: Pontiac's right side damage from impact with drainage ditch including damage to right front wheel, right A-pillar, and roof side rail

Post-Crash: The driver of the Pontiac remained inside the vehicle at final rest. She was conscious and able to exit the vehicle without any assistance. The second row right passenger also remained inside the vehicle within his child safety seat at final rest. He was conscious and able to exit the vehicle with some assistance. The investigating police agency was notified of the crash within 1 minute post-crash and responded to the scene. Traffic control procedures were established and towing services were called to assist. The driver refused emergency medical treatment for herself and her child and, according to her interview, did not seek any medical treatment for herself or her child later. Following the police investigation, the Pontiac was towed from the scene.

CASE VEHICLE

The 1999 Pontiac Grand Am SE was a front wheel drive, 5-passenger, 2-door coupe (VIN: 1G2NE12TXXM-----) equipped with a 2.4L, L-4 engine and a 4-speed automatic transmission and Advanced Occupant Protection System features including redesigned air bags and traction control. Braking was achieved by a power-assisted, front disc and rear drum, 4-wheel, anti-lock system. Inspection of the vehicle's interior revealed adjustable front bucket seats with folding backs and adjustable head restraints and a non-adjustable second row bench seat with integral head restraints for the outboard seating positions. The Pontiac's wheelbase was 272 centimeters (107.0 inches), and the odometer reading at inspection was unknown because the vehicle was equipped with an electronic odometer. The Pontiac was also equipped with an Event Data Recorder (EDR).

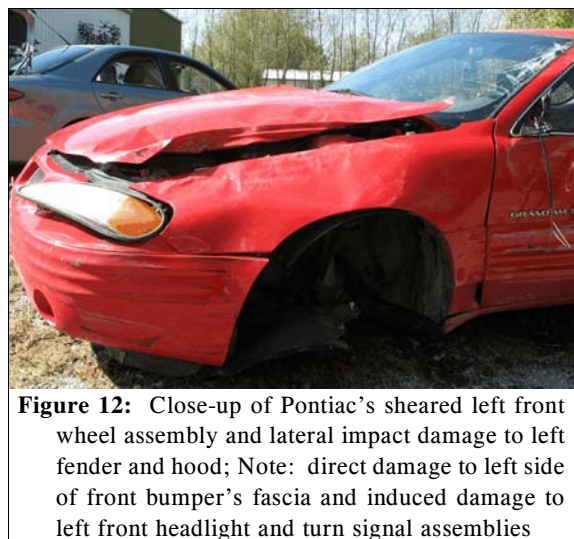


Figure 12: Close-up of Pontiac's sheared left front wheel assembly and lateral impact damage to left fender and hood; Note: direct damage to left side of front bumper's fascia and induced damage to left front headlight and turn signal assemblies

Exterior Damage: The Pontiac’s contact with the culvert involved the left front wheel which was sheared off the axle and was unavailable for inspection (**Figure 12**). The Pontiac’s damage from the rollover involved the right and left sides, as well as the hood and roof. The direct damage on the left side began at the front end of the fender (**Figure 12**) and ran longitudinally to the top of the left A-pillar and midpoint of the driver’s door (**Figure 13**). The direct damage on the right side began at the right front wheel which was positively cambered, approximately 30 degrees (**Figure 14**). The damage continued at the base of the right A-pillar and at the front of the door and ran longitudinally along the door, A-Pillar, and roof rail, ending at the back end of the roof rail (**Figure 15**). The maximum vertical and lateral crush was located 81 centimeters (32 inches) forward of the right rear axle, at the roof rail, directly over the right B-pillar (**Figure 16**). The maximum vertical crush was measured as 2 centimeters (0.8 inch), and the maximum lateral crush was measured as 5.5 centimeters (2.2 inches).



