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ON-SITE CERTIFIED ADVANCED 208-COMPLIANT VEHICLE INVESTIGATION

CASE NUMBER - IN08010
LOCATION - TEXAS
VEHICLE - 2007 CHEVROLET SILVERADO C1500 CREW CAB
CRASH DATE - February 2008

Submitted:

February 2, 2009

Contract Number: DTNH22-07-C-00044

Prepared for:

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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

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16. *Abstract* This report covers an on-site investigation of a crash that involved a 2007 Chevrolet Silverado C1500 Crew Cab pickup truck and a 2001 Bluebird school bus. The focus of this on-site investigation was the Chevrolet, which was certified by the manufacturer to be compliant to the Advanced Air Bag portion of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The Chevrolet was traveling northwest on a rural roadway approaching a 4-leg intersection. The Bluebird entered the intersection from a stop sign and proceeded northeast, and the front of the Chevrolet impacted its right side plane. Both vehicles were redirected to the north and the Bluebird rolled over one quarter turn onto its left side. The Chevrolet's 73-year-old driver was unrestrained and he sustained a fatal head injury due to loading the front header.			
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TABLE OF CONTENTS IN08010

Page No.

BACKGROUND 1

CRASH CIRCUMSTANCES 1

CASE VEHICLE: 2007 CHEVROLET SILVERADO C1500 CREW CAB 3
- CASE VEHICLE DAMAGE 3
- AUTOMATIC RESTRAINT SYSTEM 5
- EVENT DATA RECORDER 6
- MANUAL RESTRAINTS 6
- CASE VEHICLE DRIVER KINEMATICS 6
- CASE VEHICLE DRIVER INJURIES 7

OTHER VEHICLE, 2001 BLUEBIRD SCHOOL BUS 8

CRASH DIAGRAM 9

EVENT DATA RECORDER REPORT 10

This crash was brought to the National Highway Traffic Safety Administration's attention on February 14, 2008 by the sampling activities of the National Automotive Sampling System-General Estimates System. This on-site investigation was assigned on March 13, 2008. The crash involved a 2007 Chevrolet Silverado C1500 Crew Cab pickup truck (**Figure 1**) and a 2001 Bluebird school bus (on an International 3800 bus chassis). The crash occurred in February 2008 at 1610 hours, in Texas and was investigated by the Texas Department of Public Safety. The focus of this on-site investigation was the Chevrolet, which was certified by the manufacturer to be compliant to the Advanced Air Bag portion of Federal Motor Vehicle Safety Standard (FMVSS) No. 208, and the driver sustained a fatal head injury. This contractor inspected the Chevrolet, Bluebird, and crash scene on March 17, 2008. A hard copy of the Chevrolet's Event Data Recorder (EDR) report was obtained from the police on April 21, 2008. This report is based on the police crash report, police on-scene photographs, vehicle and crash scene inspections, the Chevrolet's EDR data, an exemplar Chevrolet inspection, occupant kinematic principles, and this contractor's evaluation of the evidence.

Figure 1: The damaged 2007 Chevrolet Silverado C1500 Crew Cab pickup truck

CRASH CIRCUMSTANCES

Crash Environment: The trafficway on which the Chevrolet was traveling was an undivided, county roadway, traversing in a northwest-southeast direction, and the Chevrolet was approaching a four-leg intersection. The roadway had one through lane in each direction and was bordered by bituminous shoulders. Each lane was 3.6 m (11.2 ft) in width and the shoulders were nominally 1.4 m (4.9 ft) in width. The roadway pavement markings consisted of solid white edge lines and a broken yellow centerline with reflectors located between the centerline strips. The trafficway on which the Bluebird was traveling was an undivided, county road traversing in a northeast-southwest direction and was controlled by a stop sign. The roadway had one lane in each direction and was bordered by bituminous shoulders, which were nominally 1.3 m (4.3 ft) in width. The northeast lane was 3.4 m (11.2 ft) in width and the southwest lane was 3.9 m (12.8 ft) in width. The pavement markings consisted of solid white edge lines, a solid yellow centerline for the northeast lane and a broken yellow centerline with reflectors for the northwest lane. The speed limit for the Chevrolet was 113 km/h (70 mph) and the speed limit for the Bluebird was 97 km/h (60 mph). At the time of the crash the light condition was daylight and the atmospheric condition was clear. The roadway pavement was dry bituminous and the grade was level for both vehicles. The traffic density was light and the site of the crash was rural/farming. See the Crash Diagram on page 9 of this report.

