

Side Air Bag Investigation / Vehicle to Vehicle
Dynamic Science, Inc. / Case Number: 2004-074-059F
2000 Chevrolet Impala
Nebraska
March, 2004

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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 crash-worthiness performance of the involved vehicle(s) or their safety systems.

1. Report No. 2004-074-059F	2. Government Accession No.		3. Recipient Catalog No.	
4. Title and Subtitle Side Air Bag Investigation		5. Report Date June 28, 2004		
		6. Performing Organization Report No.		
7. Author(s) Dynamic Science, Inc.		8. Performing Organization Report No.		
9. Performing Organization name and Address Dynamic Science, Inc. 530 College Parkway, Ste. K Annapolis, MD 21401		10. Work Unit No. (TRAVIS)		
		11. Contract or Grant no. DTNH22-01-C-27002		
12. Sponsoring Agency Name and Address U.S. Dept. of Transportation (NRD-32) National Highway Traffic Safety Administration 400 7th Street, SW Washington, DC 20590		13. Type of report and period Covered [Report Month, Year]		
		14. Sponsoring Agency Code		
15. Supplemental Notes				
16. Abstract This was a Side Air Bag Vehicle Investigation. This was an SCI/PSU combination case. There were two vehicles involved. The crash occurred in March, 2004 at 0740 hours in the state of Nebraska. The crash occurred on an east/west oriented two-lane state highway. The case vehicle was a 2000 Chevrolet Impala four-door sedan driven by a restrained 57-year-old female. The Impala was equipped with a driver's air bag, a front right passenger's air bag, and seat back mounted side air bags for the two front outboard seats. This vehicle was traveling westbound. The other vehicle was a 1990 Chevrolet Beretta driven by a 26-year-old male. This vehicle was traveling eastbound. It appears that the driver of the Impala lost control of her vehicle due to road conditions, traveled into the opposing lane, over-corrected to the right, and began a clockwise rotation as it slid sideways into the path of the Beretta. The driver of the Beretta braked and steered to the right but was unable to stop in time. The front of the Beretta struck the left side of the Impala. The driver's seat back mounted side air bag deployed at this time. The driver of the Impala sustained a contusion to her left arm that ran from the elbow to the shoulder, abrasions to the left arm, and abrasions to the left ankle.				
17. Key Words Air bag, side air bag, deployment injury		18. Distribution Statement		
19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No of pages	22. Price	

Dynamic Science, Inc.
Crash Investigation
Case Number: 2004-074-059F

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BACKGROUND:

Description: This Side Air Bag Vehicle Investigation was identified by the local National Automobile Sampling System (NASS) Primary Sampling Unit (PSU). The case was reported to DSI on May 11, 2004. This was an SCI/PSU combination case.

Investigation Type: Side Air Bag
 Crash Location: Nebraska
 Crash Date: March, 2004
 Notification Date: May 11, 2004
 Field Work Completed: NA, Remote Investigation

SUMMARY

Crash Site

This was a two vehicle crash. The crash occurred in March, 2004 at 0740 hours in the state of Nebraska. The crash occurred on an east/west oriented two-lane state highway. The two travel lanes area separated by solid/broken lines allowing passing for westbound traffic. Both lanes are bordered by a white line followed by a paved shoulder. The asphalt roadway was level and was wet. It was snowing at the time of the crash. The speed limit is 97 km/h (60 mph).

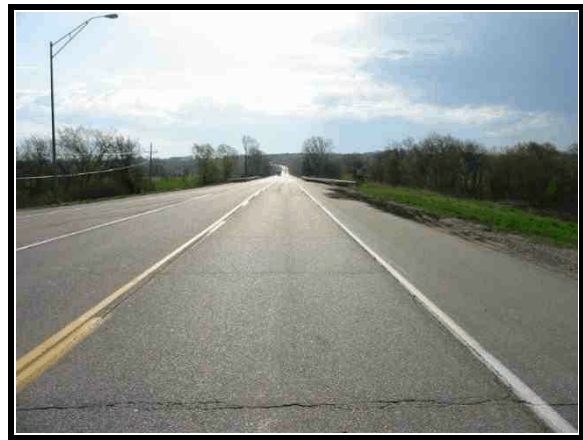


Figure 1. Approach to area of impact (west)

Pre-Crash

The case vehicle was a 2000 Chevrolet Impala four-door sedan (VIN: 2G1WF55E7Y9XXXXXX) driven by a restrained 57-year-old female (173 cm/68 in, 61 kg/134 lbs). The driver was seated on a split bench seat with separate back cushions that had been adjusted to the middle track position. The seat back was slightly reclined. The Impala was equipped with a driver's air bag, a front right passenger's air bag, and seat back mounted side air bags for the two front outboard seats. This vehicle was traveling westbound at a driver reported speed of 72 km/h (45 mph)¹.

