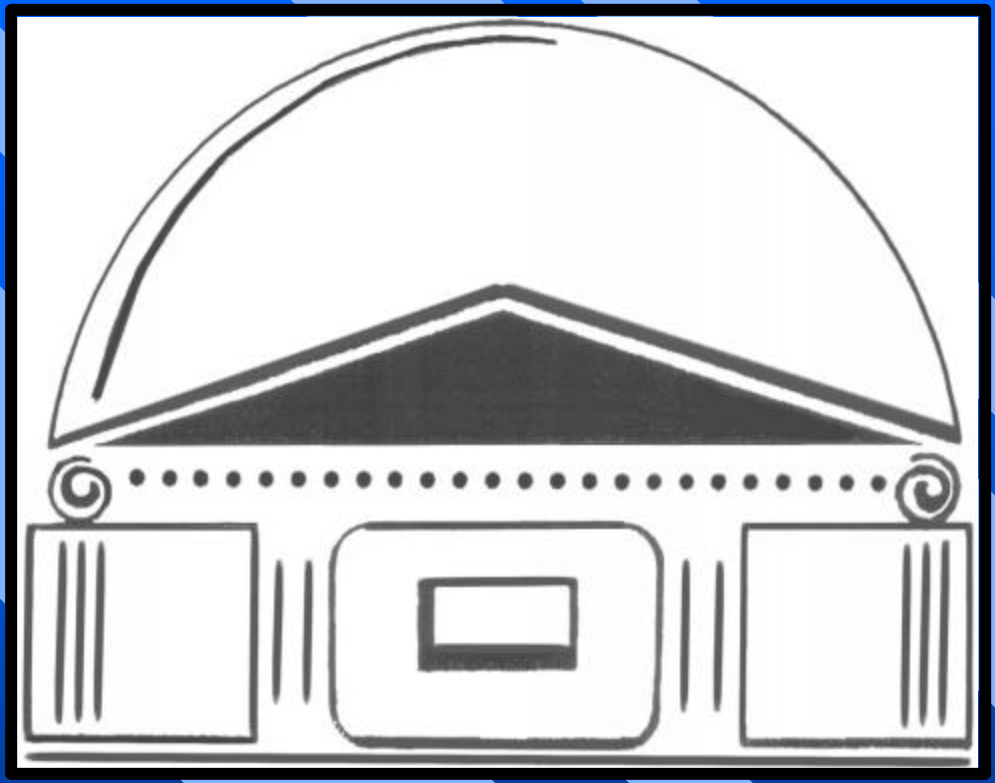


Joint Commission on Technology and Science
Advisory Committee on Privacy
July 7, 2004