Pre-Crash: The Chevrolet's unrestrained 73-year-old male driver was traveling northwest (**Figure 2**) and the driver intended to continue straight through the intersection. The Chevrolet's EDR data indicated that the vehicle was traveling 151 km/h (94 mph) at 5 and 4 seconds prior to Algorithm Enable (AE). The brake switch circuit was recorded as on from 3 to 1 seconds prior to AE and the speed decreased to 100 km/h (62 mph) at 1 second prior to AE. The Bluebird was occupied by a restrained 53-year-old male driver and was initially stopped at the stop sign heading northeast (**Figure 3**). The driver told police that he did not see the approaching Chevrolet. He proceeded into the intersection and intended to continue northeast.

Figure 2: Chevrolet's approach to impact; number on pavement shows meters to impact area; arrow shows area where Bluebird was reportedly stopped prior to the crash

Figure 3: Approach of the Bluebired to the intersection; arrow shows approach of the Chevrolet

Crash: The front of the Chevrolet (**Figures 1** and **4**) impacted and underrode the Bluebird's right side, just behind its bi-fold door (event 1, **Figure 5**). The Chevrolet's direction of principal force was within the 11 o'clock sector and the impact force was sufficient to trigger a stage 2 deployment of the driver's frontal air bag. The Chevrolet's front right passenger air bag did not deploy because no front right passenger was present within the vehicle. The impact caused both vehicles to rotate clockwise and they were redirected to the north. The Chevrolet rotated clockwise approximately 20 degrees and came to final rest in the mouth of the northeast roadway heading north (**Figure 6**). The Bluebird rotated clockwise and rolled over one quarter turn onto its left side (event 2). It came to final rest on the northeast roadway heading northeast (**Figure 6**).

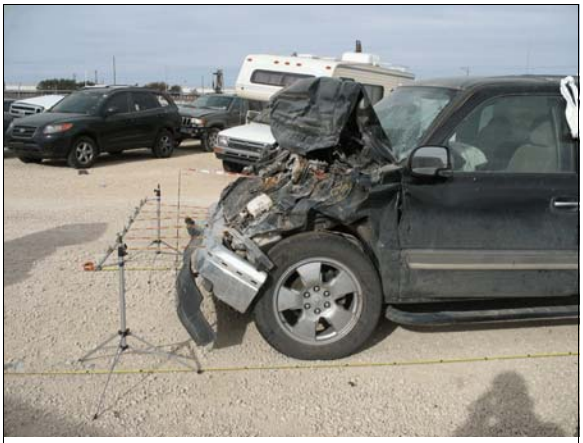


Figure 4: Profile of frontal damage measured at bumper level

Post-Crash: Emergency medical and rescue services were notified of the crash at 1615 hours and arrived on scene at 1633 hours. The police were notified of the crash at 1622 hours and arrived on scene at 1639 hours. The Chevrolet's driver was transported by ambulance to a hospital. The Bluebird's driver was not injured. Both vehicles were towed from the scene due to damage.

Case Vehicle: The 2007 Chevrolet Silverado was a rear wheel drive, four-door pickup truck (VIN: 2GCEC13V671------) equipped with a 4.8L, V-8 engine, an automatic transmission, and 4 wheel anti-lock brakes. The front row was equipped with a split bench seat with adjustable head restraints, driver and front right passenger lap-and-shoulder belts, a center lap belt, and dual stage driver and front right passenger air bags. The second row was equipped with a split bench seat with adjustable head restraints in the outboard seating positions, an integral head restraint in the center seating position, lap-and-shoulder belts, and Lower Anchors and Tethers for Children (LATCH) in the outboard seating positions. Side curtain air bags were an option for this vehicle, but it was not so equipped. The vehicle was equipped with an electronic odometer and the mileage could not be determined. The vehicle's specified wheelbase was 364 cm (143.3 in).