The other vehicle was a 1990 Chevrolet Beretta driven by an unrestrained 26-year-old male (178 cm/70 in, 86 kg/190 lbs). This vehicle was traveling eastbound.

¹According to the Vetronix report the vehicle speed was 71 km/h (44 mph) five seconds before algorithm enable.

It appears that the driver of the Impala lost control of her vehicle due to wet road conditions, traveled into the opposing traffic lane, over-corrected to the right, and began a clockwise rotation as it slid sideways into the path of the Beretta.

Crash

The driver of the Beretta braked and steered to the right but was unable to stop in time. The front of the Beretta (12FYEW1) struck the left side of the Impala (11LZEW3). The direct damage to the Impala began 147.0 cm (57.8 in) forward of the rear axle and extended rearward for 197.0 cm (77.5 in). The maximum crush measured 18.0 cm (7.1 in) and was located at C3. The impact engaged the left rear tire and pushed the left rear axle rearward 9.0 cm (3.5 in).

The total velocity change calculated by the WinSmash collision model for the Impala was 16.0 km/h (9.9 mph). The longitudinal and lateral delta v components were -14.0 km/h (-8.7 mph) and 8.0 km/h (4.9 mph), respectively.

The driver's seat back mounted side air bag deployed at this time.

This impact likely initiated an air bag non-deployment event for the Impala. A non-deployment event is an event severe enough to "wake up" the sensing algorithm but not severe enough to deploy the frontal air bags. The damage to the Impala could best be likened to a sideswipe until the Beretta engaged and then snagged the left rear wheel. The Vetronix report for this non-deployment included Pre-Crash and Crash data. Briefly, the report indicated that the driver's seat belt was buckled, that the passenger air bag was not suppressed, that the vehicle speed one second before algorithm enable was 37 km/h (23 mph), that the brakes were on, and that the vehicle sustained a maximum Sensing Diagnostic Module recorded velocity change of -0.43 km (-0.27 mph).

Post-Crash

The driver of the Impala sustained a contusion to her left arm that ran from the elbow to the shoulder, and abrasions to the left arm. Given her seated position and the fact that the vehicle was in clockwise rotation, it would appear that the driver's left shoulder/arm area was already close to door side panel and was likely struck by the deploying air bag. She was able to exit the vehicle on her own. She was transported to a local hospital where she was treated and released. She did not lose any working days.



Figure 2. Left side, oblique view, Chevrolet Impala (case vehicle)



Figure 3. Front left, Chevrolet Beretta (other vehicle)

VEHICLE DATA - 2000 Chevrolet Impala

The 2000 Chevrolet Impala four-door six passenger sedan was equipped with a four-speed automatic transmission, front wheel drive, four-wheel disk brakes, air conditioning, tilt steering wheel, power windows, and power door locks.

VIN: 2G1WF55E7Y9XXXXXX
 Odometer: 143,097 km (88,918 miles)
 Engine: 3.4L 6 cylinder
 Reported Defects: None
 Cargo: None, per the vehicle inspection

The 2000 Chevrolet Impala was equipped with Uniroyal P225/60R16 tires for the left front, right front, and right rear tires. The left rear tire was missing during the vehicle inspection. The specific tire data is as follows:

Tire	Tread	Pressure	Auto manufacturer's cold tire pressure
LF	3 mm (0.12 in)	193 kPa (28 psi)	207 kPa (30 psi)
LR	Unknown	Unknown	207 kPa (30 psi)
RF	4 mm (0.16 in)	193 kPa (28 psi)	207 kPa (30 psi)
RR	5 mm (0.19 in)	186 kPa (27 psi)	207 kPa (30 psi)

The three front seating positions in the 2000 Chevrolet Impala were configured with a 60/40 split bench with separate back cushions. The two outboard seats were equipped with adjustable head restraints that were not damaged. The three rear seating positions were configured with a bench with folding backs.

