VCU

Virginia Commonwealth University

Transportation Safety Training Center
Crash Investigation Team

Special Report Number 16 – August 2003 **(Rev. 2/03)**

ABSTRACT

This Special Report, entitled "Event Data Recorder Study", compares physical evidence found at the scenes of traffic crashes and on the involved vehicles to information collected from these vehicles equipped with Event Data Recorders (EDRs). While other research studies have evaluated the performance of the EDRs under laboratory conditions in staged collisions, this study examines actual, real-world collisions. The report provides a history of EDRs and notes what type of crash information is collected. The Report also examines eight traffic crashes that occurred in the Commonwealth during 2002 and 2003. Eight of the EDR equipped vehicles were inspected and information was downloaded and compared extensively with the corresponding physical evidence from the roadway and on the vehicles.

The data indicates a high degree of reliability between the EDR captured data and analyzed physical evidence. The Study establishes that information contained in the EDRs can provide valuable insights into the circumstances of specific crashes. The EDR data is supplemental in nature, which must be accompanied by thorough crash investigation and reconstruction techniques. This technology has the potential to revolutionize the discipline of crash reconstruction in a manner that has not been seen in decades. Through proper use, the data downloaded from the EDRs and corroborated with physical evidence will be just as significant as when crash reconstructionists first began using forensic analysis for lamp examinations or using advanced scientific equations such as the momentum, energy and time-distance analysis and airborne calculations. The EDR data, as with all data collected and analyzed from a motor vehicle crash, if misapplied may inflict harm in criminal or court proceedings.

The Crash Investigation Team urges law enforcement, crash reconstructionists and others involved with highway safety to learn more about EDRs, their strengths and weaknesses, and how to use them competently.

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INTRODUCTION

In 1997, the National Transportation Safety Board recommended that automobile manufacturers and The National Highway Traffic Safety Administration work cooperatively to gather information on automobile crashes using on-board collision sensing and recording devices. The purpose of this plan was to collect better information on crash pulses and other crash parameters than could be obtained by using conventional accident investigation and reconstruction means. This data is to be used to evaluate various crash circumstances that could ultimately lead to improvements in highway safety in the areas of vehicle crash avoidance, crash worthiness and driver behavior.

Since the early 1990's when automobiles were required to have airbags, the technology needed to capture the recommended crash pulse data, was already in place. The module that checks out the airbag when the car is started and deploys the air bag when it senses sufficient energy forces during a crash event was modified to capture this information. This module, called the Event Data Recorder (EDR) or "black box" as it is sometimes called, was designed with an accelerometer and microprocessor programmed to capture specific information. Earlier models of EDRs were proprietary, meaning only the automobile manufacturer could download data from them. Early types yielded only minimal information. EDRs have evolved into today's highly sophisticated and technical devices, capable of collecting a multitude of pre-impact, impact and post- impact data.

General Motors Corporation, in cooperation with the Vetronix Corporation, was the first automobile manufacturer to allow their EDRs to be read commercially. Beginning in 2000, Vetronix offered for sale, the Crash Data Retrieval System "Toolbox" used to download information captured in certain GM autos equipped with EDRs. Beginning in mid 2003, Ford Motor Company had several models of vehicles with EDRs that can be downloaded using the toolbox. Other manufacturers are scheduled to make this information available commercially in the near future. At the present time, Vetronix is the only company that offers the download capabilities for EDRs.

The subject vehicles EDR can be downloaded by using an interface with cables that connect the vehicle's EDR to a computer. There are two ways to connect: through

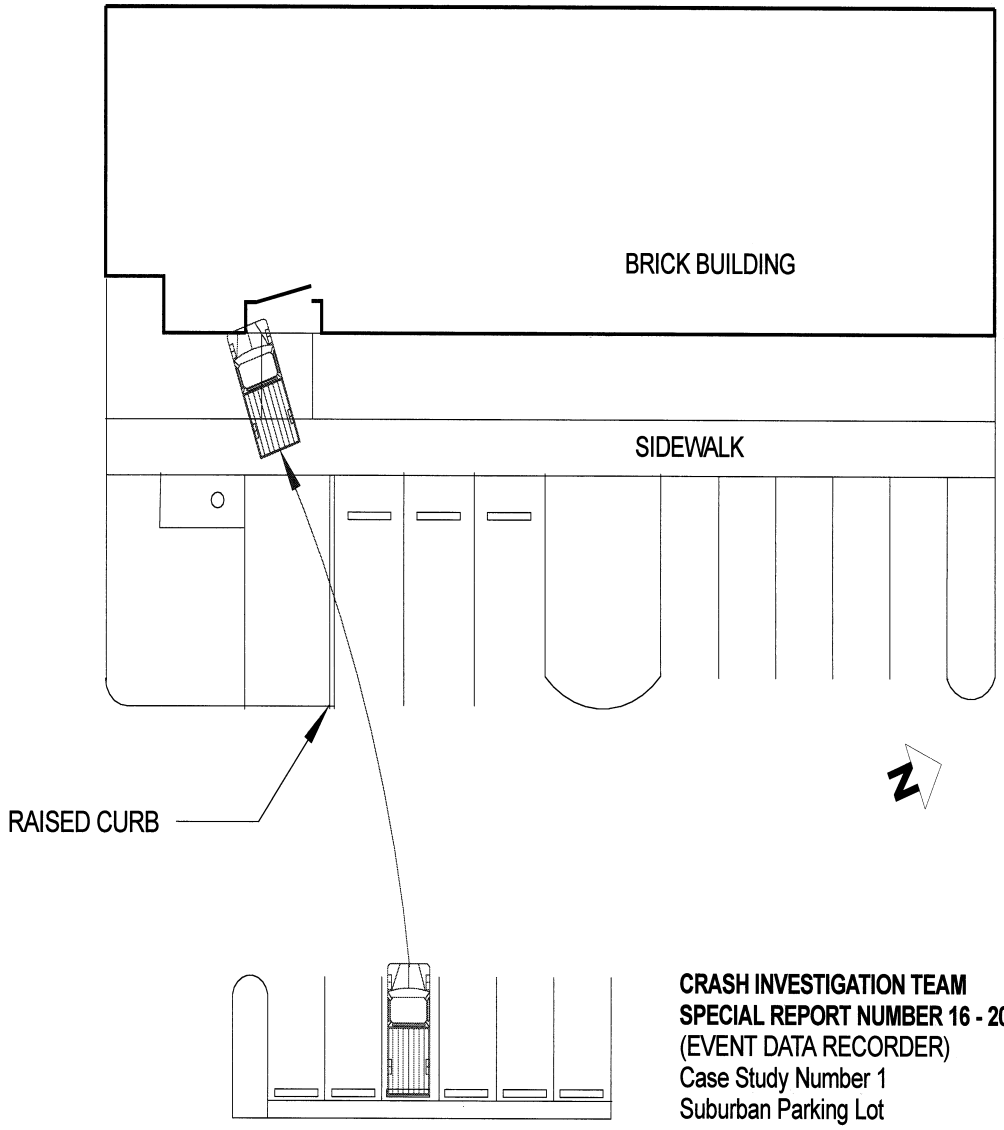
the vehicle's diagnostic link connector (DLC), which is typically located under the dashboard and/or directly into the airbag module. The information collected in the EDR differs by vehicle. Examples of the data captured on GM automobiles include vehicle speed (mph), engine speed (rpm), percent throttle, and brake switch activation status, all covering up to the last five seconds before an airbag deploys. Other information includes the "Driver's Safety Belt Use Status", the "Passenger Airbag Suppression Status" and the vehicle's change in velocity over time after impact. This information is collected and stored as a result of an airbag deployment or a non-deployment event. The post-crash data captured in Ford manufactured vehicles is similar to GM; however, no pre-crash information is collected.

Data downloaded from the various vehicles can play a vital role in understanding how a crash occurred and what happened during the collision. It is best used when supported by physical evidence and through crash reconstruction. In order to validate the EDR data, sufficient physical evidence must be examined and analyzed. Validation is critical because the data can be compromised. One limitation of this technology is that if power to the EDR is lost during a crash event, all or part of the record may not be recorded. Another limitation is that the recorded vehicle speed accuracy can be affected if the vehicle has had the tire size or the final drive axle ratio changed from factory specifications. The recorded vehicle speed accuracy can also be confounded if the vehicle becomes air born, rolls over, or a wheel breaks off the drive axle. A final concern is the driver's belt switch circuit status, which indicates whether or not the driver's seat belt is buckled. If the vehicle's electrical system is compromised during the crash, the state of the driver's belt switch may be reported as unbuckled, although the driver's seat belt was buckled. It should be emphasized that the driver's seat belt use status actually reflects if the system was buckled at the time of the crash and not specifically if the driver was belted or not. It is possible to "fool" the system by buckling the belt and then having the driver sit on top of it. In such an instance, the injuries to the driver, corresponding damages to the vehicle's interior and/or whether he was ejected must be considered to decide if the EDR reading is accurate.

At present within the Commonwealth, only The Crash Investigation Team, seven regional Crash Teams of the Department of State Police, several other governmental agencies, and reconstruction-research groups have the capability to download EDR equipped vehicles. If the data is to be used at criminal or civil court proceedings, the

normal chain of custody and proper search and seizure requirements must be followed. As of this Special Report's writing, the Team is not aware of any attempts to get the data admitted into court evidence in Virginia. Nationally, however, it has been entered and used by several state courts as a technical tool to help the courts weigh the evidence. The admission of EDR evidence was recently upheld in the Illinois Appellate Court (Bachman V. General Motors Corp., 332ILL.App.3d760, 776 N.E. 2d 262-2002). As with any attempt to enter into evidence new or scientific information, each case must be considered on its own merits, along with the competence of the investigator trying to enter the EDR data.

The Crash Investigation Team is of the strong opinion that the ability to download data contained in the EDR will be an additional, valuable tool in the reconstruction of traffic crashes. Widespread use of this technology is likely to result in the most revolutionary impact on the advancement of crash investigation and reconstruction in the past 50 years. The Team encourages the use of EDRs by advanced professionals who receive the required training and certification needed to download and correctly interpret the information.



CRASH INVESTIGATION TEAM
SPECIAL REPORT NUMBER 16 - 2003
(EVENT DATA RECORDER)
Case Study Number 1
Suburban Parking Lot

CASE STUDY NUMBER 1

Type of Crash: Single vehicle, fixed object frontal impact

Vehicle Involved: 2002 Chevrolet S-10 pickup truck **(Event Data Recorder)**

Roadway: Public parking lot/brick building

Severity: Minor injuries to driver, pickup seriously damaged

SUMMARY:

On a clear, dry Thursday morning in August at about 10:45 a.m., a lone 77-year-old male walked out to a company vehicle parked in a parking lot. His intent was to move the vehicle from the front of the building to the rear. The vehicle, a new 2002 Chevrolet S-10 pickup truck had just over 1,800 miles displayed on the odometer. After starting the engine and placing the gear selector into drive, the driver slowly depressed the accelerator pedal. Without command the pickup's motor suddenly revved up, and according to its driver, the vehicle began to lunge forward across the lot. The startled driver stepped on the brake pedal in an attempt to stop, but the pickup continued traveling forward with its rear tires spinning on the asphalt surface. The pickup traveled up the slight grade nearly 40 feet where it struck and mounted a 6-inch high concrete curb and sidewalk. It continued moving straight ahead an additional 35 feet, where it slammed head on into the corner of the brick office building. After impact the driver's airbag deployed, and the unbelted driver was thrown forward into the airbag and steering wheel. The pickup's engine continued running with the truck pressed against the damaged building, its rear tires still spinning on the sidewalk. The driver turned off the ignition switch and the pickup's movement stopped. Due to the downgrade of the parking lot, the pickup rolled backward about 25 feet from the building.

The driver was evaluated by medical services and after deciding that only minor bruising injuries had occurred to his chest and knees he was released. The driver's supervisor contacted the company's investigator. The site was then photographed and measured. The pickup was taken to a secure location to be examined at a later time. An investigation of the truck's history since its purchase was undertaken. The investigator

contacted the Crash Investigation Team since he knew that the Team was conducting an investigation/analysis of EDRs. Assistance was requested and the Team responded to inspect the site, examine the damage on the pickup and download the information contained within the EDR.

Although this pickup had a history of two other unexpected sudden and rapid acceleration episodes, the Crash Investigation Team did not address the nature of those specific problems. The possibility of a sticking accelerator or other related rapid/sudden accelerator problems on this model truck was searched on the National Highway Traffic Safety's Administration's problem/recall "hotline." No similar occurrences had been reported to NHTSA and General Motors had conducted no recalls of this nature, on this pickup model.