Figure 5: Damage to right side of Bluebird from impact with the Chevrolet

Figure 6: Police on-scene photo showing the Chevrolet and Bluebird at final rest

CASE VEHICLE DAMAGE

Exterior Damage: The Chevrolet's impact with the Bluebird involved the front plane. The bumper, grille, hood, headlamp/turn light assemblies, and fenders were all directly damaged. The direct damage began at the front left bumper corner and extended 164 cm (64.6 in) across the bumper. The crush measurements were taken at the bumper level and due to the underride, a second set of crush measurements were taken at the upper radiator support (**Figures 4** and **7**). The maximum residual crush at the bumper level was 45 cm (17.7 in) occurring at C_4. The maximum residual crush at the upper radiator support level was 71 cm (28 in) occurring at C_3. The table below shows the crush profile based on the average of the crush at the two levels.

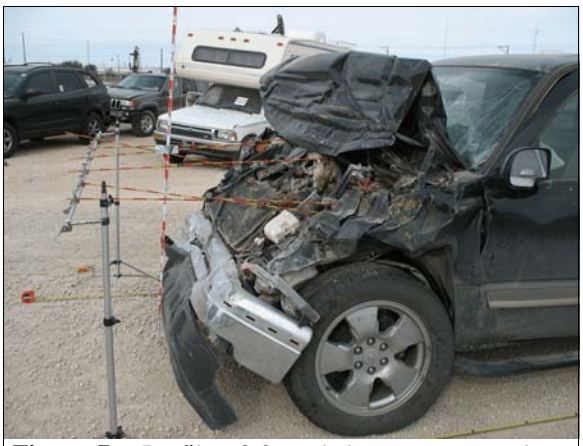


Figure 7: Profile of frontal damage measured at upper radiator support level

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	164	71	166	42	53	58	56	51	32	0	0
in		64.6	28.0	65.4	16.5	20.9	22.8	22.0	20.1	12.6	0.0	0.0

The Chevrolet's right side wheelbase was shortened 6.0 cm (2.4 in) and the left side wheelbase was shortened 7.0 cm (3.7 in). Induced damage involved both fenders, both front doors, and the windshield.

Damage Classification: The Chevrolet's Collision Deformation Classification (CDC) was **11-FDEW-3** (**340** degrees). The WinsSMASH program could not be used to reconstruct the Chevrolet's Delta V because an impact with a bus is out of scope for the program. However, the Barrier algorithm of the WinSMASH program was used to calculate a Barrier Equivalent Speed (BES) based on the Chevrolet's front crush profile, and the BES was 55.0 km/h (34.2 mph). The vehicle's EDR recorded a maximum longitudinal Delta V of -50.52 km/h (-31.39 mph).

The Chevrolet's recommended tire size was P275/55R70 and the vehicle was equipped with the recommended size tires. The Chevrolet'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	138	20	207	30	7	9	None	Yes	No
LR	97	14	207	30	4	5	None	No	No
RR	207	30	207	30	3	4	None	No	No
RF	207	30	207	30	7	9	None	Yes	No

Vehicle Interior: The inspection of the Chevrolet's interior revealed occupant contact to the steering wheel, driver's knee bolster, the driver's sunvisor swivel post, and the adjacent front header. The top half of the steering wheel rim was deformed forward 3 cm (1.2 in) and the energy absorbing steering column was compressed 3 cm (1.2 in) due to occupant loading (**Figure 8**). The steering column was also displaced upward an unknown amount (the pre-crash tilt position of the steering column could not be determined due to the damage) and to the left 2 cm (0.8 in). The driver's knee bolster was scuffed due to contact by the driver's knees. Hair was found in the sunvisor swivel post bracket (**Figure 9**) and the adjacent front header was scuffed due to contact by the driver's head. All the doors remained closed and operational during the crash

and all the window glazing was either closed or fixed. The windshield glazing was in place and cracked due to contact by the hood, which did not penetrate the windshield. The backlight was disintegrated due to contact by a large tool box in the bed of the truck.