Figure 13: Direct damage to Pontiac’s left side view mirror, left A-pillar and windshield’s glazing, and contact along mid-door level



Figure 14: Direct damage to Pontiac’s right front wheel assembly during rollover



Figure 15: Direct damage to Pontiac’s right side view mirror, A-pillar, windshield’s glazing, roof, and roof side rail; Note: grass in right A-pillar



Figure 16: Pontiac’s maximum vertical and lateral crush on right roof rail just above right B-pillar

The wheelbase on the Pontiac’s left side was shortened 1 centimeter (0.4 inches) while the right side was shortened 2 centimeters (0.8 inches). The Pontiac’s left front wheel, fender, A-

pillar, door, windshield’s glazing, and bumper fascia were directly damaged with minimal crush. The Pontiac’s right front wheel, door, A-pillar, windshield’s glazing, and side rail were all directly damaged, also with minimal crush. There was induced damage to the left headlight and turn signal assemblies as well as the hood and right roof. Furthermore, the windshield glazing on both left and right sides sustained induced cracking from impact forces, and the right front window glazing was disintegrated. In addition, the right front door was jammed shut (**Figure 11**), and back left bumper fascia was cracked from the impact forces on the left rear side of the vehicle (**Figure 17**). There was no obvious induced damage or remote buckling noted to the remainder of the Pontiac’s exterior.



Figure 17: Induced damage to Pontiac’s back left bumper fascia, most likely from impact along left rear side

The Pontiac manufacturer’s recommended tire size was P215/60R15, and the Pontiac’s tires were the recommended size. The tire data are shown in the table below.

Tire	Measured Pressure		Vehicle Manufacturer’s Recommended Pressure		Tread Depth		Damage	Restricted	Deflated
	kPa	psi	kPa	psi	milli-meters	32 nd of an inch			
LF	Unk	Unk	Unk	Unk	Unk	Unk	Missing, unknown	Unknown	Unknown
LR	Flat	Flat	303	44	6	8	None, nearly deflated	No	No
RR	200	29	303	44	7	9	None	No	No
RF	Flat	Flat	303	44	3	4	None	No	Yes

Interior Damage: Inspection of the Pontiac’s interior revealed that there was no evidence of occupant contact on the vehicle’s interior surfaces (**Figures 18, 19, and 20**). There was intrusion in the front right passenger area (**Figure 21**). Specifically, the right roof side rail intruded 3 centimeters (1.2 inches) laterally and 1 centimeter (0.4 inches) vertically. There was no evidence of compression of the energy absorbing shear capsules in the base of the steering column and no deformation of the steering wheel rim.

Damage Classification: The CDCs for the Pontiac were determined to be: **09-LFWN-1** (280 degrees) for the left front wheel impact and **00-TYDO-2** for the rollover damage. No

WinSMASH reconstruction program was computed for this crash because wheel impacts and rollovers are out-of-scope for the reconstruction program. The crash severity to the Pontiac was estimated to be moderate [24-40 km/h (15 to 25 mph)] for the wheel impact and minor [2-13 km/h (1-8 mph)] for the rollover impact.



Figure 18: Pontiac's driver seating area showing no evidence of occupant contact to steering wheel, left and middle instrument panels, and greenhouse area; Note: non-deployed driver air bag



Figure 19: Pontiac's front right seating area showing no evidence of occupant contact to middle and right instrument panel areas and greenhouse area; Note: non-deployed front right air bag



Figure 20: Pontiac's back right passenger seating area showing no evidence of occupant contact



Figure 21: Pontiac's front seating area; intrusions were noted along right roof side rail

MANUAL RESTRAINT SYSTEM

The Pontiac's manual restraint systems are shown in the table below.

	Left	Center	Right
First Row	Continuous loop, lap-and-shoulder, safety belt system without adjustable upper anchorage for the D-ring; light weight locking type latch plate with ELR		Continuous loop, lap-and-shoulder, safety belt system without adjustable upper anchorage for the D-ring; light weight locking type latch plate with ELR

	Left	Center	Right
Second Row	Continuous loop, lap-and-shoulder, safety belt system without upper anchorage adjustor for the D-ring; light weight locking type latch plate with ELR	Lap safety belt system; locking type latch plate with no retractor	Continuous loop, lap-and-shoulder, safety belt system without upper anchorage adjustor for the D-ring; light weight locking type latch plate with ELR
ELR = Emergency Locking Retractor Switchable = either ALR = Automatic Locking Retractor			

Both front and all three second row seat belts exhibited indications of historical usage. The inspection of the driver’s safety belt webbing, D-ring, shoulder belt guide, and latch plate showed no evidence of loading. The inspection of the second row right passenger’s safety belt webbing, shoulder belt guide, and latch plate showed the webbing was pinched in the latch plate, but there were no scuffs or burn marks on the webbing, only slight webbing deformation (**Figure 22**).