VEHICLE DAMAGE

Exterior Damage - 2000 Chevrolet Impala

Damage Description:	Moderate left side damage. Vehicle towed from the scene. Left rear tire missing.	
CDC:	11LZEW3	
Delta V:	Total	16.0 km/h (9.9 mph)
	Longitudinal	-14.0 km/h (8.7 mph)
	Latitudinal	8.0 km/h (4.0 mph)
	Energy	17,489 joules (12,899 ft lbs)

The side impact with the Chevrolet Beretta resulted in moderate damage to the left door and left rear quadrant of the Impala. The direct damage began 147.0 cm (57.8 in) forward of the left rear axle and extended 197.0 cm (77.5 in) rearward along the left side. Six crush measurements were documented at the mid door level: C1=1.0 (0.4 in), C2=13.0 cm (5.1 in), C3=18.0 cm (7.0 in), C4=15.0 cm (5.9 in), C5=8.0 cm (3.1 in), C6=2.0 cm (0.8 in). The maximum crush was located at C3 and measured 18.0 cm (7.0 in). The left axle was deformed rearward 9.0 cm (3.5 in).



Figure 4. Close up of left side damage to Impala

Interior Damage - 2000 Chevrolet Impala

Interior damage to the Chevrolet Impact was moderate and was attributed to vehicle intrusion. The intrusion was limited to the left rear seating area and included the back door panel, the B pillar, and the sill. The maximum intrusion was 5.0 cm (1.9 in) as measured to the door panel and B pillar. The left front and rear doors were jammed shut. There was no integrity loss.

MANUAL RESTRAINT SYSTEMS - 2000 Chevrolet Impala

The interior of the Impala consisted of a six passenger seating configuration with front (split) and rear bench seats (with separate/folding backs). The front outboard seats were equipped with 3-point manual lap and shoulder belts. Both front seat belts were configured with adjustable shoulder belt anchorages that were found in the full up position. The front middle seat was equipped with a lap belt. All three rear seat locations were equipped with 3-point manual lap and shoulder belts.

AIR BAG SYSTEMS - 2000 Chevrolet Impala

This 2000 Chevrolet Impala was equipped with an advanced occupant protection system. The system consists of the Sensing Diagnostic Module (SDM), a driver's front air bag, a front right passenger air bag, seat belt pretensioners for both front seats, driver's seat belt latch usage detector, and seat back mounted side air bags for the two front outboard seats. The driver's air bag module was mounted in a typical mode within the two-spoke steering wheel rim. The front right passenger's air bag module was a mid mount configuration within the upper right instrument panel. The system is controlled by the SDM. The SDM is located beneath the driver's seat.



Figure 5. Non deployed front air bags in case vehicle

The primary function of the SDM is to control the deployment of the occupant protection systems. The system records the vehicle's forward velocity change. For non-deployments, the SDM will record the first 150 milliseconds of data after algorithm enable.

The downloaded data indicated that the case vehicle had a maximum recorded longitudinal velocity change of -0.43 km/h (-0.27 mph).

The Vetronix report (see Attachment 2) further indicates that:

1. A Non-Deployment event was recorded.
2. The driver's belt switch status was buckled.
3. The SIR warning lamp status was OFF.
4. The passenger front air bag was not suppressed.
5. The ignition cycle at non-deployment was 8785.
6. The brake switch status was ON one second before algorithm enable (AE).
7. The vehicle speed was 71 km/h (44 mph) five seconds before AE, decelerating to 37 km/h (23 mph) one second before AE.

As a result of the impact with the Chevrolet Beretta, the driver's seat back mounted air bag deployed. The side air bag measured 69.0 cm (27.2 in) high by 42.0 cm (16.5 in) wide at the top and 22.0 cm (8.7 in) wide at the bottom. There was one tether and the air bag was internally vented. There were no indications of damage or contact to the air bag.