The passenger compartment intrusion involved the left toe pan and windshield. The left toe pan intruded into the left sector 3 cm (1.2 in) while the windshield intruded into all three front sectors. The windshield intrusion was due to contact by the hood and the intrusion from left to right was 4 cm (1.6 in), 3 cm (1.2 in), and 2 cm (0.8 in), respectively.

Figure 8: Deformation of the steering wheel and compression of the steering column due to occupant loading

AUTOMATIC RESTRAINT SYSTEM

The Chevrolet was equipped with a Certified Advanced 208-Compliant (CAC) frontal air bag system that consisted of dual stage driver and front right passenger air bags, seat belt usage sensors, retractor-mounted pretensioners, and a front right passenger weight sensor and seat position sensor. The frontal air bag sensors were located on the left and right lower radiator supports. The manufacturer has certified that the vehicle is compliant to the Advanced Air Bag portion of the Federal Motor Vehicle Safety Standard (FMVSS) No. 208.

Figure 9: Hair embedded in the driver's sunvisor swivel post bracket and contact to the front header

The driver's air bag was located in the steering wheel hub. An inspection of the air bag module revealed that the cover flaps opened at the designated tear points (**Figure 10**). The cover flaps were constructed of vinyl and the tear seams were configured across the top, bottom and vertically down the middle. The module flaps were 15 cm (5.9 in) in width at the top, 10 cm (3.9 inches) in width at the bottom and 13 cm (5.1 in) in height at the vertical tear seam. The deployed air bag (**Figure 11**) was round with a diameter of 65 centimeters (25.6 inches), and two vent ports were located on the back of the air bag at the 11 and 1 clock positions. The damage to

Figure 10: Steering wheel damage and air bag flaps

the steering assembly indicated that the driver had loaded and ridden down the air bag during the crash, but there was no discernable evidence of occupant contact on the air bag material and no damage to the air bag.

The front right passenger air bag was located in the middle of the instrument panel. There was no front right passenger in the vehicle at the time of the crash and this air bag did not deploy.

Figure 11: The driver's deployed frontal air bag

EVENT DATA RECORDER

The Chevrolet's EDR had been removed from the vehicle by the police. A hard copy of the report was subsequently sent to this contractor and is presented on page 10 of this report. The police imaged the EDR data using version 3.0 of the Bosch Crash Data Retrieval tool. The EDR recorded a stage 2 deployment event. The data indicated that the SIR warning lamp was off and the driver's seat belt switch circuit was recorded as unbuckled. The first stage deployment criteria was met at 7.5 msec following AE, and the second stage deployment criteria was met at 17.5 msec following AE. The maximum recorded velocity change was recorded as -50.52 km\h (-31.39 mph) occurring 160 msec following AE. The pre-crash data is discussed in the Pre-Crash section on page 2 of this report.

MANUAL RESTRAINT SYSTEM

The Chevrolet was equipped with integral lap-and-shoulder belts in the driver and left front passenger seating positions and a lap belt in the center seat position. The second row was equipped with lap-and-shoulder belts in all three seating positions. The driver's seat belt consisted of continuous loop belt webbing, retractor-mounted pretensioner, sliding latch plate, and an Emergency Locking Retractor (ELR). The front right seat belt was similarly equipped but had a switchable ELR/Automatic Locking Retractor (ALR). The three second row seat belts consisted of continuous loop belt webbing, sliding latch plates, switchable ELR/ALRs, and fixed upper anchors.

Inspection of the driver's seat belt assembly revealed no evidence of usage. There was also no evidence that the pretensioner had actuated in the crash. The evidence indicated that the driver was not restrained at the time of the crash. The remaining seat positions were unoccupied.