DISCUSSION:

Data contained within the EDR was compared to physical evidence documented at the scene and to the damage on the vehicle. At least five of the recorded data entries could be directly compared with the physical evidence. The speed of the pickup recorded within one second before deployment according to the EDR, was "22 mph." The previous four seconds of time prior to impact, beginning at five seconds before, were "17, 11, 3, and 0 mph" respectively. Matched with these values were the corresponding "Percent Throttle" readings of 100% occurring between four to two seconds before deployment. The "Engine Speed" was also correspondingly high (1664-2688 RPM's) over this time period. The significance of these values indicates that the high acceleration rate was indeed almost instantaneous once the driver started the engine and placed the transmission in drive from a parked position. Based on the 17 inches of frontal penetration damage to the pickup and the distance that it traveled while accelerating at a rapid rate from its stopped position to the point of impact, a speed range of between 18 and 21 mph was calculated. These calculations were conducted by typical methods used in accident reconstruction techniques, such as the *Conservation of Energy* and *Acceleration/Distance Analysis.*

Although the driver said he was attempting to stop the pickup's movement by depressing the brake pedal, no evidence of this exists. There were no braking skid marks on the parking lot surface or on the sidewalk in front of the building. The "Brake Switch

Circuit Status" as recorded by the EDR indicated that it was "off" over the entire five seconds.

According to the EDR, the "Driver's Belt Switch Circuit Status" was "unbuckled". The driver said that he was not wearing his safety belt at the time of the crash. This statement, combined with the fact that he sustained slight chest bruising from the contact with the steering wheel and that the belt webbing and hardware showed no evidence of loading, matches the belt usage information from the EDR download.

The right front passenger airbag did not deploy. The EDR indicated that this system had been "suppressed". The vehicle is equipped with a switch to deactivate the passenger airbag. The position of the switch at the time of investigation showed it in the "off" mode. In this case, the airbag's failure to deploy validates the EDR suppression indication.

Lastly, the maximum EDR "Recorded Velocity Change" noted at 110 milliseconds after impact was 21.50 mph. Since this collision was a frontal impact with an immoveable, fixed object, a Delta V will closely match the vehicle's actual speed at impact. In this case, the pickup's speed at the collision point was about 22 mph, which closely matches the Delta V speed recorded by the EDR. Based on these two readings and the aforementioned speeds from crush (18 mph) and acceleration (21 mph), it would appear that the speed of the pickup as indicated on the EDR was accurate.

In conclusion, the available physical evidence indicates that the data contained in the EDR was indeed reliable and accurate.

CDR File Information

Vehicle Identification Number	1GCCS14WX28
Investigator	
Case Number	08-15-02
Investigation Date	08-19-02
Crash Date	08-15-02
Filename	PCKUP.CDR
Saved on	8/19/02 4:48:16 PM
Data check information	5601EE40
Collected with CDR version	Crash Data Retrieval Tool 1.600
Collecting program verification number	B093ECC4
Reported with CDR version	Crash Data Retrieval Tool 2.10
Reporting program verification number	B6B4FDF8
Interface information	Block number: 00 Interface version: 31 Date: 06-13-02 Checksum: 5B00
Event(s) recovered	Deployment Non-Deployment

SDM Data Limitations

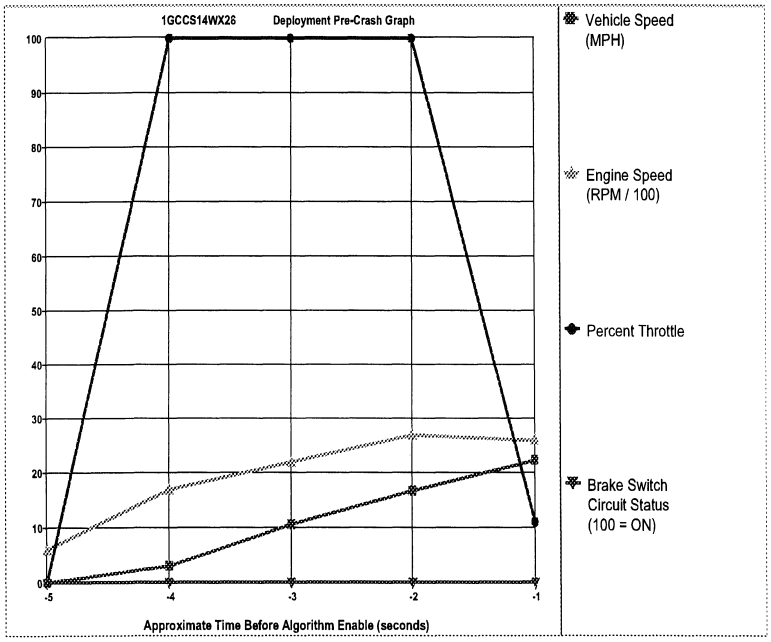
SDM Recorded Crash Events:
There are two types of SDM recorded crash events. The first is the Non-Deployment Event. A Non-Deployment Event is an event severe enough to "wake up" the sensing algorithm but not severe enough to deploy the air bag(s). It contains Pre-Crash and Crash data. The SDM can store up to one Non-Deployment Event. This event 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 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 Limitations:
-SDM Recorded Vehicle Forward Velocity Change is one of the measures used to make air bag deployment decisions. SDM Recorded Vehicle Forward Velocity Change reflects the change in forward velocity that the sensing system experienced during the recorded portion of the event. 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. The SDM will record 100 milliseconds of data after deployment criteria is met and up to 50 milliseconds before deployment criteria is met. The SDM will also record 150 milliseconds of data after non-deployment criteria is met.
-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.
-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
-Passenger Front Air Bag Suppression Switch Circuit Status indicates the status of the suppression switch circuit.
-The Time Between Non-Deployment and Deployment 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.

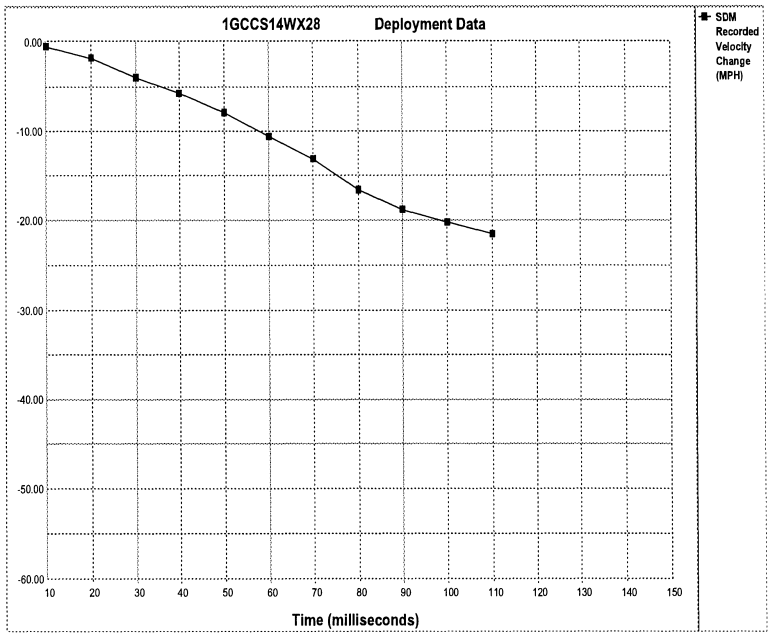
SDM Data Source:
All SDM recorded data is measured, calculated, and stored internally, except for the following:
-Vehicle Speed, Engine Speed, and Percent Throttle data are transmitted once a second by the Powertrain Control Module (PCM), via the Class 2 data link, to the SDM.
-Brake Switch Circuit Status 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.
-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 Deployment

SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	UNBUCKLED
Passenger Front Air Bag Suppression Switch Circuit Status	Air Bag Suppressed
Ignition Cycles At Deployment	266
Ignition Cycles At Investigation	269
Maximum SDM Recorded Velocity Change (MPH)	-21.48
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	105
Time Between Non-Deployment And Deployment Events (sec)	N/A
Time From Algorithm Enable to Deployment Command Criteria Met (msec)	12.5



Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status
-5	0	640	0	OFF
-4	3	1664	100	OFF
-3	11	2240	100	OFF
-2	17	2688	100	OFF
-1	22	2624	11	OFF



Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
SDM Recorded Velocity Change	-0.44	-1.76	-3.95	-5.70	-7.90	-10.53	-13.16	-16.67	-18.87	-20.18	-21.50	N/A	N/A	N/A	N/A

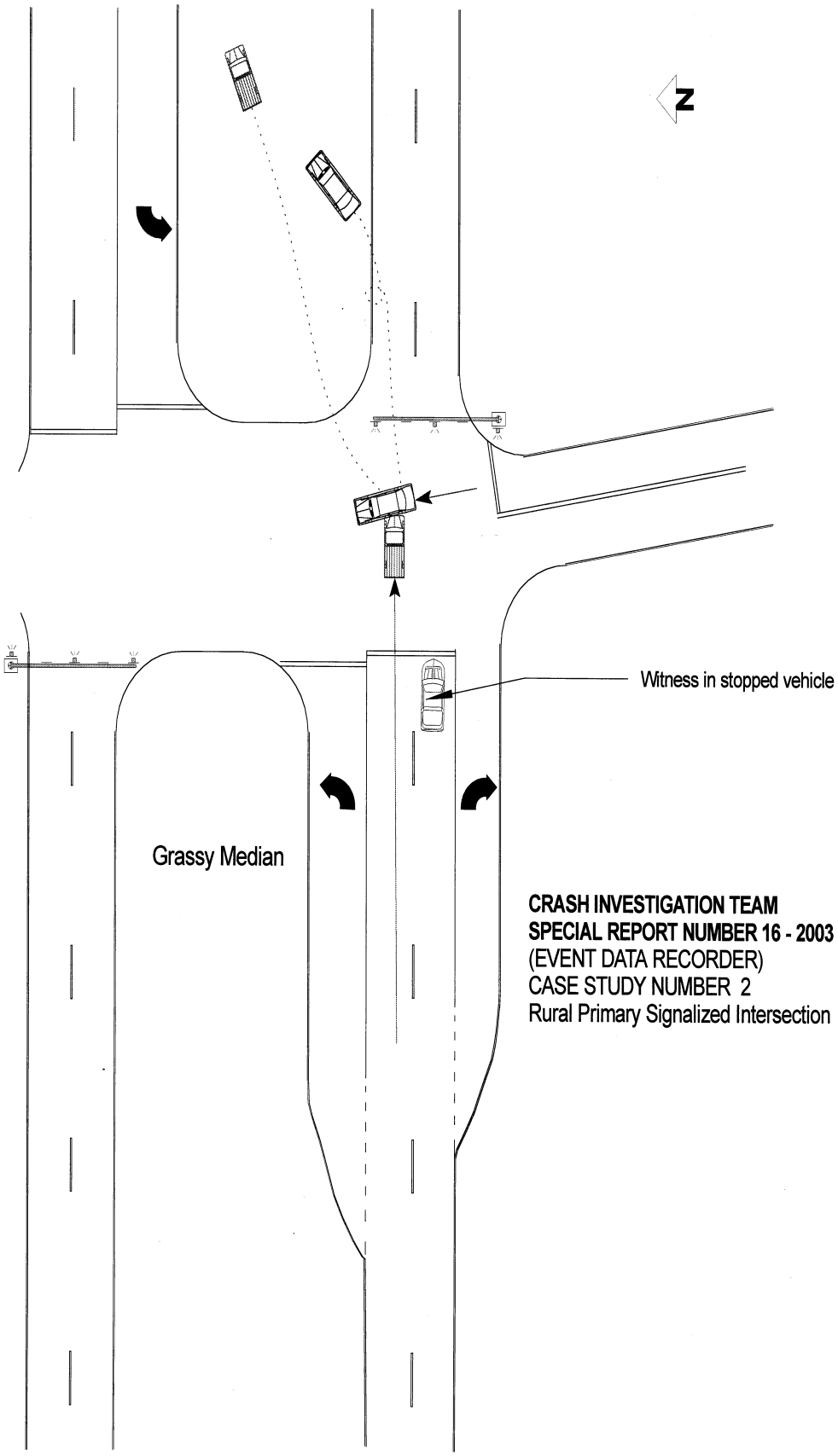
Hexadecimal Data

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

```
$01  08 23 00 00
$02  DB B1
$03  41 53 32 30 39 35
$04  4B 34 4C 30 55 31
$05  00
$06  15 07 32 51
$10  FF DE E0
$11  AA AC AC F6 B4 00
$14  03 A4 34 80
$18  84 84 84 5A FF 00
$1C  FA FA FA FA FA FA
$1D  FA FA FA FA FA FA
$1E  FA FA
$1F  FF 02 00 00 30
$20  A0 00 00 FF 09 F8
$21  FF FF FF FF FF FF
$22  FF FF FF FF FF FF
$23  FF 03 00 21 00 00
$24  00 01 01 01 FF FF
$25  FF FF FF FF FF FF
$26  FF FF 05 25 26 26
$27  26 23 00 80 00 00
$28  00 00 01 1E 00 10
$29  11 11 12 18 00 FF
$2A  F6 E0 FF FF FF FF
$2B  FF FF FF B4 28 00
$2C  00 00 00 00
$2D  09 0B 05 00
$30  A0 00 00 FF 21 FF
$31  FF BF FF FF FF FF
$32  FF FF FF FF FF FF
$33  7E 0B 03 00 01 04
$34  09 0D 12 18 1E 26
$35  2B 2E 31 FF FF FF
$36  FF 0B 54 06 20 24
$37  1B 11 05 00 00 04
$38  00 1D FF FF FF 00
$39  00 29 2A 23 1A 0A
$3A  00 FF DE FC 00 00
$3B  28 04 00
$3C  05 2A 54 2A
$40  FF FF FF FF FF FF
$41  FF FF FF FF FF FF
$42  FF FF FF FF FF FF
$43  FF
```

Photo #1- Damage to the 2002 Chevrolet S-10 pickup truck caused by striking the corner of a brick building. Maximum static deformation or "crush" was measured at 17 inches. The EDR recorded a maximum speed of 22 mph.