Virginia Commonwealth University

Transportation Safety Training Center

Training

Curriculum Development

Technical Assistance

Box 843023
Richmond, Virginia 23284
804-828-6235
rbreiten@vcu.edu

Traffic Safety Technology

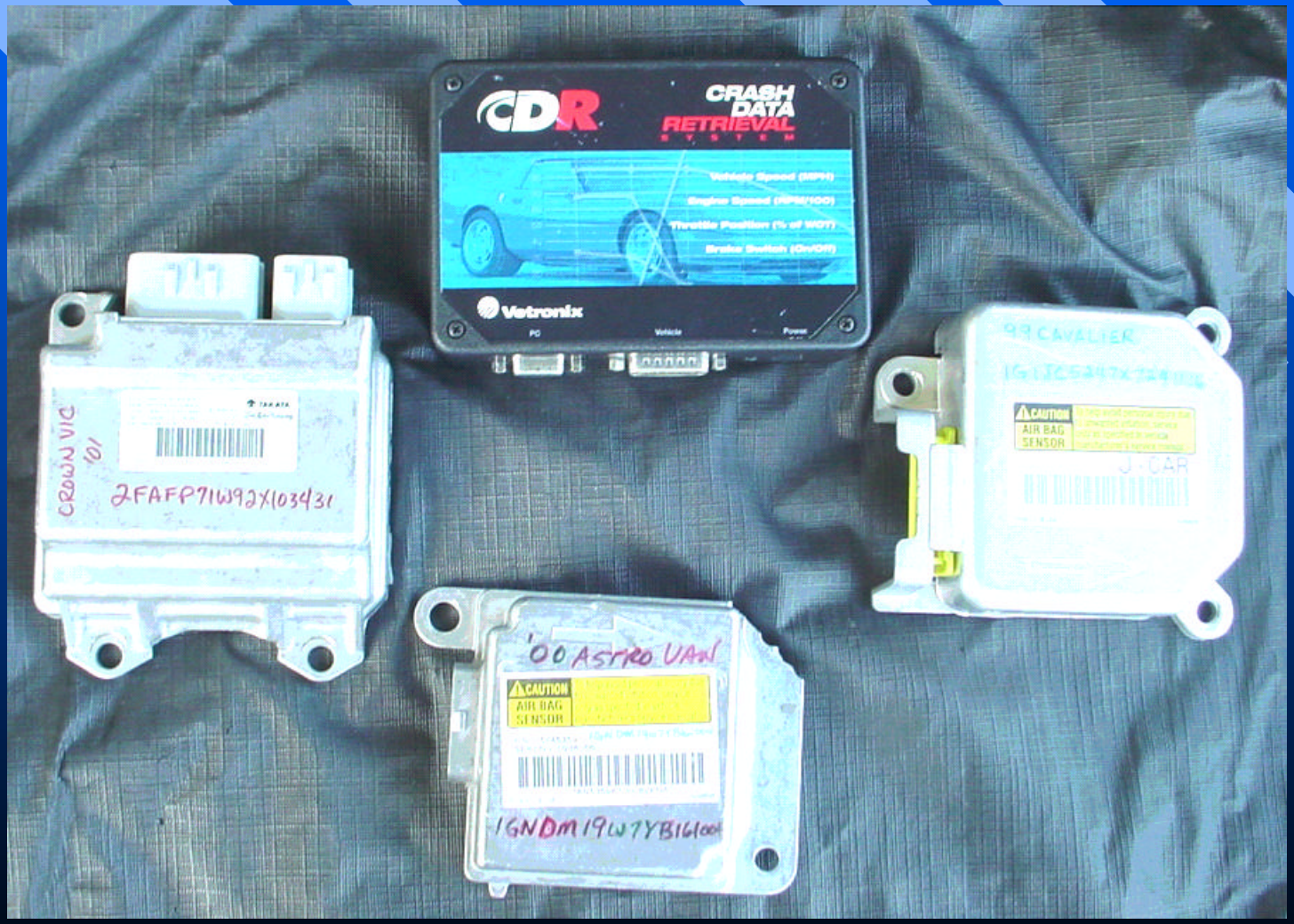
Event Data Recorders

-Vehicle Black Boxes-

Add a New Dimension to Crash Reconstruction

These ARE “Black Boxes”

These are NOT “Black Boxes”



Event Data Recorders

Essentially every production vehicle sold in North America since model year 1997 has some sort of crash data recording capability

National Transportation Safety Board Directive

H-97-18 to Manufacturers and NHTSA:

"Develop and implement, in conjunction with the domestic and international manufacturers, a ***plan*** to gather better *information on* ***crash pulses*** and ***other crash parameters*** in actual crashes, utilizing current or augmented sensing and recording devices."