CASE VEHICLE DRIVER KINEMATICS

The unbelted Chevrolet's driver [73-year-old, male; unknown height and weight] was seated in an unknown posture. At the time of inspection, the driver's seat track was adjusted to the full rear position and the seat back was slightly reclined. The steering wheel assembly was displaced

upward during the crash due to driver loading and it's original tilt position could not be determined.

Based on the EDR data, the driver was applying the brakes just prior to the impact. It is probable that he was also bracing for the impact with both hands on the steering wheel. The Chevrolet's impact with the Bluebird displaced the driver forward and his face and chest loaded the air bag and his knees loaded the knee bolster. He rode down the air bag and his chest and abdomen loaded the steering wheel (**Figure 8**), which resulted in medically reported blunt trauma to his chest and abdomen. The driver was also displaced upward and his head loaded the front header and sunvisor swivel post bracket (**Figure 9**), which caused a nonanatomic brain injury and a basilar skull fracture. The driver rebounded back into the seat following the impact and was subsequently removed from the vehicle through the left front door by rescue personnel.

CASE VEHICLE DRIVER INJURIES

The driver was pronounced deceased in the hospital emergency room 87 minutes following the crash. No autopsy was performed and no X-rays were taken of his head injury. 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	Nonanatomic brain injury with loss of consciousness, PEA, flaccid, unresponsive post extrication from vehicle, GCS=3, pupils non-reactive, fixed, and dilated	critical 160824.5,0	Front (windshield) header, driver's	Certain	Emergency room records
2	Fracture, basilar skull, with blood and clear fluid oozing from ears bilaterally	serious 150204.3,8	Front (windshield) header, driver's	Certain	Emergency room records
3	Trauma, blunt, chest, not further specified	unknown 415999.7,0	Steering wheel hub and/or spokes and rim	Certain	Emergency room records
4	Trauma, blunt, abdomen, not further specified	unknown 515999.7,0	Steering wheel hub and/or spokes and rim	Certain	Emergency room records
5	Laceration, 4 cm (1.6 in) over left eyebrow	minor 190602.1,7	Sun visor, driver's	Probable	Emergency room records
6	Abrasions {scrapes}, several, on arms, not further specified	minor 790202.1,3	Air bag, driver's	Probable	Emergency room records