AUTOMATIC RESTRAINT SYSTEM

The Pontiac was equipped with a Supplemental Restraint System (SRS) that consisted of redesigned frontal air bags at the driver and front right passenger positions. The driver’s air bag was located in the steering wheel hub (**Figure 18**). The front right passenger’s air bag was located in the top of the instrument panel (**Figure 19**). Neither redesigned air bag deployed during the crash.

CHILD SAFETY SEAT

The second row right passenger was seated in a booster/forward-facing child safety seat (BSS/FSS) that was used in its forward-facing configuration (**Figure 23**). The FSS was manufactured by Cosco/Dorel on December 20, 2002. The child seat was identified by model name Eddie Bauer High Back Booster and model number **22 870 BLT**. The FSS was designed with a five-point harness which attached between the child’s legs into a buckle which was sewn to a piece of webbing at the bottom of the seat. The FSS was equipped with a top tether (**Figure 24**), and there were two slots to thread the harness through. At the time of the crash, the harness belts were threaded through the top slots. The FSS was in the upright position.



Figure 22: Pontiac’s second row right safety belt showing slight pinching in latch plate but no clear evidence of stress or loading on webbing; Note: wear pattern on seat’s cushion from child seat’s presence



Figure 23: Pontiac's forward-facing child safety seat used by second row right passenger



Figure 24: Pontiac's forward-facing CSS used by second row right passenger showing top tether clip which was not used in crash

The CSS consisted of a plastic one-piece shell. The driver indicated that she had placed the child in the seat and buckled the safety belt through the forward-facing slots prior to the crash. The driver did not recall doing anything specific to make sure that the safety belts were tight. In addition, the CSS harness retainer clip was used and positioned about the chest/armpit level.

An inspection of the CSS revealed no apparent fractures to the seat's shell, but there were semicircular stress marks (possibly indicating buckling of the plastic) on the seat's left side (**Figure 25**) about shoulder level and at the top of the CSS (**Figure 26**). In addition, no damage or fractures were noted along the seat's belt path (**Figure 24**). The inspection of the CSS's harness revealed no evidence of loading.

The CSS, when used in the forward-facing configuration, was designed for use by children with weight and height limitations of approximately 10.0 - 18.1 kilograms and 74-102 centimeters (22-40 pounds, 29-40 inches) for the forward-facing configuration. When used as a booster seat the weight and height limitations were approximately 13.6 - 36.3 kilograms and up to 132 centimeters (30-80 pounds, up to 52 inches).

The data downloaded from the Pontiac's EDR reported the vehicle's SIR warning lamp status, driver's seat belt switch circuit status, ignition cycles at non-deployment, time from algorithm enable to maximum SDM (Sensing and Diagnostic Module) recorded velocity change, and the vehicle's velocity change (Delta V). Downloaded data of interest indicated the following. The driver's seat belt switch circuit was recorded as not buckled, and the Delta V reached a value of -8.84 km/h (-5.49 mph) at the 80 millisecond mark of recorded data. See **EVENT DATA RECORDER DATA (Figures 27 and 28)** at the end of this report.

CASE VEHICLE KINEMATICS—OVERVIEW

The Pontiac's driver steered left and right and most likely braked during the crash sequence, attempting to avoid the crash, but she does not recall her exact maneuvers. Based on this contractor's experience, the driver probably steered leftward to reenter the roadway and then rightward, attempting to correct her initial oversteer. The driver probably braked when the vehicle traveled off the roadway. As a result of these attempted avoidance maneuvers and the use of their available safety belts, both vehicle occupants probably moved side-to-side and slightly forward just prior to the vehicle's impact with the culvert. The Pontiac's primary impact with the culvert enabled the vehicle's occupants to continue slightly leftward, forward, and upward along a path opposite the 280 degree Direction of Principal Force as the vehicle decelerated. During the Pontiac's combination rollover and flip over, the occupants were certainly tossed about (i.e., displaced in multiple directions) within (loading) their applicable restraints.