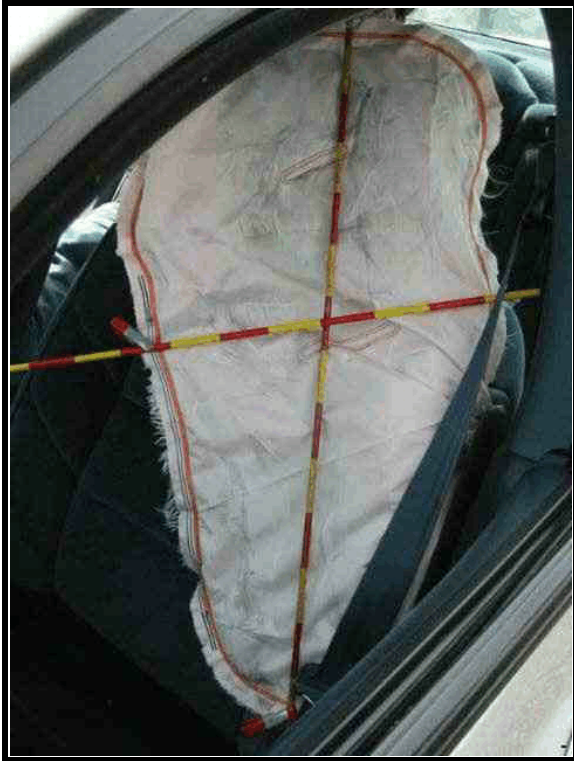


Figure 6. Driver's seat back mounted side air bag, exterior view



Figure 7. Driver's seat back mounted side air bag, interior view

VEHICLE DATA - 1990 Chevrolet Beretta

Description:	1990 Chevrolet Beretta two-door coupe	
VIN:	1G1LV14G6LExxxxxx	
Odometer:	259,055 km (160,974 miles)	
Engine:	2.2 L, 4 cylinder	
Reported Defects:	None	
Cargo:	None, per vehicle inspection	
Damage Description:	Moderate front end damage. Left front tire restricted. Vehicle towed from the scene due to damage.	
CDC:	12FYEW1	
Delta V:	Total	20.0 km/h (12.4 mph)
	Longitudinal	-20.0 km/h (-12.4 mph)
	Latitudinal	4.0 km/h (2.5 mph)
	Energy	26,974 joules (19,895 ft lbs)

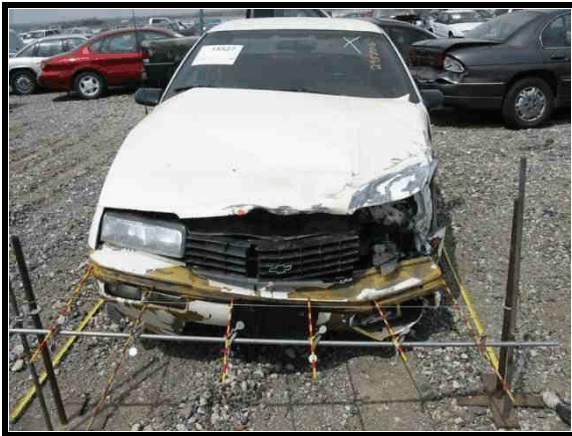


Figure 8. Front, Chevrolet Beretta (other vehicle)



Figure 9. Interior, Chevrolet Beretta (other vehicle)

OCCUPANT DEMOGRAPHICS - 2000 Chevrolet Impala

	Driver
Age/Sex:	57/Female
Seated Position:	Front left
Seat Type:	Split bench with separate back cushions. Seat adjusted to middle track position. Seat back slightly reclined.
Height:	173 cm (68 in)
Weight:	61 kg (134 lbs)
Occupation:	Unknown
Pre-existing Medical Condition:	None noted
Alcohol/Drug Involvement:	None
Driving Experience:	Presumed to be greater than 20 years.
Body Posture:	Normal, upright
Hand Position:	Both hands on steering wheel, unknown o'clock position, actively steering
Foot Position:	Both feet on floor or foot controls. Foot not on brake.
Restraint Usage:	Lap and shoulder belt available, used.
Air bag:	Driver's air bag available, did not deploy. Seat back mounted side air bag, deployed.