Photo #2- View of the brick building struck. Although the structure did not yield significantly, the corner, directly at impact point, was deformed about two inches from the collision.



CRASH INVESTIGATION TEAM
SPECIAL REPORT NUMBER 16 - 2003
(EVENT DATA RECORDER)
CASE STUDY NUMBER 2
Rural Primary Signalized Intersection

CASE STUDY NUMBER 2

Type of Crash: Two vehicles, angle collision

Vehicles Involved: 2001 Chevrolet Cavalier **(Event Data Recorder)**
1992 Chevrolet Silverado Pickup truck

Roadway: Rural, four lane divided primary road and two lane secondary intersection (signalized)

Severity: One fatality, one injury and two vehicles totaled

SUMMARY:

On a clear, dry Thursday morning in April at 7:41 a.m., a lone 51-year-old female had just pulled up and stopped her car at a major crossroad intersection controlled by a red traffic signal. She was en route from her home to her place of employment and was driving her employer's 2001 Chevrolet Cavalier four-door sedan. She was properly wearing her car's combination lap and shoulder safety belt. After the light turned green, she slowly accelerated north to enter the intersection. Her intent was to cross the eastbound lanes, turn left beyond the median crossover, and proceed west on the primary highway. After traveling about 75 feet from the stop line, she crossed the right eastbound lane and entered the left, inside lane, where she was violently struck by an eastbound pickup truck.

The 1992 full size, Chevrolet Silverado pickup truck was driven by its 25-year-old male driver who was en route to work from his home nearby. The pickup driver had violated the red stoplight and entered the intersection at a straight angle. The driver had just left a convenience store where he had purchased a beverage and a breakfast biscuit. Without any evasive action on the part of the pickup's driver, the truck's front struck the left side of the Cavalier at the driver's door.

With the truck initially over-riding and penetrating the car's driver compartment by almost two feet, the two vehicles, now stuck together, began to travel eastward along the left, inside lane and toward the grassy median. As the two vehicles entered the median, the car separated from the truck and rotated clockwise while traveling partly on the pavement and grass. It came to rest facing northeast about 145 feet beyond the

intersection. The belted car driver remained inside her car but she died instantly from massive head, neck and chest injuries. The car's airbag system deployed. The pickup came to rest facing east on the opposite side of the median adjacent to the westbound lanes, about 150 feet beyond the impact point. Its' driver sustained minor chest and head injuries.

The truck driver advised the investigating Trooper that he did not see the red traffic light facing him due to the position of the morning sun shining into his eyes. However, a motorist in the eastbound right lane beside and just in front of the pickup truck was able to see the changing traffic signal and come to stop with no mishap. Inside the pickup lying on the top dash against the base of the windshield, was the half-eaten breakfast biscuit.

DISCUSSION:

Neither vehicle left any pre-impact skid marks. The only marks on the road were collision tire scuffmarks, gouges and scrapes, denoting the point of impact in the left lane. After impact, the vehicles disengaged cleanly and their paths of travel could easily be traced along the roadway pavement and into the sod median. Because the damages on each vehicle could be measured and analyzed and the deceleration values could be evaluated, the collision speeds for each vehicle could be scientifically calculated. By using an application of the *Conservation of Linear Momentum* theory (an equation which utilizes each vehicle's post impact speeds, approach/ departure angles, and their weights), the Cavalier and pickup truck's speeds at the instant of impact were calculated. The pickup was traveling about 52 mph and the Cavalier about 12 mph.

The 2001 Cavalier was equipped with an Event Data Recorder (EDR), which in General Motor's vehicles, is called a Sensing and Diagnostic Module (SDM). The EDR is in effect a microprocessor whose primary functions are to check the airbag system upon startup of the ignition cycle and trigger the system to deploy in the event of a crash. Within the EDR is an accelerometer that measures and records the change in velocity over time after the airbag deploys. Other values are captured as well and recorded within the EDR that can be downloaded onto a computer and analyzed. In this case, certain pertinent data can be compared with crash investigation and reconstruction findings in an attempt to assess their accuracy and validity. Two such items that can be compared in this

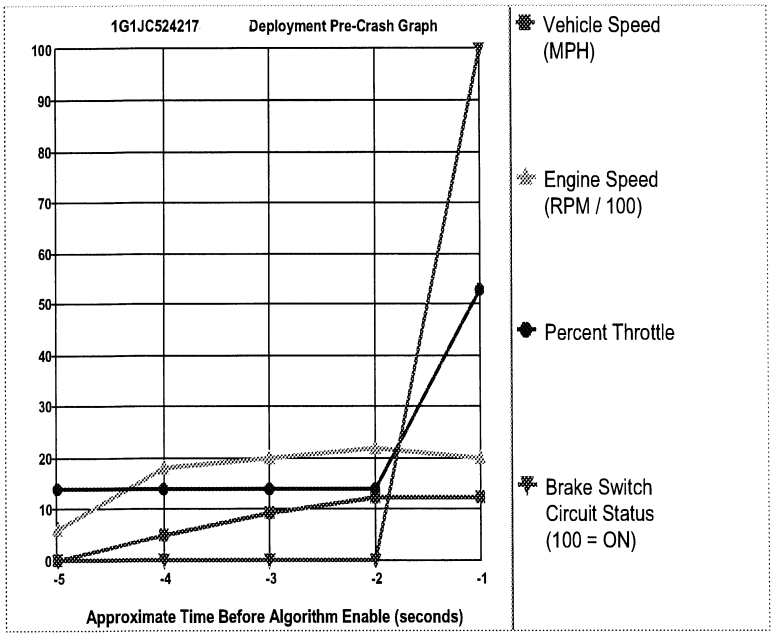
crash are the Cavalier's speed prior to impact, and whether its' driver was belted. The Cavalier's speed five seconds before impact was recorded at "0 mph," which confirms that the Cavalier was indeed stopped before pulling into the intersection. The speeds recorded for the succeeding three seconds then increased to " 5, 9, and 12 mph", respectively, up to impact. At collision, when the airbags deployed, the Cavalier was traveling "12 mph." The "Driver's Belt Switch Circuit Status" indicated from the EDR that the driver's belt was "buckled" at the time of impact. The facts that the deceased was found wearing her belt and that both the belt webbing and D-ring displayed energy transfer striations positively confirm the accuracy of this reading.

One other recorded value within the EDR, which cannot be precisely corroborated by the available physical evidence collected and analyzed, was the "Velocity Change" (Delta V) for the Cavalier instantly after collision. A measurement of 19.51 mph Delta V means that the Cavalier, whose speed at impact was about 12 mph was instantly accelerated to this value. When considering the 26 1/2 inches of crush or intrusion on the car's side, and the fact that the car instantly changed its' direction of travel at impact, it is likely that the recorded Delta V is consistent with what would be expected.

Based on the physical evidence collected at the scene and analyzed through accepted crash investigation/reconstruction methods, it appears that the data captured in the EDR was indeed reliable and accurate.

System Status At Deployment

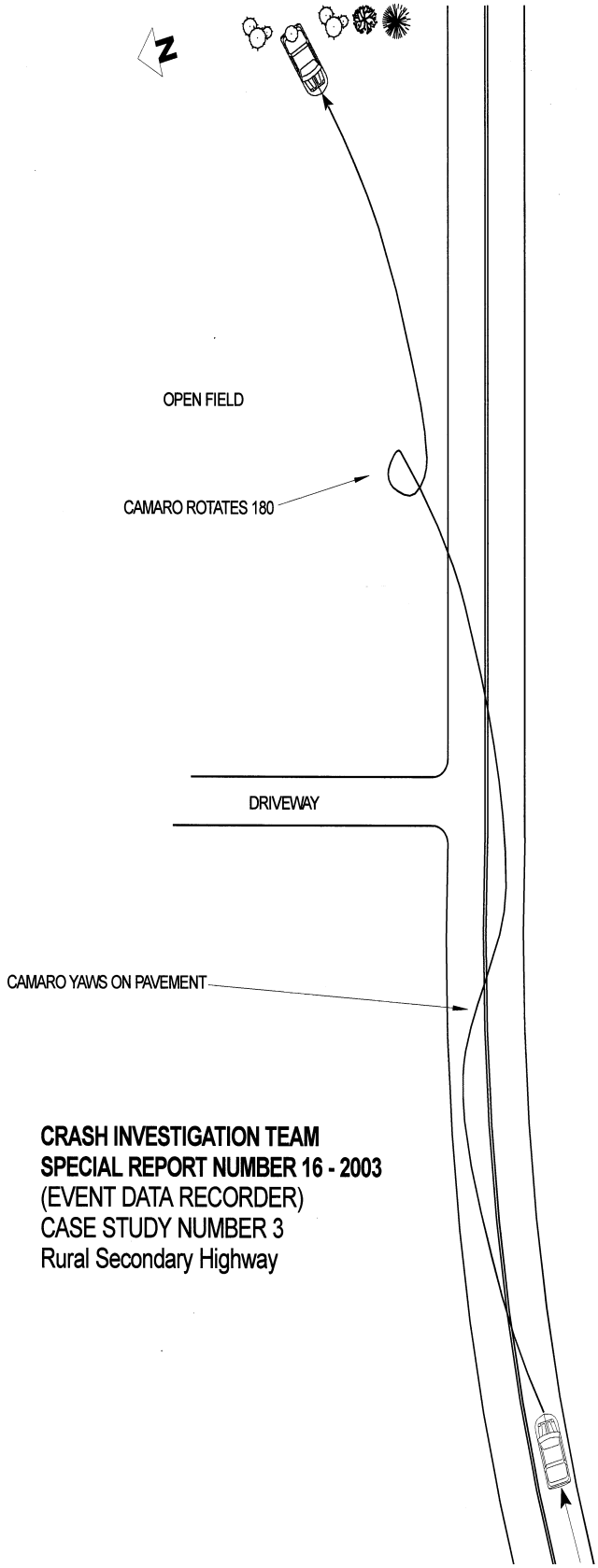
SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	BUCKLED
Passenger Front Air Bag Suppression Switch Circuit Status	Air Bag Not Suppressed
Ignition Cycles At Deployment	836
Ignition Cycles At Investigation	837
Maximum SDM Recorded Velocity Change (MPH)	-19.51
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	102.5
Time Between Non-Deployment And Deployment Events (sec)	N/A
Time From Algorithm Enable to Deployment Command Criteria Met (msec)	12.5



Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status
-5	0	576	14	OFF
-4	5	1792	14	OFF
-3	9	1984	14	OFF
-2	12	2240	14	OFF
-1	12	1984	53	ON

Photo #3- Damage to the 2001 Chevrolet Cavalier from a collision with the full size pickup truck. Maximum static deformation in its left front door measured 26 ½ inches. After the collision, it was pushed 145 feet beyond the impact point. The maximum EDR recorded speed was 12 mph.

Photo #4- Damage to the 1992 Chevrolet Silverado pickup truck from colliding with the Cavalier. Maximum static front-end crush was measured at 12 ½ inches. Momentum analysis indicated that the car and truck were traveling about 12 and 52 mph respectively at impact.



CRASH INVESTIGATION TEAM
SPECIAL REPORT NUMBER 16 - 2003
(EVENT DATA RECORDER)
CASE STUDY NUMBER 3
Rural Secondary Highway

CASE STUDY NUMBER 3

Type of Crash:	Single vehicle, fixed object rear-end impact
Vehicle Involved:	2000 Chevrolet Camaro Super Sport **(Event Data Recorder)**
Roadway:	Rural, secondary highway
Severity:	Two fatalities, one injury and Camaro totaled.

SUMMARY:

On a clear, dry Sunday morning in January at about 2:15 a.m., a 22 year-old-male was driving his 2000 Chevrolet Camaro east on a rural, two-lane secondary road. He was not wearing his safety belt and was accompanied by two other males who were also unbelted. Located in the right front was a 21-year-old and a 22-year-old was in the right rear, both were friends of the driver. The driver was en route to take his passengers home from a night out together and was traveling at a high rate of speed. After the Camaro had just negotiated a long straight, downgrade section of road, which had been four-lanes and divided, the road abruptly changed to a two-lane undivided highway. At this point, the road also turned to the right at a sharp seven-degree curve.