DRIVER KINEMATICS

The Pontiac's driver {mother of child [23-year-old, female; 168 centimeters and 52 kilograms (66 inches, 115 pounds)]} was seated in an upright posture with her back against the



Figure 25: Semicircular stress mark on left side/in-board side of CSS used by Pontiac's second row right passenger



Figure 26: Semicircular stress marks across top of CSS used by Pontiac's second row right passenger

seat back, her left foot on the floor, her right foot on the brake, and both hands on the steering wheel at the 9 o'clock and 3 o'clock positions. Her seat track was located between its middle and forward-most positions, the seat back was upright, and the tilt steering wheel was located between its center and upmost positions.

According to the Police Crash Report and the interview with Pontiac's driver, she was restrained by her safety belt system. However, this conclusion was not supported by the EDR data. In addition, there was no mention by the driver of belt pattern bruising and/or abrasions to the driver's torso. Although it is unknown exactly why the EDR data reported the belt as unbuckled, it is known that General Motors buckle circuits of this era were hardwired to the SDM and instances of wire breakage have been documented which could leave Unbuckled as the default data record in the EDR. The conclusion that the driver was using her safety belts is based on the absence of occupant contacts observed in the vehicle's interior and the lack of significant injuries to the driver, given the moderate and prolonged severity of the crash.

As a result of the impact with the culvert, the driver loaded both the lap and torso portions of her safety belt and her head probably hyper-flexed (bent forward) because her trunk was restrained by her safety belts. During the Pontiac's overturn, the driver was certainly tossed about loading her safety belts. Her restraints limited her movements and prevented her from sustaining any significant injuries. Her exact position at final rest is unknown.

DRIVER INJURIES

According to her interview, she sustained a minor injuries which included swelling above her left eye and a cervical strain.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source	Source Confidence	Source of Injury Data
1	Strain, acute cervical, not further specified	minor 640278.1,6	Noncontact injury: impact forces	Probable	Interviewee (same person)

SECOND ROW RIGHT PASSENGER KINEMATICS

Immediately prior to the crash, the Pontiac's second row right passenger [3-year-old, male; 86-91 centimeters and 15 kilograms (34-36 inches, 33 pounds)] was seated with his back against the back of his FSS. The seat was position against the back cushion of second row seat. His feet were dangling over the front edge of the child seat's cushion, angled downward, and his hands were holding a blanket. The second row right seat had no seat track, and the seat back was not adjustable.