OCCUPANT DEMOGRAPHICS -1990 Chevrolet Beretta

Age/Sex:	26/Male
Seated Position:	Front left
Seat Type:	Bucket with folding back. Seat adjusted to middle track position. Seat back slightly reclined.
Height:	178 cm (70 in)
Weight:	86 kg (190 lbs)
Occupation:	Unknown
Pre-existing Medical Condition:	None noted
Alcohol/Drug Involvement:	None
Driving Experience:	Unknown
Body Posture:	Normal, upright
Hand Position:	Unknown
Foot Position:	Unknown
Restraint Usage:	Three point automatic belt available, belt not in use

OCCUPANT INJURIES -2000 Chevrolet Impala

	<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Driver:	Contusion, left arm, from elbow to shoulder	790402.1,2	Side air bag	Certain
	Abrasion, left arm	790202.1,2	Side air bag	Certain

OCCUPANT INJURIES - 1990 Chevrolet Beretta

	<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Driver:	Chest contusion	490402.1,9	Belt webbing	Certain
	Lumbar spine strain	640678.1,8	Seat back support	Certain
	Thoracic spine strain	640478.1,7	Belt webbing	Certain

OCCUPANT KINEMATICS - 2000 Chevrolet Impala

The 57-year-old female driver of the Chevrolet Impala was seated upright in a normal, forward facing fashion. Both hands were on steering wheel (unknown o'clock position). The tilt steering column adjusted to the center position. Both feet were on either the floor or the foot controls. She was wearing the available 3-point lap and shoulder belt. The lap belt was reported to be snug and low across the hips and the shoulder harness adjusted snugly across the collarbone and over the shoulder. The shoulder belt upper anchorage was adjusted to the full up position. The split bench seat with separate back cushions had been adjusted to the middle track position. The seat back was slightly reclined. She was wearing glasses at the time of the crash.

Prior to impact, the Chevrolet Impala was in a moderate clockwise yaw. This motion would have shifted the driver to left—possibly pressing against the door side panel. Both hands were on the steering wheel and actively turning to the right. At impact, the driver's seat mounted side air bag deployed—striking and causing the contusion and abrasion to the left upper arm. The driver's left leg pitched to the left and engaged the lower kick panel—causing a left ankle abrasion.



Figure 10. Driver's seated position. Side air bag visible.