Due to the Camaro's high speed, it traveled out of its lane and across the double solid yellow centerlines and entered the westbound lane at the end of the curve. The driver steered hard to his right in an attempt to correct his errant movement and, as a result, the car abruptly re-entered the eastbound lane. Apparently realizing that the car was coming back too sharply into the lane, the driver steered back to the left in a hard fashion. This movement caused the Camaro to travel out of control, while rotating counter-clockwise as it yawed diagonally across the centerlines and the westbound lane. After sideslipping 238 feet across the pavement, the car left the road sliding on the gravel/sod shoulder bordering the westbound lane. It traveled down a slight ditch line while furrowing in the soft dirt/gravel then entered a large, grassy open field. While in the field, the car rotated until it was positioned nearly 180 degrees from its original heading. It was now traveling backwards through the field. From the point it ran off the

pavement to the point its' rear struck the first of three trees, the car traveled 217 feet. The Camaro's rear bumper and trunk struck a six-inch diameter tree, causing the car to abruptly stop. The tree penetrated 39 inches into the car's rear directly in the center of the trunk.

Due to the driver not wearing his safety belt, he was partially ejected through the driver's door. He received multiple injuries to his head, neck, and chest, which proved fatal. The passenger in the car's rear also died instantly in the traumatic collision. The right front passenger survived the collision with serious multiple injuries to his chest, head, and back. Both he and the rear seated passenger remained in the car after the collision.

DISCUSSION:

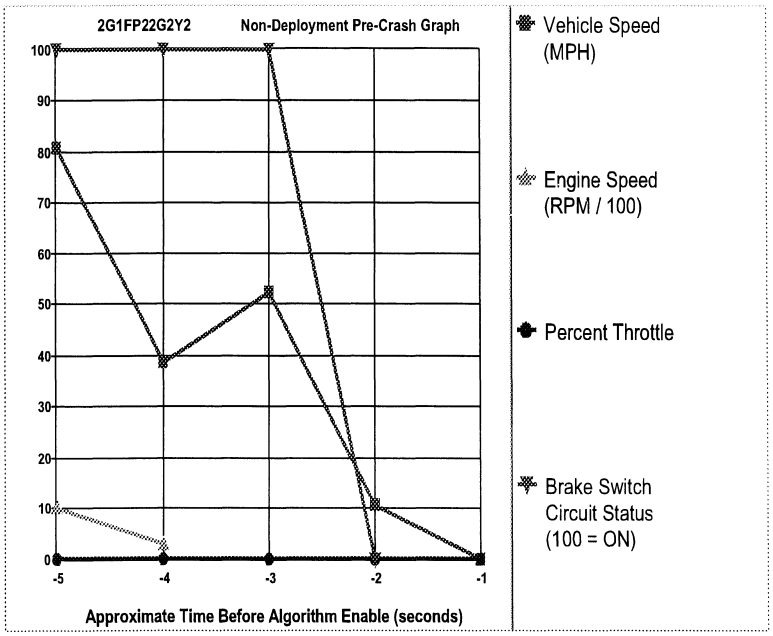
The Camaro's two front airbag systems did not deploy. It is believed that they did not deploy because of the rear impact and that the car had decelerated enough that frontal impact forces were insufficient to fire the airbags. (It should be noted that the non-deployment of the airbags is not a defect in the system and that their lack of deployment did not increase the injuries sustained to the car's occupants). According to the car's Event Data Recorder (EDR), this collision resulted in a "Near Deployment" event, thus the EDR captured certain crash related information. Of the information that was captured, at least two items could be compared with the available physical evidence on the roadway and on the vehicle. The maximum vehicle speed occurring about five seconds before the airbag triggering system activated (referred to as algorithm enable) was recorded at 81 mph. This speed was recorded while the Camaro was still on the pavement as it diagonally crossed the roadway. Over the following two seconds, the car slowed to about 52 mph before it stopped against the trees. The Crash Team measured the car's yaw marks on the pavement. Using the critical speed equation, which utilizes the pavement's friction coefficient and the car's center-of-gravity radius, the Team calculated that the speed of the car was 82 mph. The probable impact speed of the Camaro, as indicated by its damage, was calculated at about 33 mph. Combining the several speeds along the several different surfaces that the Camaro crossed with the impact speed yielded a probable initial speed of about 79 mph. This combined speed matches very closely the EDR's speed of 81 mph.

The “Brake Switch Circuit Status” recorded on the EDR indicated that it was “on” just before the car struck the tree. The double filament brake and tail lamp bulb removed from the car’s left rear revealed a hot shock distortion and a hot fracture to both the taillight and brake-light coils respectively. These two conditions on the lamp filament, part of a forensic examination and analysis, prove conclusively that the brakes were being applied by the driver at least two seconds prior to impact. By virtue of these comparisons, it is conclusive that the Camaro driver did in fact brake in an attempt to stop.

In conclusion, it would appear that the limited amount of information captured by the Camaro’s EDR matched both the crash investigation and forensics analysis in this case.

System Status At Non-Deployment

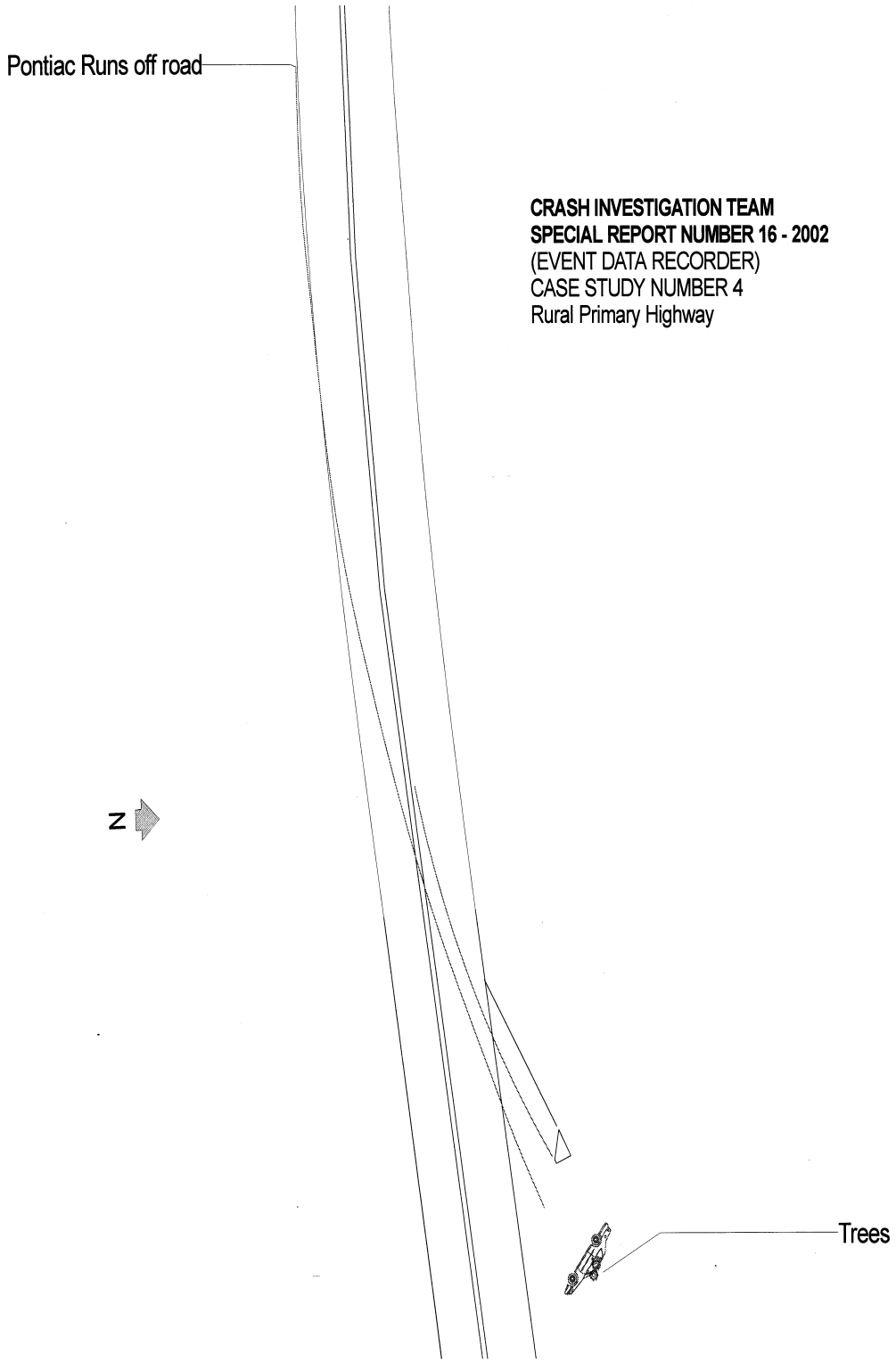
SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	UNBUCKLED
Passenger Front Air Bag Suppression Switch Circuit Status	Air Bag Not Suppressed
Ignition Cycles At Non-Deployment	875
Maximum SDM Recorded Velocity Change (MPH)	0.00



Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status
-5	81	960	0	ON
-4	39	320	0	ON
-3	52	Invalid	0	ON
-2	11	Invalid	0	OFF
-1	0	Invalid	0	Invalid

Photo #5- Damage to the rear trunk area of the 2000 Chevrolet Camaro Super Sport from impact with the tree. The six-inch diameter tree penetrated 39 inches into the car's rear. A reading of 52 mph was recorded on the EDR during the car's last three seconds before the airbag triggering system activated, or algorithm enable (AE).

Photo #6- Final rest of the Camaro was against the pine tree in the center of photo. The tree did not yield in the collision. The car's EDR recorded a high speed of 81 mph before it ran off the road. The yaw mark analysis indicated a speed of 80 mph measured on the pavement, about 375 feet before impact with the tree, while the car was sideslipping across the pavement.


Pontiac Runs off road
CRASH INVESTIGATION TEAM
SPECIAL REPORT NUMBER 16 - 2002
(EVENT DATA RECORDER)
CASE STUDY NUMBER 4
Rural Primary Highway
N
Trees

CASE STUDY NUMBER 4

Type of Crash: Single vehicle, fixed object side/roof impact

Vehicle Involved: 2001 Pontiac Grand Am **(Event Data Recorder)**

Roadway: Rural primary highway

Severity: One fatality, Pontiac totaled

SUMMARY:

On a clear, dry Wednesday evening in May at about 10:30 p.m., a lone 24-year-old male was driving his 2001 Pontiac Grand Am east on a rural, two-lane primary highway. He was not wearing his safety belt and had been drinking alcoholic beverages. It was reported that he had been visiting some friends and was returning home. The 55 mph speed limit roadway is asphalt, in excellent condition and is marked with typical solid white edge lines and double solid yellow centerlines. Just before reaching a relatively sharp left hand curve posted with a 50 mph advisory sign, the driver sped up to a high rate of speed. Once the Pontiac entered the curve, it traveled about 350 feet within the curve's 550 feet total length, where its right side tires gradually left the pavement. With these tires on the narrow gravel and sod shoulder, the driver steered around the curve for approximately 125 feet. Obviously aware of his situation, he steered hard to his left in an attempt to regain the roadway. In doing so, the car crossed the pavement at an abrupt angle and began to yaw on the asphalt surface as it headed toward the opposite side of the highway.

The Pontiac traveled 115 feet, diagonally crossing the roadway. It also rotated counter-clockwise, and the sudden weight change onto the right side caused the car to leave two dark scuffmarks from the right side tires and two faint scuffmarks from the left tires. The out-of-control Pontiac then ran off the left side of the road onto a grassy shoulder, traveling an additional 67 feet. Because the shoulder was several feet lower than the roadway, the car went partially airborne bouncing across the grass, and began to roll onto its right side. Before rolling completely, the Pontiac slammed into three trees,

abruptly halting its movement, and causing severe crush damage to the right passenger side and roof. The right front door and roof were crushed inward/downward nearly two feet. The car came to rest on its wheels, facing northeast, several feet from the struck trees. The unbelted driver died instantly in the collision from multiple head, body, and neck injuries. He remained inside the car, slumped rearward partially behind the right front seat. The car was located about 25 feet from the pavement in some brush, and trees and was found by a motorist who notified the authorities.

DISCUSSION:

Two recorded items from the Pontiac's Event Data Recorder (EDR) were comparable to the physical evidence collected at the scene and on the car. The data were vehicle speed and whether the driver was belted.