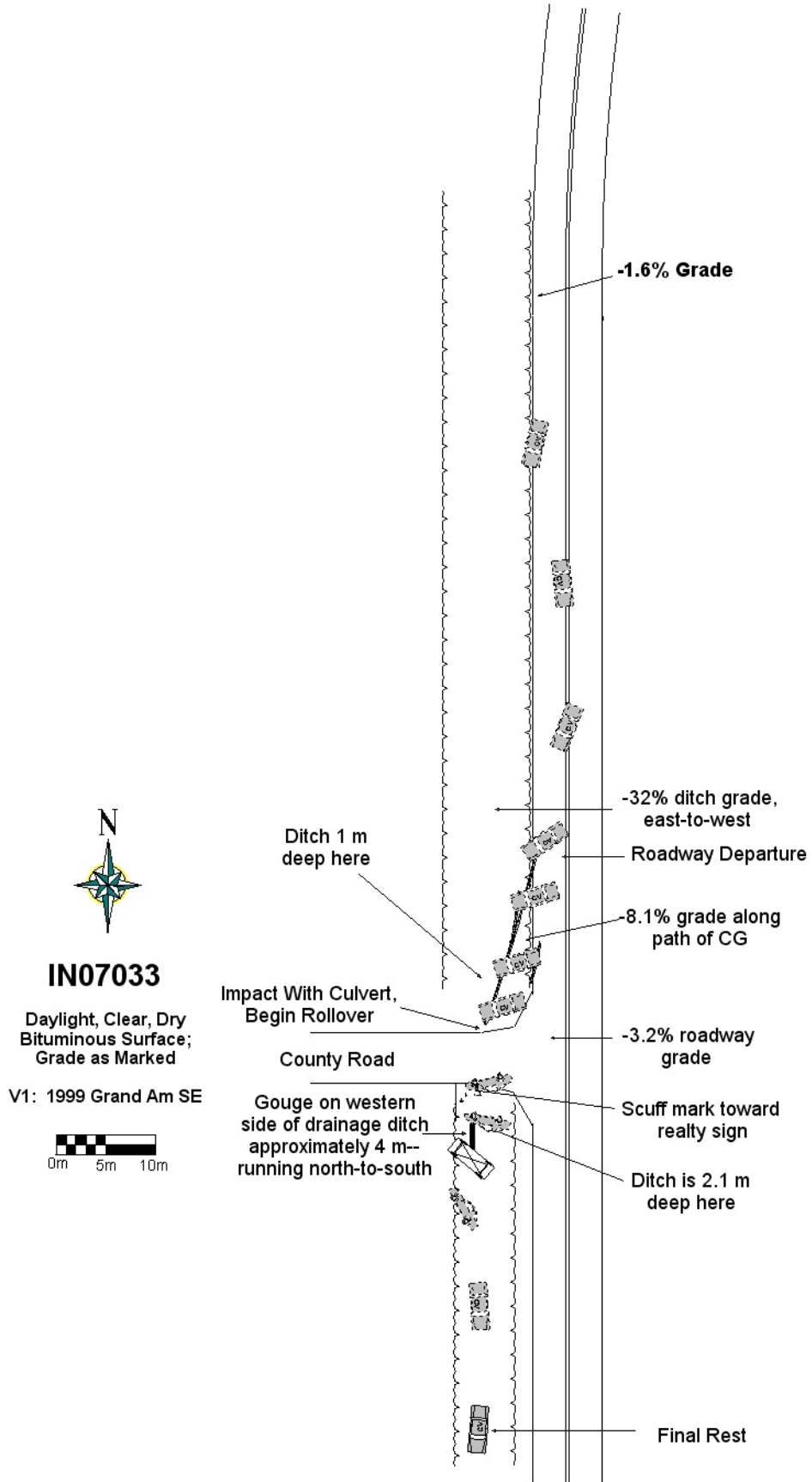
Based on the vehicle inspection, the Pontiac's second row right passenger (son) was restrained by his child seat's five-point harness (**Figures 23**) and the child seat was secured through the seat's forward-facing slots by the lap-and-shoulder, safety belt system. There was no

mention by the driver during her interview of harness belt pattern bruising and/or abrasions to this passenger's torso.

As a result of the culvert impact, the second row right passenger loaded his CSS's harness straps which enabled the child to remain in the CSS and prevented him from sustaining any injuries. In addition, the top portion of the seat probably tipped forward, primarily, trying to rotate about the vehicle's safety belts which were securing the child seat. This tipping occurred because the CSS was not secured by its available tether strap (no tether anchor was available). This tipping has been noted by this contractor when observing video of child seat crash tests. During the Pontiac's combination rollover and flip over, this passenger was certainly tossed about within his CSS, loading the seat's harness straps. The seat's harness straps limited his movements and prevented him from sustaining any injuries. At final rest, the child remained restrained in his CSS.

SECOND ROW RIGHT PASSENGER INJURIES

The second row right occupant was not transported by ambulance to the hospital, and he did not sustain any injuries as a result of this crash.