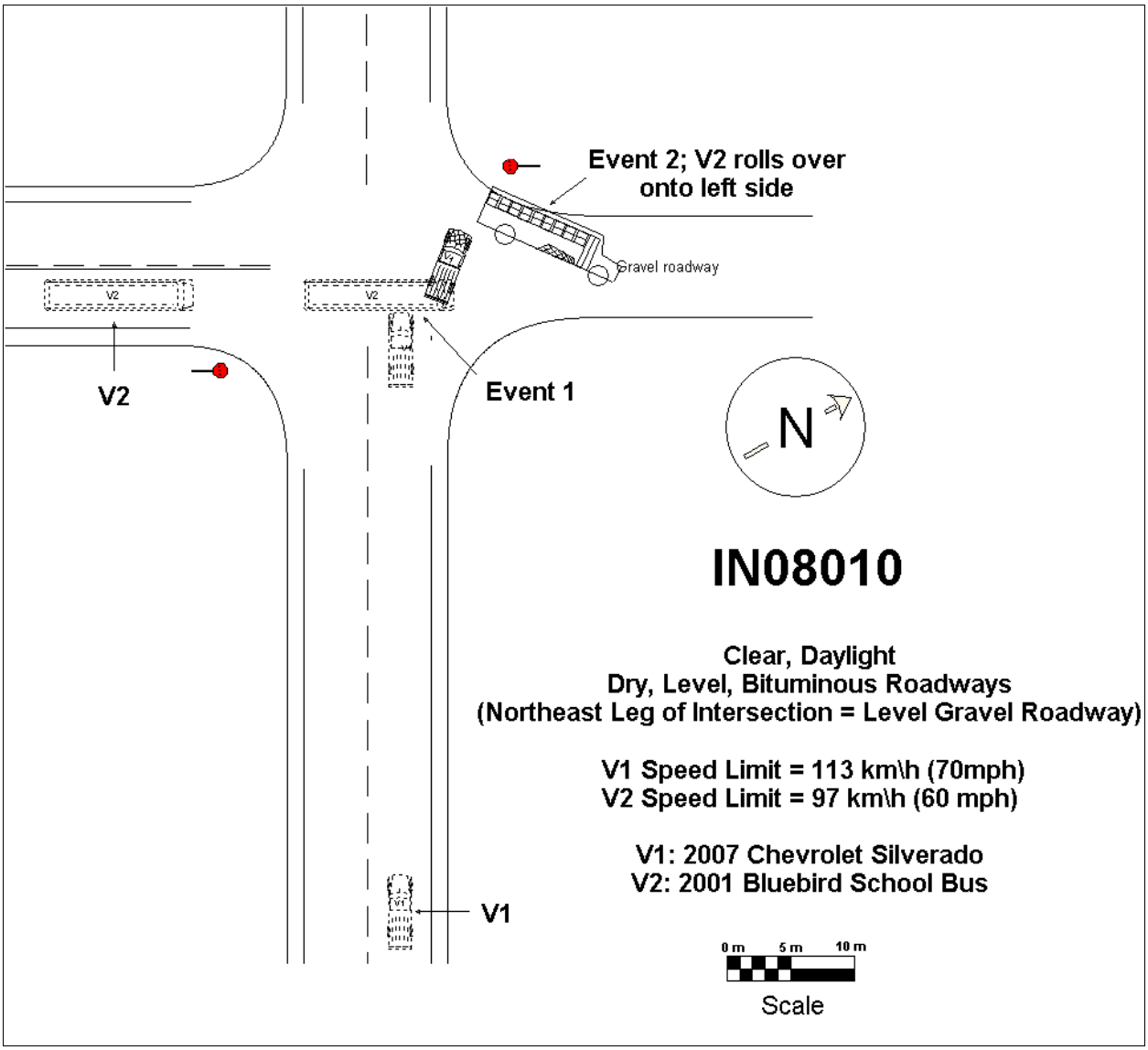
The 2001 Bluebird was a rear wheel drive, conventional school bus built on an International 3800 bus chassis (VIN: 1HVBBAAL81H-------). The Bluebird was equipped with a 7.6L, 6 cylinder diesel engine.

Exterior Damage: The Bluebird's impact with the Chevrolet involved the right side of the vehicle (**Figure 5**). The direct damage started just behind the bi-fold door and measured 245 centimeters (96.5 inches) in width. The Bluebird's fuel tank was located directly in the area of the impact (**Figure 12**). The fuel tank was protected by a steel frame and the fuel tank and frame were displaced inward by the impact. The fuel tank's protective frame loaded the bus's right frame member and bent it and the left frame member. The fuel tank was not damaged and there was no fuel leakage.

Figure 12: Arrow shows fuel tank and fuel tank frame; there was no damage to the tank or fuel leakage

A damage classification could not be assigned to the Bluebird because buses are out of scope for the Truck Deformation Classification (TDC) and the Collision Deformation Classification (CDC) protocols.

Bluebird's Driver: According to the police crash report, the Bluebird's driver (53-year-old male) was restrained by his lap-and-shoulder belt. He was not injured in the crash.


Event 2; V2 rolls over onto left side
Gravel roadway
V2
V2
V2
Event 1
N
IN08010
Clear, Daylight
Dry, Level, Bituminous Roadways
(Northeast Leg of Intersection = Level Gravel Roadway)
V1 Speed Limit = 113 km\h (70mph)
V2 Speed Limit = 97 km\h (60 mph)
V1: 2007 Chevrolet Silverado
V2: 2001 Bluebird School Bus
V1
0 m 5 m 10 m
Scale

CDR File Information

Vehicle Identification Number	2GCEC13V671
Investigator	
Case Number	
Investigation Date	Thursday, March 6 2008
Crash Date	
Filename	
Saved on	
Collected with CDR version	Crash Data Retrieval Tool 3.00
Reported with CDR version	Crash Data Retrieval Tool 3.00
EDR Device Type	airbag control module
Event(s) recovered	Deployment

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 can be overwritten by an event that has a greater SDM recorded vehicle forward velocity change. This event will be cleared by the SDM after the ignition has been cycled 250 times.