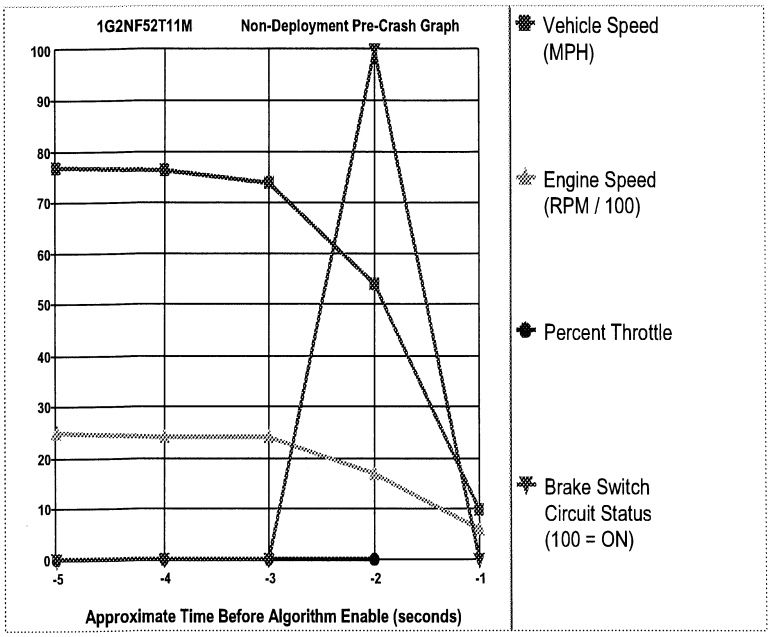
In this situation, the Pontiac's speed as recorded over the last five seconds before the airbag's sensor was triggered (also referred to as algorithm enable) was 77, 76, 74, 54 and 10 mph respectively. The measured yaw mark radius from the car's right front tire scuffmark indicated a speed of about 71 mph. This speed was calculated while the car was sideslipping across the eastbound lane. This measurement was taken about 155 feet prior to impact. Since the Pontiac traveled off the pavement the second time and started furrowing across the grassy shoulder leading up to the trees, it would have naturally slowed over this distance. Therefore, it appears the yaw mark speed of 71 mph is consistent with the recorded EDR speeds of 74-76 mph. Likewise, it would appear that the EDR speed of 54 mph recorded up to two seconds before the airbag system was to deploy is consistent with the car decelerating across the shoulder as it slid up to the trees before impact.

The airbags inside the car did not deploy during the crash sequence mainly because impact forces on the car centered on the right side and roof. This evidence confirms the EDR classifying it as a "Non-Deployment Event". The EDR indicated that the driver' belt switch circuit status was "not buckled" at the time of the crash. Due to the driver being partially thrown into the backseat and because no energy transfer marks on his lap/shoulder belt system were detected, this recording is confirmed.

Although the captured data was limited in this instance, the two readings of the EDR match the available physical evidence at the scene.

System Status At Non-Deployment

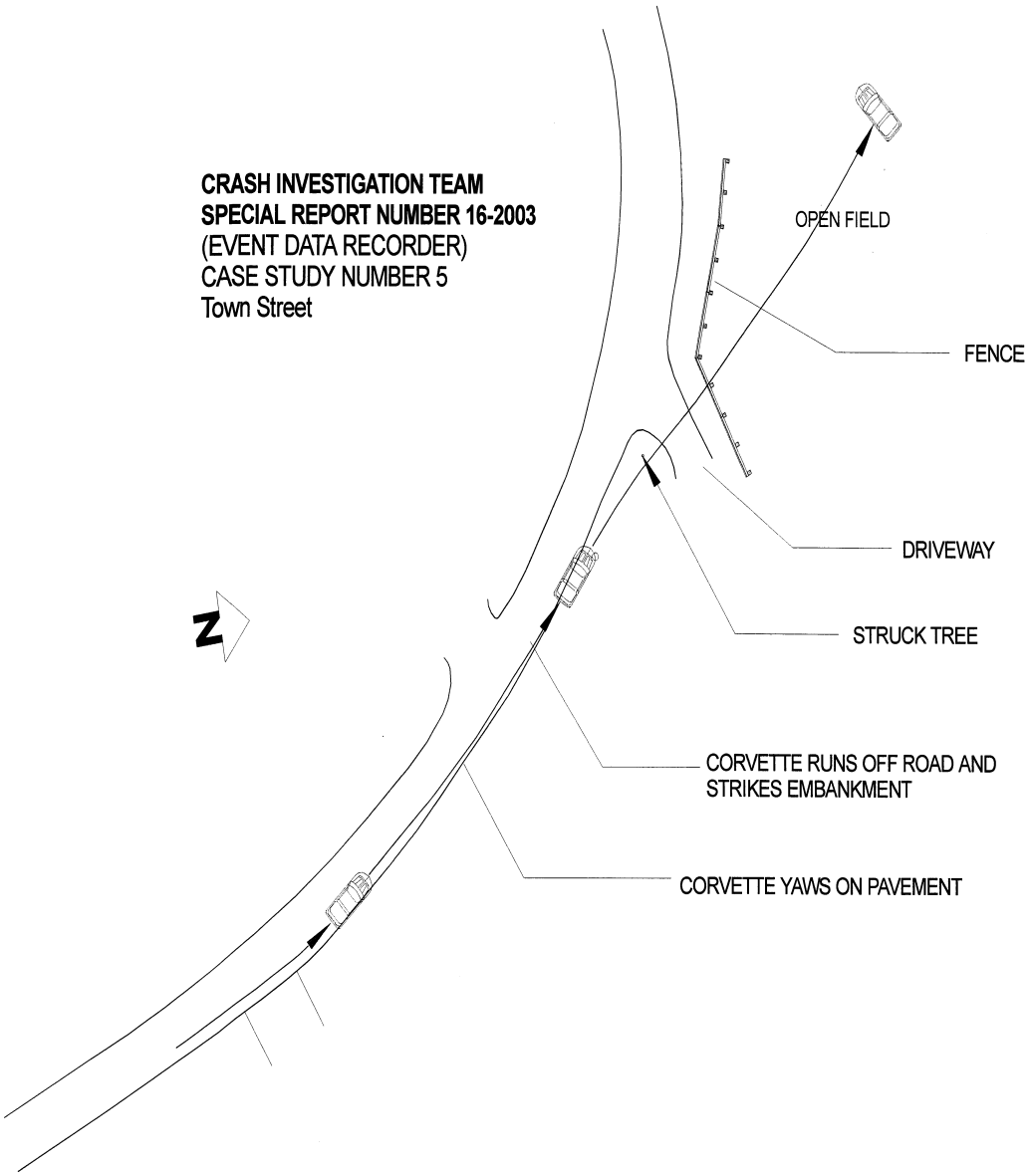
SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	UNBUCKLED
Passenger Front Air Bag Suppression Switch Circuit Status	Air Bag Not Suppressed
Ignition Cycles At Non-Deployment	3915
Maximum SDM Recorded Velocity Change (MPH)	0.00



Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status
-5	77	2496	0	OFF
-4	76	2432	0	OFF
-3	74	2368	0	OFF
-2	54	1664	0	ON
-1	10	576	Invalid	OFF

Photo #7- Damage to the 2001 Pontiac Grand Am from impact with the tree. Initial collision occurred on the car's right side and roof, collapsing the top nearly two feet onto the driver. The EDR recorded a high speed of 76 mph about four seconds before the airbag triggering system activated (AE).

Photo #8- Final rest of the Grand Am was against the trees in the center of photo. The trees did not yield in the collision. The yaw mark analysis indicated a speed of 71 mph measured on the pavement, about 125 feet before impact with the trees.


CRASH INVESTIGATION TEAM
SPECIAL REPORT NUMBER 16-2003
(EVENT DATA RECORDER)
CASE STUDY NUMBER 5
Town Street
OPEN FIELD
FENCE
DRIVEWAY
STRUCK TREE
CORVETTE RUNS OFF ROAD AND
STRIKES EMBANKMENT
CORVETTE YAWS ON PAVEMENT
N

CASE STUDY NUMBER 5

Type of Crash: Single vehicle, fixed object frontal impact

Vehicles Involved: 2001 Chevrolet Corvette **(Event Data Recorder)**

Roadway: Town street in rural subdivision

Severity: One fatality and extensive property damage

SUMMARY:

On a clear, dry Monday afternoon in January at 1:54 pm., a 2001 Chevrolet Corvette was traveling north on a town street within a rural subdivision. The car was being operated at a high rate of speed over this hilly and winding roadway posted for 25 mph, by a lone, unbelted 55-year-old male. The driver was a retired military man who had been medically discharged and was leasing the Corvette from a new car dealership located in the town. The driver, after having an altercation with his sister about keeping a scheduled doctor's appointment, drove out of his driveway in a huff and headed in the direction opposite his doctor's office.

Near a point where the narrow, asphalt roadway dead-ends into a cul-de-sac, the driver accelerated down a steep grade. At the bottom of the grade, the road turns to the left and ascends a steep upgrade. Bordering the road on the right is a four-foot-high grassy embankment adjacent to several trees and a large pasture surrounded by a wooden fence. As the Corvette was negotiating the first quarter of the curve, it began to sideslip on the pavement. Near the edge of the northbound lane, the car's right side tires made two scuff marks on the asphalt. These tire marks were in a classic, yaw mark pattern, initially starting as narrow/faint with diagonal striations throughout their width and darkening as they continued northbound. The tire marks also displayed a "crossover" pattern, indicating that the right rear tire had crossed on top of the front tire mark as the car's rear was beginning to travel in a yawing movement. After sideslipping on the pavement about 110 feet, the Corvette ran off the road, where it struck and mounted the raised embankment. It then traveled 103 feet along the embankment and struck an old tree stump at the top of the grade. It then went airborne a short distance and its front end

collided with a tree about five feet above the ground. The impact was so great that the 13-inch diameter tree broke in half and the Corvette traveled further colliding with and passing through a wooden fence. It then came to rest on its wheels in a pasture, facing west about 100 feet beyond the fence. The car's front end was destroyed and its dislodged battery was thrown more than 90 feet from final rest.

The Corvette's unbelted driver remained inside the car. He had violently struck the steering wheel, windshield and dashboard as the car's air bags were deploying. He died instantly from massive head and chest injuries. Residents in the neighborhood found him several minutes after the crash, slumped over the center console to his right. He was unbelted and had already expired. No signs of evasive action by the Corvette driver were detected over the nearly 215 feet the car traveled on the pavement and along the embankment.

DISCUSSION:

The Crash Investigation Team learned that the Corvette driver was emotionally and mentally disturbed at the time of the crash. Because of his troubled background (physical, mental, financial and personal), it is possible that he was driving at such a high speed and in an irresponsible manner with the intent to commit suicide. The physical evidence found at the scene and the data contained in the Event Data Recorder (EDR) match the operator's driving actions immediately before the fatal crash.

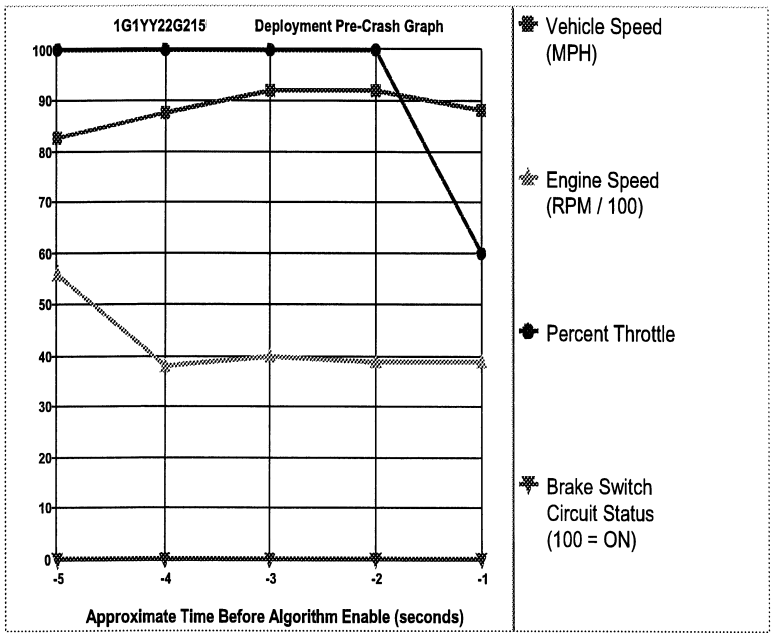
The Crash Team downloaded the EDR. The information captured during this deployment event was compared to the evidence from the investigation. The passenger front airbag suppression switch circuit status was noted as "Not Suppressed". The deployment of both air bags indicated that the system was indeed working properly and that the passenger side airbag had not been suppressed. The "Driver's Belt Switch Circuit Status" was noted as "Unbuckled" on the EDR record. This reading was validated by the lack of energy transfers on the belt webbing and D-ring/latch plate assemblies and by the obvious impact injuries to the driver and the corresponding damage to the car's interior caused by contact with the driver's body. The EDR also recorded speeds of between 83-92 mph over the five seconds before the airbag system triggered (referred to as algorithm enable). Over this same corresponding time-period, the percent throttle was recorded at 100% during the first four seconds and 60% during the last second before the airbags

deployed. These speeds closely match the 79 mph speed calculation computed from the Corvette's right front tire yaw mark on the pavement. "The Brake Switch Circuit Status" indicated that it was "Off" during the entire five seconds of recorded data. This corroborates the findings at the scene, where no braking skid marks were detected on the pavement before the Corvette struck and mounted the embankment.

The data recorded on the EDR and the information collected at the scene and from the car closely correspond and appear to be reliable and accurate with the actual circumstances during the pre-crash and crash events surrounding this mishap.