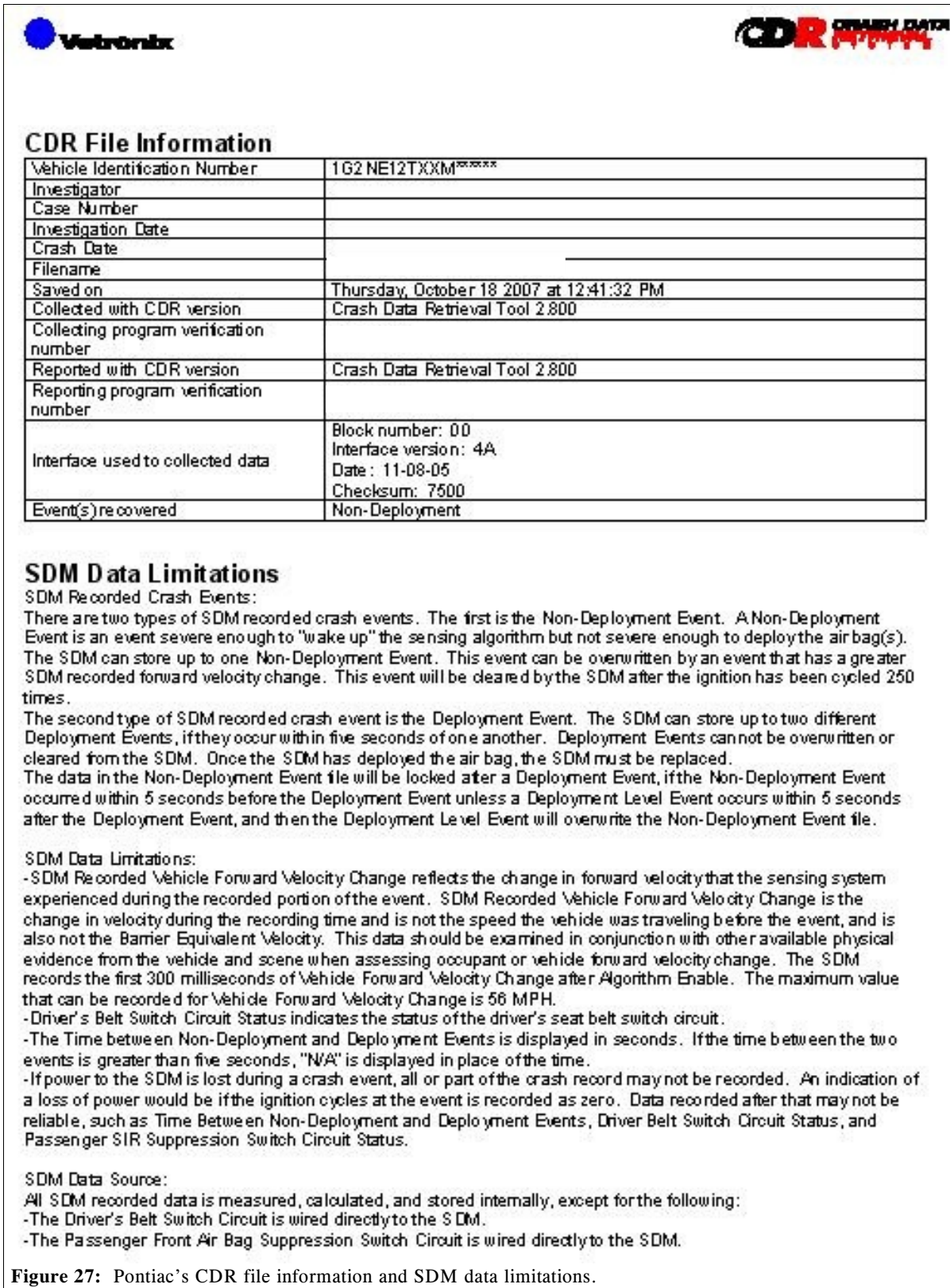


Figure 27: Pontiac's CDR file information and SDM data limitations.



System Status At Non-Deployment

SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	UNBUCKLED
Passenger Front Air Bag Suppression Switch Circuit Status	Air Bag Not Suppressed
Ignition Cycles At Non-Deployment	18819
Ignition Cycles At Investigation	18820
Algorithm Enable to Maximum SDM Recorded Velocity Change (in sec)	71.25
Maximum SDM Recorded Velocity Change (MPH)	-5.49
A Deployment was Commanded Prior to this Event	No



Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Recorded Velocity Change (MPH)	-0.66	-1.76	-3.07	-3.95	-4.83	-5.05	-5.27	-5.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time (milliseconds)	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
Recorded Velocity Change (MPH)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Figure 28: Pontiac's System Status At Non-Deployment report. The Pontiac sustained an SDM recorded velocity change of approximately -8.8 km/h (-5.5 mph) during the first 80 milliseconds after the algorithm was enabled; maximum velocity change was recorded as -8.84 km/h (-5.49 mph) at 71.25 milliseconds.