The second type of SDM recorded crash event is the Deployment Event. It also contains Pre-Crash and Crash data. The SDM can store up to two different Deployment Events, if they occur within 25.4 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. If multiple Non-Deployment Events occur within 5 seconds prior to a Deployment Event, then the most severe Non-Deployment Event will be recorded and locked. If multiple Non-Deployment Events precede a Deployment Event, and multiple Non-Deployment Events occur within 5 seconds of each other (but not necessarily all within 5 seconds of the Deployment Event), and subsequent Non-Deployment Events are less severe than prior Non-Deployment Events, and the last of the multiple Non-Deployment Events occurs within 5 seconds of a Deployment Event, then the most severe of the Non-Deployment Events (which may have occurred more than 5 seconds prior to the Deployment Event) will be recorded and locked.

SDM Data Limitations:

-SDM Recorded Vehicle Forward Velocity Change reflects the change in forward velocity that the sensing system experienced during the recorded portion of the event. SDM Recorded Vehicle Forward Velocity Change is the change in velocity during the recording time and is not the speed the vehicle was traveling before the event, and is also not the Barrier Equivalent Velocity. This data should be examined in conjunction with other available physical evidence from the vehicle and scene when assessing occupant or vehicle forward velocity change. For Deployment Events and Deployment Level Events, the SDM will record 100 milliseconds of data after deployment criteria is met and up to 50 milliseconds before deployment criteria is met. For Non-Deployment Events, the SDM will record the first 150 milliseconds of data after algorithm enable.

-Event Recording Complete will indicate if data from the recorded event has been fully written to the SDM memory or if it has been interrupted and not fully written.

-SDM Recorded Vehicle Speed accuracy can be affected if the vehicle has had the tire size or the final drive axle ratio changed from the factory build specifications.

-Brake Switch Circuit Status indicates the status of the brake switch circuit.

-Pre-Crash Electronic Data Validity Check Status indicates "Data Invalid" if the SDM receive an invalid message from the module sending the pre-crash data.

-Driver's and Passenger's Belt Switch Circuit Status indicates the status of the seat belt switch circuit. If the vehicle's electrical system is compromised during a crash, the state of the Belt Switch Circuit may be reported other than the actual state.

-The Time Between Non-Deployment and Deployment Events is displayed in seconds. If the time between the two events is greater than 25.4 seconds, "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.

-Multiple Events Associated with this Record: This parameter will indicate whether one or more associated events preceded the recorded event.

-One or More Associated Events Not Recorded: If a single event is recorded, this parameter will indicate whether one or more associated events, prior to the recorded event, was not recorded.

If two associated events are recorded, this parameter for the first event will indicate whether one or more associated events, prior to the first event, was not recorded.

If two associated events are recorded, this parameter, for the second event, will indicate whether one or more associated events, between the first and second events, was not recorded.

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.