System Status At Deployment

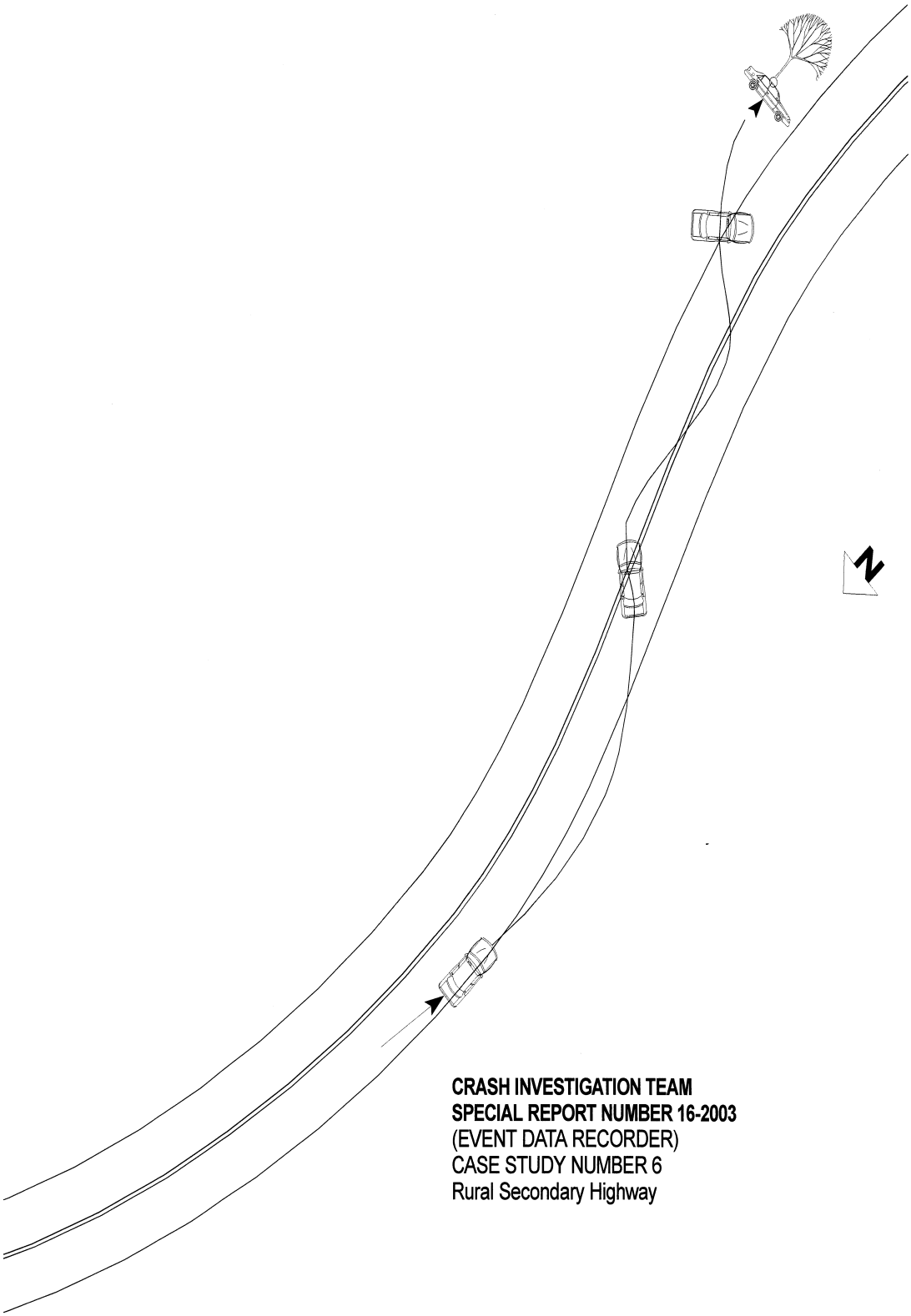
SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	UNBUCKLED
Passenger Front Air Bag Suppression Switch Circuit Status	Air Bag Not Suppressed
Ignition Cycles At Deployment	743
Time Between Non-Deployment And Deployment Events (sec)	.3



Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status
-5	83	5632	100	OFF
-4	88	3840	100	OFF
-3	92	3968	100	OFF
-2	92	3904	100	OFF
-1	88	3904	60	OFF

Photo #9- Right side view of the 2001 Chevrolet Corvette. The entire front end was destroyed by the impact with the tree, yard and wooden fence. The maximum speed as recorded on the EDR was 92 mph measured in the roadway about 300 feet prior to running off the road.

Photo #10- Measurements taken of the tire yaw marks made by the Corvette's right side tires about 110 feet before the car ran off the road. A pre-impact speed of 79 mph was calculated from using the car's right front tire mark.



CRASH INVESTIGATION TEAM
SPECIAL REPORT NUMBER 16-2003
(EVENT DATA RECORDER)
CASE STUDY NUMBER 6
Rural Secondary Highway

CASE STUDY NUMBER 6

Type of Crash: Single vehicle, fixed object side impact

Vehicles Involved: 2001 Chevrolet Cavalier Z-24 (**Event Data Recorder)**

Roadway: Rural, secondary highway

Severity: Two fatalities, one serious injury and extensive property damage

SUMMARY:

On a misty and damp Sunday morning in April at 3:57 a.m., a 22-year-old male driver, accompanied by a 21-year-old male in the right front and a 15-year-old male in the left rear, was driving south on a winding and hilly secondary road. The two front seat occupants were wearing their safety belts and the rear-seated passenger was not belted. The three occupants were good friends and were returning home after visiting with other friends in the area. The two front seat occupants were on-leave from active military service and were drinking heavily.

The driver was operating his two-door 2001 Chevrolet Cavalier Z-24 at a high rate of speed on this residential road posted for 35 mph. The roadway in the vicinity was marked with double solid yellow centerlines, solid white fog lines and bordered by trees/brush and intermittently spaced houses. After negotiating a long straight downgrade, the car entered a short, relatively sharp, "S" shaped curve to the left. At a point near the end of the first curve and after rounding about 220 feet of the curve's 250 foot length, the Cavalier's right side tires ran off the right edge of the road about three feet and traveled nearly 100 feet along the grassy shoulder bordering the pavement.

The intoxicated driver, obviously aware of his situation, steered back to the left in an attempt to regain the road. The car abruptly re-entered the pavement and traveled diagonally across both lanes as the curve now turned to the right. As the car was traveling across the damp pavement, the driver over-steered a second time, this time to the right. The car's direction began to change from eastward to southward, but the steering angle was so sharp that the car began to yaw, causing the two left tires to leave scuffmarks on the asphalt. The Cavalier sideslipped approximately 120 feet across the pavement to where it ran off the left side of the road. It slid across the grassy shoulder bordering the northbound lane and crossed a shallow ditch while furrowing through the sod. After

traveling nearly broadside about 100 feet in the wet soil, the car began to tip over onto its left side just before it struck two hardwood trees with its left side and roof. The car at this point was facing west and the trees instantly stopped its forward movement. The Cavalier bent around the trees and its two doors and roof collapsed onto the two front-seated occupants. During this sequence, the unbelted rear passenger was ejected through the rear glass and came to rest on the grassy shoulder 35 feet beyond the struck trees.

At final rest, the car remained on its left side, facing west, 18 feet from the edge of the road. Both belted occupants died instantly in the collision from massive head and neck injuries. The ejected passenger received multiple body and head injuries and is still in critical condition at the time of this report's writing, three months after the crash. He is expected to survive but will have physical and mental disabilities.

DISCUSSION:

The Cavalier was equipped with an Event Data Recorder (EDR). Physical evidence existed on the car and on the roadway that was analyzed in this crash. Both front airbags deployed because of the impact with the two trees; even though the impact was to the roof and the side of the Cavalier. The front passenger airbag suppression switch circuit status was noted by the EDR as "Airbag Not Suppressed". It was functioning properly and responded as designed as confirmed by this airbag deploying in the collision. The driver's belt switch circuit status was noted as "Buckled". This was validated when rescuers found that the driver remained in his seat with the belt around him after the crash. In order to extract him, they had to cut the webbing.

From a yaw mark analysis the calculated speed from two different locations within the left front tire mark's radius indicate the car was traveling at least 76 mph. The last five seconds of time before the airbags deployment, as noted by the EDR and starting with the fifth second, indicates the car was traveling "93, 88, 80, 60 and 33mph". These readings indicate that the SDM began to record the car's movement about 500 feet before impact with the trees. This location would have placed the Cavalier on the straightaway just before the beginning of the reverse (S-shaped) curve. The yaw mark's speed estimate was taken as the car was sideslipping across the yellow centerlines, a point that was 150 feet before impact. At this location, the car would have naturally slowed down from the highest speed recorded, due to the effects of gravity and the resistance of the tires slipping on the pavement. It was noted on the EDR that the "Brake Switch Circuit Status" was "on" during only the fifth second before impact and off the following four seconds.

The percent throttle was noted as "2%" during the entire time line and the engine speed (RPM's) were also reducing for each second. These readings indicate that the car was decelerating on its own, without braking on the part of the driver, over the last four seconds before deployment. However, due to a faulty reading in the Brake Switch Circuit Status the Cavilier driver was actually braking over the last four seconds (See Addendum below).

Based on the last speed recorded, which was within one second before airbag deployment, the Cavalier had slowed to "33 mph". Since the car sustained nearly 24 inches of crush in its two doors, and the roof was collapsed onto the top of the front seats and the frame was noticeably bent, an accurate speed estimate from crush alone is not possible. Considering that the vehicle continued to decelerate even during the last second before impact with the tree, the 24 inches of crush appears consistent with the 33mph, which is the speed the EDR recorded one second out.

It is concluded that the speed ranges recorded on the EDR, while the car was traveling on the roadway, appear to be reliable and accurate and when compared to the physical evidence.

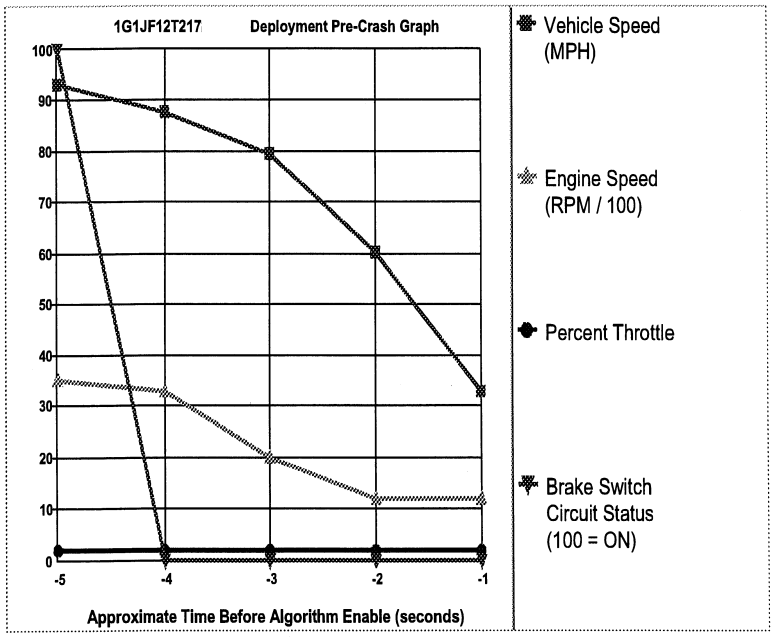
ADDENDUM:

Since this investigation, the Crash Team was alerted of an anomaly with certain model GM vehicles that have the potential of a reversed brake switch signal indication. It is our understanding that the issue is not with the Vetronix Crash Data Retrieval Software but rather with an inappropriate signal from the power control module on the specific vehicle. If the car is a 2000-2002 Chevrolet Cavalier Z-24 or a Pontiac Sunfire GT with a manual transmission and a 2.4 litre engine, the "Brake Switch Circuit Status" 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" and vice versa.

The Crash Team examined the 2001 Chevrolet Cavalier Z-24 noted in this case study and determined that the brake lamp bulb filament incurred excessive hot shock distortion at the time of impact. This confirmed that the driver was in fact braking over the last several seconds prior to impact and that the anomaly had occurred as indicated. Therefore, the indications of the "Brake Switch Circuit Status" for the last 5 seconds before AE are reversed in this case. In newer versions of the download software, this has been noted within the SDM Data Limitations section. This reinforces the need to examine the physical evidence in conjunction with the EDR download.