Attachment 1. Scene Diagram

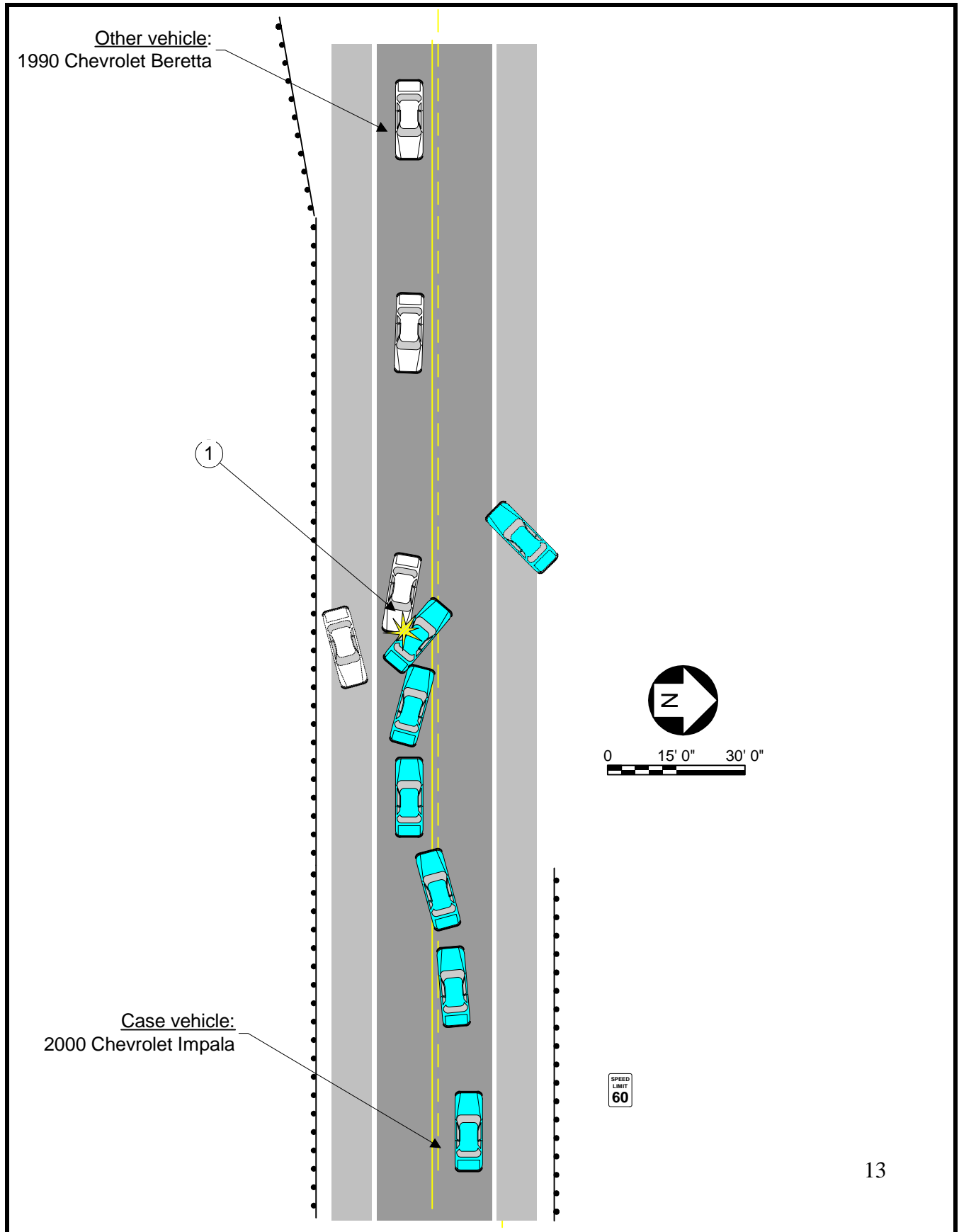


Figure 11. Scene diagram

Attachment 2. Vetronix Report

CDR File Information

Vehicle Identification Number	2G1WF55E7Y [REDACTED]
Investigator	LJ
Case Number	059F
Investigation Date	Monday, April 5 2004
Crash Date	Monday, March 15 2004
Filename	059WITHOUTVIN.CDR
Saved on	Monday, April 5 2004 at 12:47:45 PM
Data check information	49E436FE
Collected with CDR version	Crash Data Retrieval Tool 2.24
Collecting program verification number	70CD83DD
Reported with CDR version	Crash Data Retrieval Tool 2.24
Reporting program verification number	70CD83DD
Interface used to collected data	Block number: 00 Interface version: 39 Date: 10-09-03 Checksum: 0300
Event(s) recovered	Non-Deployment

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 deployments, 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-deployments and deployment level events, the SDM will record the first 150 milliseconds of data after algorithm enable. 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, from the Deployment file, may be recorded after algorithm enable, if the Deployment event has a long crash pulse.

-Pre-Crash Electronic Data Validity Check Status indicates "Data Invalid" if the SDM does not receive a valid message.

-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 as unbuckled, although the driver's seat belt was buckled.

-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, "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.

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 can 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 can not 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 file will be locked after a deployment, if the non-deployment occurred within 5 seconds before the deployment or a deployment level event occurs within 5 seconds after the deployment.

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 Class 2 data link, to the SDM.

- Brake Switch Circuit Status data is transmitted once a second by either the ABS module or the PCM, via the Class 2 data link, to the SDM. Depending on vehicle option content, the Brake Switch Circuit Status data may not be available.