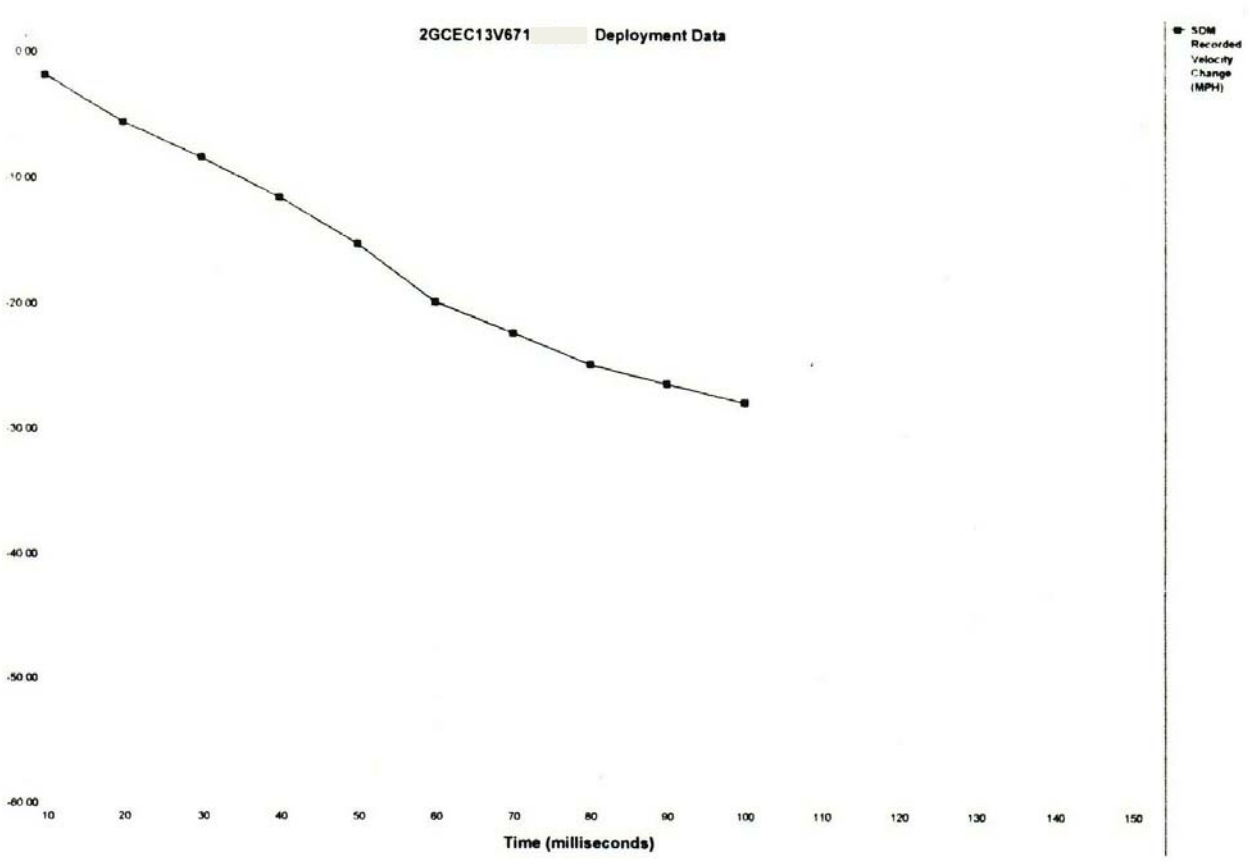
-The SDM may obtain Belt Switch Circuit Status data a number of different ways, depending on the vehicle architecture. Some switches are wired directly to the SDM, while others may obtain the data from various vehicle control modules, via the vehicle's communication network.

System Status At Deployment

SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	UNBUCKLED
Passenger's Belt Switch Circuit Status	UNBUCKLED
Passenger Seat Position Switch Circuit Status	Rearward
Ignition Cycles At Deployment	6103
Ignition Cycles At Investigation	6104
Maximum SDM Recorded Velocity Change (MPH)	-31.39
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	160
Driver 1st Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	7.5
Driver 2nd Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	17.5
Passenger 1st Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	Suppressed
Passenger 2nd Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	Suppressed
Time Between Non-Deployment And Deployment Events (sec)	N/A
Frontal Deployment Level Event Counter	1
Event Recording Complete	Yes
Multiple Events Associated With This Record	No
One Or More Associated Events Not Recorded	No

Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle
-5	94	2304	30
-4	94	2240	0
-3	90	2176	0
-2	80	1856	0
-1	62	1472	0

Seconds Before AE	Brake Switch Circuit Status
-8	OFF
-7	OFF
-6	OFF
-5	OFF
-4	OFF
-3	ON
-2	ON
-1	ON



Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Recorded Velocity Change (MPH)	-1.86	-5.58	-8.37	-11.47	-15.19	-19.84	-22.32	-24.80	-26.35	-27.90	N/A	N/A	N/A	N/A	N/A