Relevant EDR Rollout

- General Motors
  - Began installing EDR's with *limited* data on air bag equipped vehicles in Model Year (MY) 1990
  - "EDR" functionality was first introduced in essentially its current form in MY1998

- Ford Motor Company
  - Began installing EDR's on a limited fleet basis beginning in MY 1997

Deployment & Non-Deployment Events

Non-Deployment (ND)

Negative acceleration observed along the car's longitudinal (X) axis ***sufficient*** to cause the module's crash sensing algorithm to "enable" or "wake up" but which is ***insufficient*** to warrant an actual deployment

Deployment (D)

Negative acceleration observed along the car's longitudinal (X) axis ***sufficient*** to cause the module's crash sensing algorithm to "enable" or "wake up" *and* ***anticipate*** a collision severity which warrants an actual deployment for that vehicle

The Deployment Level Event

Deployment Level Event (DLE)

Negative acceleration observed along the car's longitudinal (X) axis ***sufficient*** to cause the GM SDM's crash sensing algorithm to "enable" *and* ***anticipate*** a collision severity which warrants an actual deployment for that vehicle but the deployment had been previously commanded

This is *not* the same as a "deployment event."
It is only recorded by GM modules.

GM EDR Outputs

- Dash air bag warning lamp on/off at event
- Diagnostic trouble codes present at event
- Time from “algorithm enabled” to deployment
- Ignition cycle count at event
- Maximum delta-V for non-deployment
- Adjusted DV & time from frontal deployment

GM EDR Outputs

- Driver's seat belt switch buckled/unbuckled
- Time between deployment & non-deployment <5s
- Passenger air bag enabled/disabled
- 5 seconds pre-"AE": engine speed
- 5 seconds pre-"AE": percent throttle
- 5 seconds pre-"AE": vehicle speed
- 5 seconds pre-"AE": brake switch on/off

Ford Crown Victoria EDR Outputs

- Driver's seat belt buckled/unbuckled
- Passenger's seat belt buckled/unbuckled
- Driver's seat track forward or not
- Airbag fire status passenger and driver
- Pretensioner fire status driver and pass.
- Longitudinal Crash Pulse (g's & delta v)
- Lateral Crash Pulse (g's & delta v)

VETRONIX
Crash Data Retrieval System

Crash Data Retrieval System

Vetronix
CORPORATION

Data Retrieval Methods

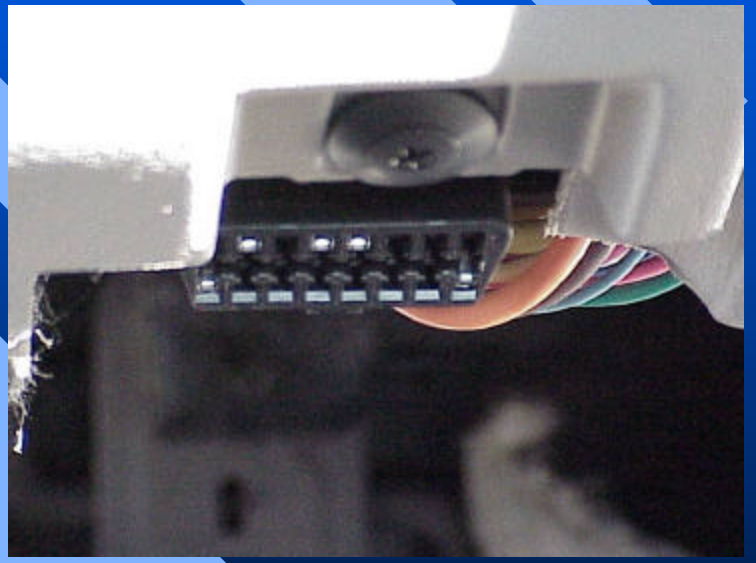
Two Ways to Download Data-

- Through the Vehicle's Diagnostic Link Connector (DLC)
- Direct to the Air Bag Module

Vetronix CORPORATION

Data Retrieval Methods

- **Diagnostic Link Connector (DLC)**
  - Typically located under the dashboard
  - SAE J1962 connector (equipped on all 1996 and newer vehicles sold in the U.S.)