System Status At Deployment

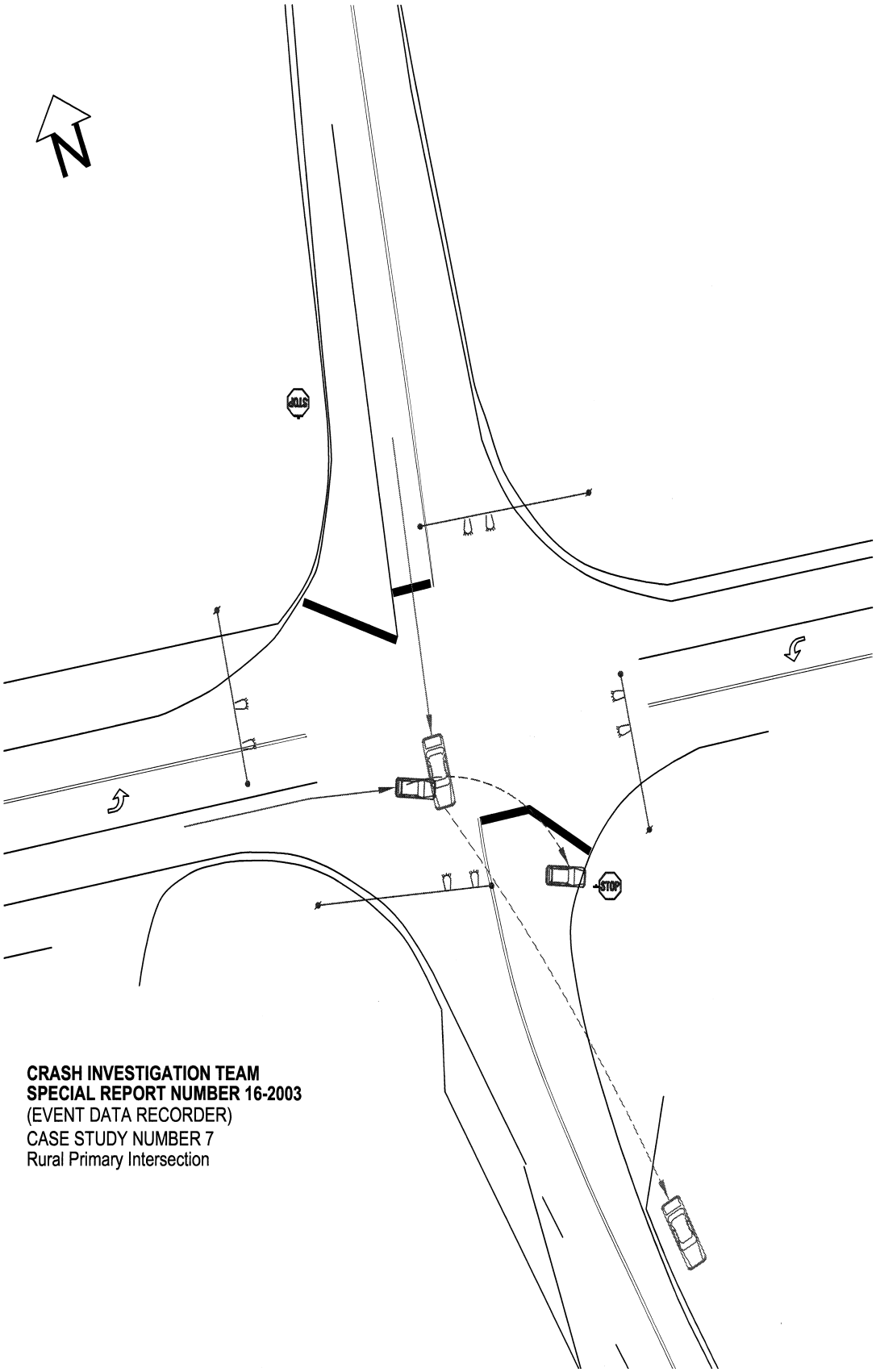
SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	BUCKLED
Passenger Front Air Bag Suppression Switch Circuit Status	Air Bag Not Suppressed
Ignition Cycles At Deployment	4658
Ignition Cycles At Investigation	4659
Maximum SDM Recorded Velocity Change (MPH)	-9.45
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	142.5
Time Between Non-Deployment And Deployment Events (sec)	0
Time From Algorithm Enable to Deployment Command Criteria Met (msec)	47.5



Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status
-5	93	3456	2	ON
-4	88	3264	2	OFF
-3	80	2048	2	OFF
-2	60	1216	2	OFF
-1	33	1152	2	OFF

Photo #11- Damage to the 2001 Chevrolet Cavalier Z-24 from impact with the trees. The roof and sides were collapsed nearly 24 inches onto the occupants. The last reading as indicated by the EDR was recorded at 33 mph.

Photo #12- View of the soft grassy-ditch line and the trees where the Cavalier came to rest. The maximum speed, as recorded on the EDR, was 93 mph at about 500 feet before impact. The yaw marks yielded a speed of at least 76 mph measured about 150 feet before impact.



CRASH INVESTIGATION TEAM
SPECIAL REPORT NUMBER 16-2003
(EVENT DATA RECORDER)
CASE STUDY NUMBER 7
Rural Primary Intersection

CASE STUDY NUMBER 7

Type of Crash:	Two vehicles, angle collision
Vehicles Involved:	2000 Cadillac Seville **(Event Data Recorder)** 1998 Ford Escort
Roadway:	Rural, two lane primary roads/intersection
Severity:	Two fatalities, two injuries and extensive property damage

SUMMARY:

On a clear, dry Wednesday morning in April at 10:34 a.m., a 78-year-old male was driving his 2000 Cadillac Seville SLS, four-door sedan south on a rural two lane undivided primary highway. He was from out of state and not familiar with the roadway or his surroundings. The driver was visiting with friends and taking them to a business location about 30 miles away. Accompanying the driver was a 78-year-old male in the right front and 77-year-old female in the right rear. All the occupants were properly wearing the car's lap and shoulder safety belts.

After exiting an interstate highway, the driver turned right onto the primary highway and then proceeded south about one mile. The two-lane roadway is posted for 55 mph and typically marked with yellow and white pavement striping. At a point 1000 feet before an upcoming intersection, the level road gently turns to the left and then straightens. Typical signing is posted, advising southbound motorists that a stop requirement is approaching. Above the four-way crossroad intersection were two flashing red traffic signals. An oversize stop sign complimented with a white stop line are located just before the intersection. It was the intent of the Cadillac driver to go straight through the intersection and continue to his destination. However, the driver apparently failed to detect the appropriate warnings and traffic controls and did not stop before entering the intersection. Approximately 52 feet beyond the stop line, in the center of the right, eastbound lane of the intersecting roadway and still within the intersection, an eastbound auto struck the Cadillac.

The eastbound car was a 1998, Ford Escort ZX2 two-door coupe, driven by a lone, unbelted 24-year-old male. Apparently seeing the Cadillac enter the intersection when he was also entering the intersection, the Ford driver slammed on his brakes and steered slightly to his right. After skidding 36 feet on the slight downgrade, asphalt surface, the Ford's full front impacted the Cadillac in its right front side, squarely in the right front door adjacent to the front passenger. The Cadillac sustained 18 inches of collapse in the side door and the Ford about 20 inches of collapse to its front. Because the Cadillac was moving at impact and crossing the Ford's path left-to-right, the Ford's front end was pulled to the right, about 10 inches off its normal design. The Ford then rotated clockwise on the road surface nearly 340 degrees and came to rest about 50 feet southeast of the point of impact. The Cadillac was initially pushed about 10 feet eastward at impact where it ran off the eastern edge of the highway. At final rest, it was still facing south and located on the gravel/sod shoulder 137 feet south of the impact point. No evasive pre-crash evidence was found for the Cadillac.

All occupants remained inside the vehicles when they came to rest. The Cadillac's right front passenger died instantly in the collision from massive head, neck and chest injuries. The Cadillac driver was still conscious and alert although he received severe contusions to his upper body. He died within three weeks of the crash, however, from complications of his injuries. The Cadillac's rear passenger survived the collision with only minor physical injuries. The Ford driver survived the collision with varying moderate chest, extremity and head injuries.

DISCUSSION:

The Cadillac was equipped with an Event Data Recorder (EDR). Since the car still had its battery connected and the electrical system was functioning properly, the EDR was read by connecting the cable to the Diagnostic Link Connector port. Several of the captured items were then compared to the relevant physical evidence, both on the roadway and vehicles. The "Front Passenger Airbag Suppression Switch Circuit Status" was noted as "Airbag Not Suppressed". Both front airbags deployed, indicating that the system was working properly. The "Driver's Belt Switch Circuit Status" indicated the driver was "Buckled". Since the drivers webbing had to be cut by rescuers and he reported that he was belted, the reading on the EDR was confirmed. The Cadillac's

speeds over the last five seconds before deployment, beginning with the fifth second, were "44,40,40,39 and 39" respectively. The recorded "Percent Throttle" was "3, 3, 3, 3 and 0". The "Brake Switch Circuit Status" indicated that the driver braked at five and four seconds and that no braking occurred during the last three seconds before deployment.

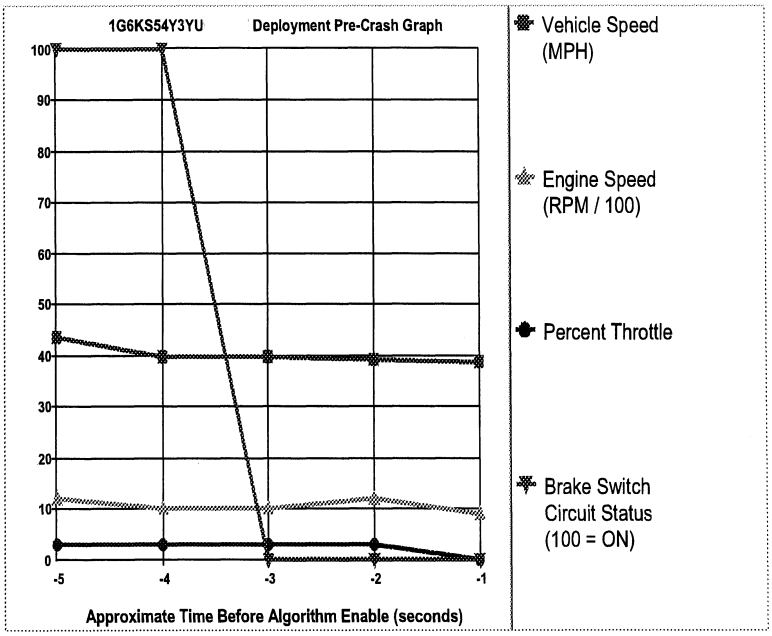
By using the principles of the *Conservation of Momentum,* the Team calculated that the Cadillac and Ford were traveling about 37 and 49 mph respectively at the instant of impact. When interviewed by the investigating Trooper, the Cadillac driver insisted that he could not believe that he did not stop before pulling into the intersection. Due to his injuries and the shock of the crash, he could not recall the actual circumstances leading up to the collision. The Team used another accepted method in an attempt to calculate the maximum speed the Cadillac could have obtained had it accelerated from a stopped position at the stop line to the point of impact. The speed from this calculation was only about 22 mph or about 17 mph below what the EDR recorded and 15 mph below the momentum analysis.

The Ford driver and an off duty sheriff's deputy who witnessed the collision, both said that the Cadillac never stopped before entering the highway. The deputy confirmed that the Ford driver attempted to stop by skidding as it entered the intersection. This witness also said that the Ford's speed before it began to skid was "hot", indicating that the Ford, at least in the witnesses' mind, was exceeding the posted speed limit of 55 mph. When the Team combined the Ford's pre-impact skid marks speed (29 mph) with the momentum-calculated speed (49), an initial minimum speed was estimated at 57 mph. However, when considering that the speeds calculated by using these types of equations tend to be conservative, it is likely that the Ford was traveling at least several mph higher than the 57 mph estimate.

The Crash Team concludes that the data contained in the Cadillac EDR could be corroborated with the existing physical evidence.

System Status At Deployment

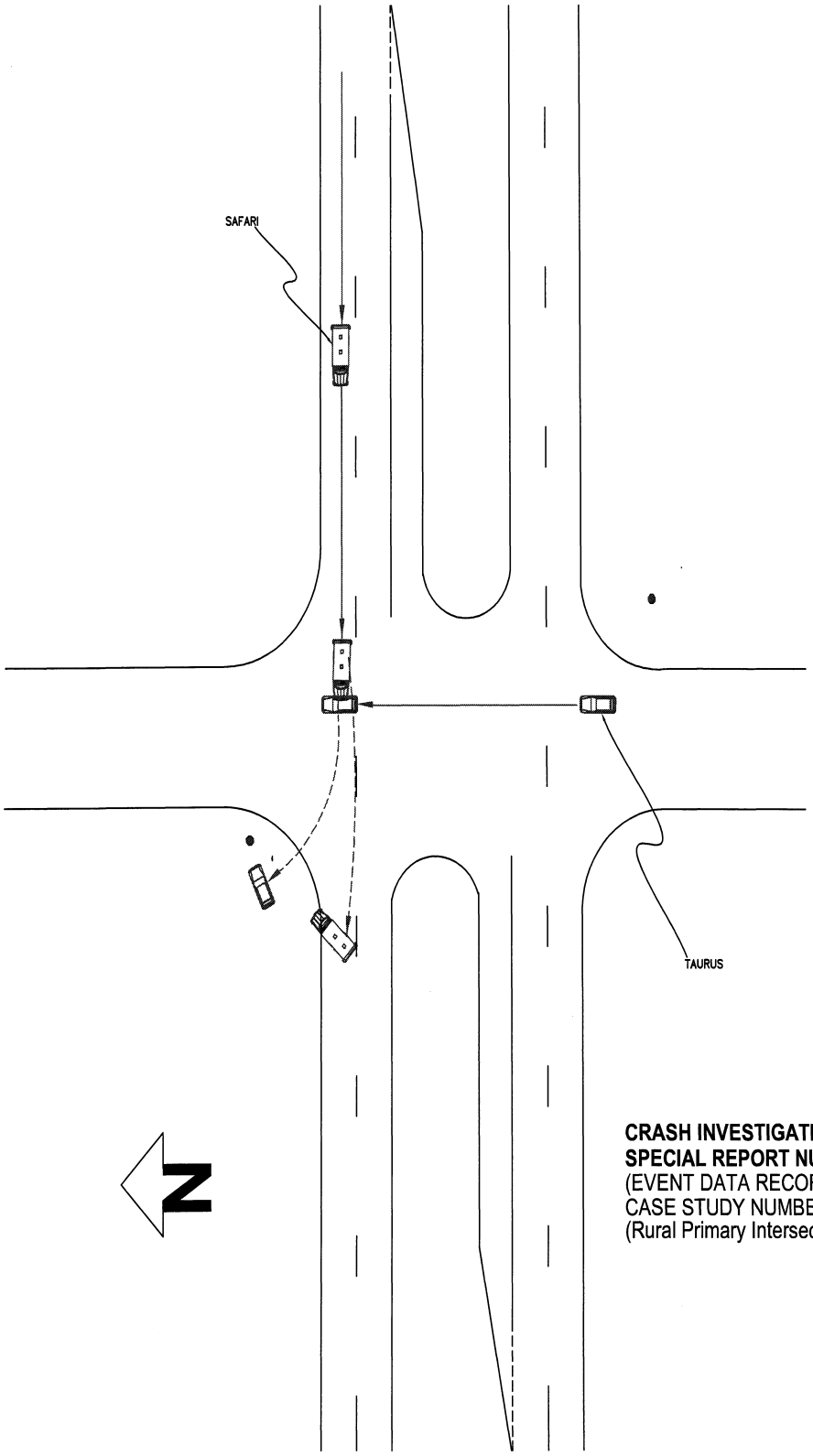
SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	BUCKLED
Passenger Front Air Bag Suppression Switch Circuit Status	Air Bag Not Suppressed
Ignition Cycles At Deployment	6634
Time Between Non-Deployment And Deployment Events (sec)	N/A



Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status
-5	44	1152	3	ON
-4	40	1024	3	ON
-3	40	1024	3	OFF
-2	39	1152	3	OFF
-1	39	896	0	OFF

Photo #13- Damage to the 2000 Cadillac Seville SLS from impact with the Ford Escort. Maximum deformation was measured on the right side at 18 inches. The EDR recorded the speed of the Cadillac at 44-39 mph before the airbag triggering system activated (AE).

Photo #14- Damage to the 1998 Ford Escort ZX2 caused from colliding with the Cadillac. Maximum static crush sustained to the Ford's front was measured at 20 inches. Momentum analysis indicated that at impact the Ford was traveling at least 49 mph and the Cadillac at 37 mph.



CRASH INVESTIGATION TEAM
SPECIAL REPORT NUMBER 16-2003
(EVENT DATA RECORDER)
CASE STUDY NUMBER 8
(Rural Primary Intersection)

CASE STUDY NUMBER 8

Type of Crash: Two vehicle, angle collision

Vehicles Involved: 2001 GMC Safari Van **(Event Data Recorder)**
2003 Ford Taurus **(EDR not readable)**

Roadway: Rural, four lane divided primary road/intersection

Severity: One fatality, four injuries and extensive property damage

SUMMARY:

On a clear, dry Sunday afternoon in July at 3:35 p.m., a 2001 GMC Safari van was traveling west on a rural four lane divided highway. The full size cargo van loaded with computers and related components, was driven by a lone unbelted 36-year-old male. As the van was cresting a long straight upgrade section of the roadway posted for 55mph and approaching a four-way intersection, a northbound car was approaching through a median crossover in front of the van. The car, a 2003 Ford Taurus four-door sedan, was driven by a belted 54-year-old male. The driver was accompanied by three family members, all on vacation and visiting the area. Seated in the right front, adjacent to the driver was his 6-year-old son. The driver's unbelted wife sat in the right rear of the Ford accompanied on her left by her 6 year old daughter, the boy's twin. Both children wore their combination lap and shoulder belts.

The Taurus driver had just pulled out of the south intersection and intended to completely cross the highway. Apparently, while in the crossover, he did not see the van's approach to his right and entered the westbound lanes without stopping. Upon reaching the entrance to the intersection, when the car was near the center of the right westbound lane, it was struck in its right side by the van's front. The van driver at the last instant attempted to steer to his right and brake in an unsuccessful evasive movement. However, contact was made to the Ford's right rear door and wheel areas. The van penetrated the car's side about 13 inches, directly in the seated position of the Ford driver's wife. The van's front immediately collapsed rearward 13 inches. Because the Taurus was moving at impact, it caused the van's front end to be pulled to the right,

nearly 10 inches from its normal alignment. Both vehicles, while momentarily stuck together, began to rotate clockwise while traveling in a northwest direction toward the northern side of the roadway. After sliding across the westbound right lane about 20 feet, the vehicles separated and the car traveled another 30 feet to its final rest on the grassy berm just west of the intersection. It slid broadside off the pavement and furrowed across the grassy shoulder and up a slight embankment where its left rear fender knocked down a four inch wide wooden highway sign post. The car was facing northeast after rotating nearly 75 degrees from its original direction at impact. The unbelted right rear passenger received massive head and chest injuries and died instantly in the collision. The remaining three occupants received moderately severe injuries which were not life threatening. The Ford's airbag did not deploy; however, the belt system's pretensioners had fired during the collision. All occupants remained in the vehicle at final rest.

After impact, the van rotated about 125 degrees, entirely on the level asphalt pavement, and came to rest approximately 55 feet from the impact point. It was facing northeast, still within the westbound lane. The van's two front airbags had deployed and the driver stayed inside the vehicle.

The van's driver advised the investigating Trooper that he briefly saw the car cross the median and thought it was going to stop before entering the highway. But as he got closer, it suddenly pulled out in front of him with little time or distance for him to avoid the collision. He told the trooper that he was traveling about 55 mph, that he braked and swerved at the last minute and that he was wearing his safety belt.

The Ford driver advised that he did not see the van's approach and pulled out into the highway without stopping in the crossover. The reason his wife was in the back seat and not belted was because they had been regularly getting in and out of the car while visiting the Civil War battlefield in the immediate area. Their intent was to enter the park and use the facility's restrooms before driving to their next sightseeing stop within the park. He said that he and his children were belted.

DISCUSSION:

Physical evidence at the scene indicated that neither vehicle left any pre-impact skid marks. The only marks on the pavement were collision tire scuffmarks and light scrapes denoting the point of impact in the right lane. After impact, the vehicles

disengaged cleanly and their paths of travel could be traced along the roadway pavement and onto the grassy shoulder to their final rests. Because the damage to each vehicle was measured and analyzed, the vehicles' post-impact speeds could be calculated, and their speeds at impact could be estimated. These estimates were calculated by using *Conservation of Momentum and Energy*. Also, the Ford's speed could be calculated by using the accepted acceleration from a stop equation. These different methods could then be compared to the data recorded in the van's Event Data Recorder (EDR).

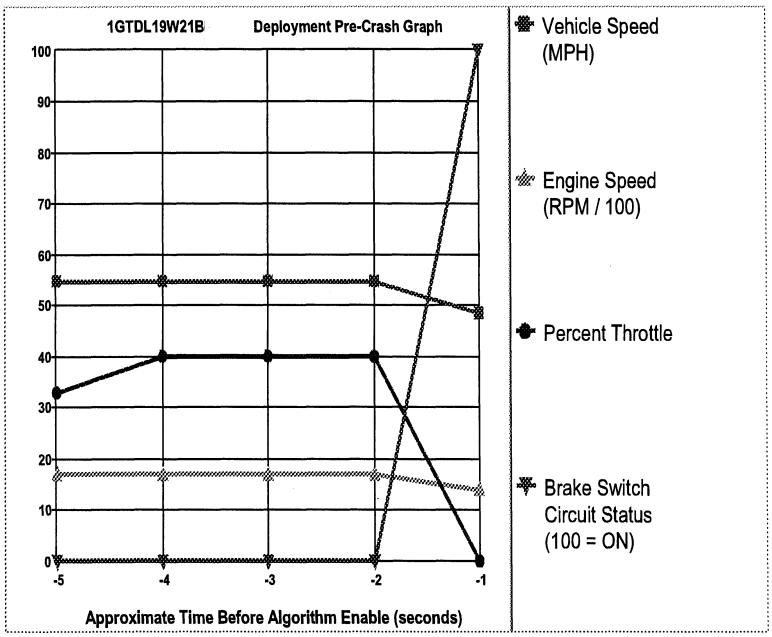
Both the van and Taurus sustained a maximum static crush or penetration of about 13 inches. When this was included in the speed estimation and was combined with the post-impact travel speed from both vehicles, a speed of about 47 mph was calculated for the van at impact. Momentum analysis indicated that the van and Ford's likely speeds at impact were about 45 and 17 mph respectively. Using the acceleration equation, the Ford's speed necessary to reach the point of impact from a stop at the stop sign was calculated at about 18 mph. The van's speed, as indicated on the EDR covering the last four seconds before deployment was recorded at 55 mph and over the last one second before deployment at 48 mph. Over the same corresponding time-period, the percent throttle was recorded at 33 and 40 percent, and over the last second before deployment at zero. The brake switch circuit status indicated that it was "off" over the first four seconds and "on" during the final one second. All of these readings indicate that the initial speed of the van was about 55 mph, as the driver said. In addition, the likely impact speed of the van was below 48 mph, as calculated by the *Conservation of Momentum and Energy* analysis. The percent throttle and brake switch circuit status readings confirm that the driver was in fact trying to avoid the collision by braking. The presence of the van's front tire collision scuffmarks on the pavement likewise confirm that the van was at a slight angle in the westbound lane at the impact point, indicating that he tried to avoid the crash by steering at the last instant.

The driver said he was wearing his safety belt. However, the EDR noted that the driver's belt switch circuit status was "unbuckled". The driver's belt system (webbing, D-ring, sliding latch plate and buckle) was examined and displayed no obvious load forces. This, combined with the driver sustaining chest bruising from striking the air bag as it deployed, indicated that he was not belted at the time of the collision. The right passenger airbag was not suppressed as indicated on the EDR. This data appears valid because of deployment of both airbags.

The 2003 Ford Taurus was also equipped with an Event Data Recorder (EDR) but not the type used in the 2001 GMC Safari van. General Motors' EDRs installed in most later model vehicles (1999 and later) are capable of recording a wide array of information, including real pre-impact speeds. The systems presently installed in Fords, called Restraint Control Modules (RCMs), are not designed to record real speeds, but do capture post-impact "changes in velocity" and other data regarding the deployment of restraint devices. However, the 2003 Taurus RCM is not supported at this time by commercially available software and thus the data cannot be downloaded. At present, only 2001 Taurus's and Sables as well as several other Ford cars and mini vans covering the years of 2001-2003, can be commercially read.

System Status At 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 Deployment	1694
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	55	1664	33	OFF
-4	55	1664	40	OFF
-3	55	1664	40	OFF
-2	55	1664	40	OFF
-1	48	1408	0	ON

Photo #15- Damage to the 2001 GMC Safari Van from impact with the Ford Taurus. Maximum static deformation was measured on the van's front at 13 inches. The EDR recorded the speed of the van at 55-48 mph before the airbag triggering system activated (AE).

Photo #16- Damage to the 2003 Ford Taurus from impact with the Safari Van. Maximum static deformation was measured at about 13 inches. Momentum analysis indicated that at impact, the van was traveling at least 45 mph and the Ford at least 17 mph. While the Ford was equipped with an EDR, it was not commercially readable and could not be downloaded by the team.

CONCLUSIONS

The Team found that the proper interpretation of data downloaded from EDR technology can be invaluable in verifying findings based on accepted methods of conducting accident investigation and reconstruction. Generally, the data recorded by the EDR was consistent with physical data observed with respect to seat belt usage, application of brakes, and whether or not the front passenger air bag deployment was suppressed. Significantly, in all but one of the illustrated case studies, the speed estimates from applying accepted methods of reconstruction were more conservative than the EDR readouts.

However, the Team also identified potential problems with the inappropriate use of this technology and with failure to interpret the information correctly. These potential problems can all be avoided by using EDR technology as a secondary supplement to accident investigation and reconstruction. First, it is imperative that the technology not be used as a stand-alone replacement for thorough crash investigation. It has been shown that a driver buckling the belt behind him would result in the data showing the belt as buckled. This did not mean, however, that the driver was actually wearing the belt. Likewise, the circumstances of any given crash could give misleading EDR readings. If a car leaves the ground, or a wheel breaks from the drive axle, while pressure is continuously applied to the accelerator, speed, throttle and engine speed may all be spiked inordinately high. In such cases, the EDR data, if used alone, would be interpreted out of the context of the actual crash, resulting in potentially faulty conclusions. Second, the Team strongly advocates that those teaching EDR operator certification classes stress that technicians conduct the reconstruction first then compare results with the EDR download. This will eliminate the tendency to rely primarily on the EDR data and then try to make the physical findings and measurements “fit” the downloaded information, a reversal that could lead to the wrong conclusions.

In summary, the Team considers EDR technology to be a valuable tool—and a significant advancement—when used in conjunction with accepted methods of crash investigation and reconstruction.