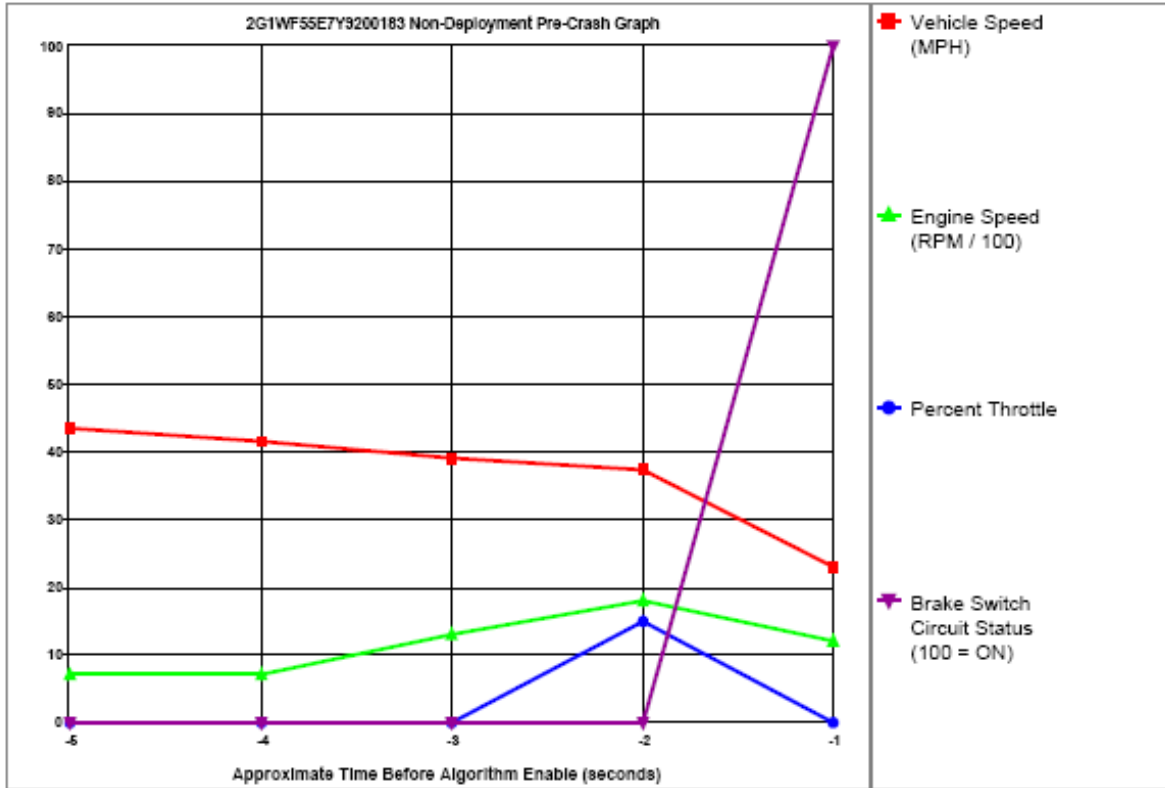
- If the vehicle is a 2000 - 2002 Chevrolet Cavalier Z24 or a Pontiac Sunfire GT, with a manual transmission (RPO MM5) and a 2.4L engine (RPO LD9), the Brake Switch Circuit Status data will be reported in the opposite state than what actually occurred, e.g. an actual brake switch status of "ON" will be reported as "OFF".

- In most vehicles, the Driver's Belt Switch Circuit is wired directly to the SDM. In some vehicles, the Driver's Belt Switch Circuit Status data is transmitted from the Body Control Module (BCM), via the Class 2 data link, to the SDM.

- The Passenger Front Air Bag Suppression Switch Circuit is wired directly to the SDM.

System Status At Non-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 Non-Deployment	8785
Maximum SDM Recorded Velocity Change (MPH)	-0.27



Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status
-5	44	704	0	OFF
-4	42	704	0	OFF
-3	39	1280	0	OFF
-2	37	1792	15	OFF
-1	23	1152	0	ON

Hexadecimal Data

This page displays all the data retrieved from the air bag module.
It contains data that is not converted by this program.

```
$01 93 23 2F 00
$02 8C D9
$03 41 53 39 32 39 32
$04 4B 34 38 52 45 32
$05 00
$06 09 38 30 30
$11 82 01 82 F8 89 00
$14 07 44 AB 80
$18 7D 7C 7D 83 82 83
$1C 31 35 57 46 48 48
$1D 48 31 35 57 46 48
$1E 48 48
$1F FF 02 05 00 00
$20 83 00 00 FF 80 FE
$21 FF BF FF FF FF FF
$22 FF FF FF FF FF FF
$23 7B 05 00 14 03 00
$24 00 00 00 00 00 00
$25 00 00 FF FF FF FF
$26 FF FF 09 25 3C 3F
$27 43 46 00 80 00 00
$28 27 00 00 00 00 12
$29 1C 14 0B 0B 00 FB
$2A B5 FE FF 0D 60 0D
$2B 8B 22 51 00 00 00
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