Vetronix CORPORATION

Direct to Air Bag Module

Typical GM Air Bag Module Location- Under Passenger Front Seat

Vetronix CORPORATION

Pre-Crash Graph

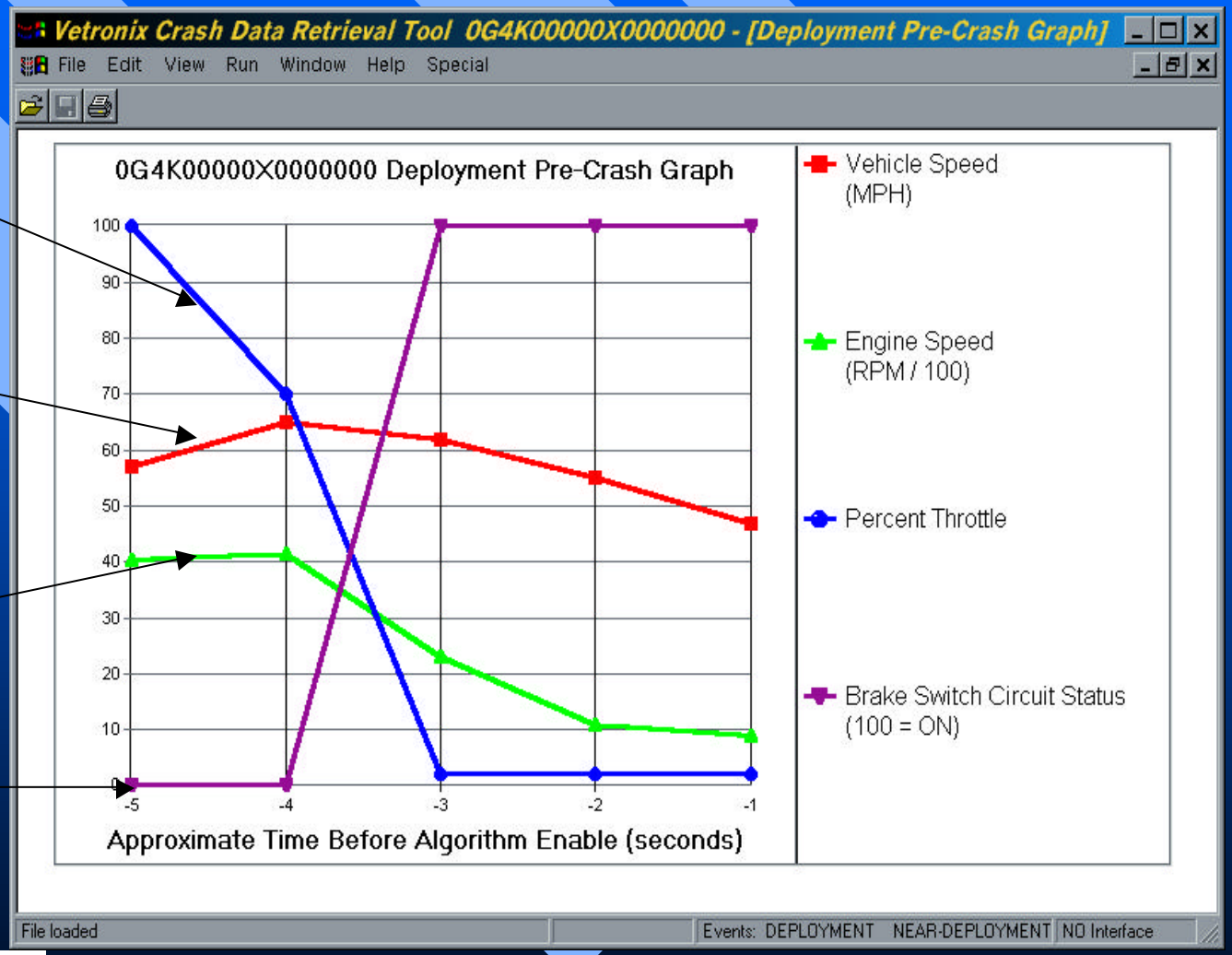
GM Air Bag Module

Percent of Wide Open Throttle

Vehicle Speed (MPH)

Engine Speed (RPM)

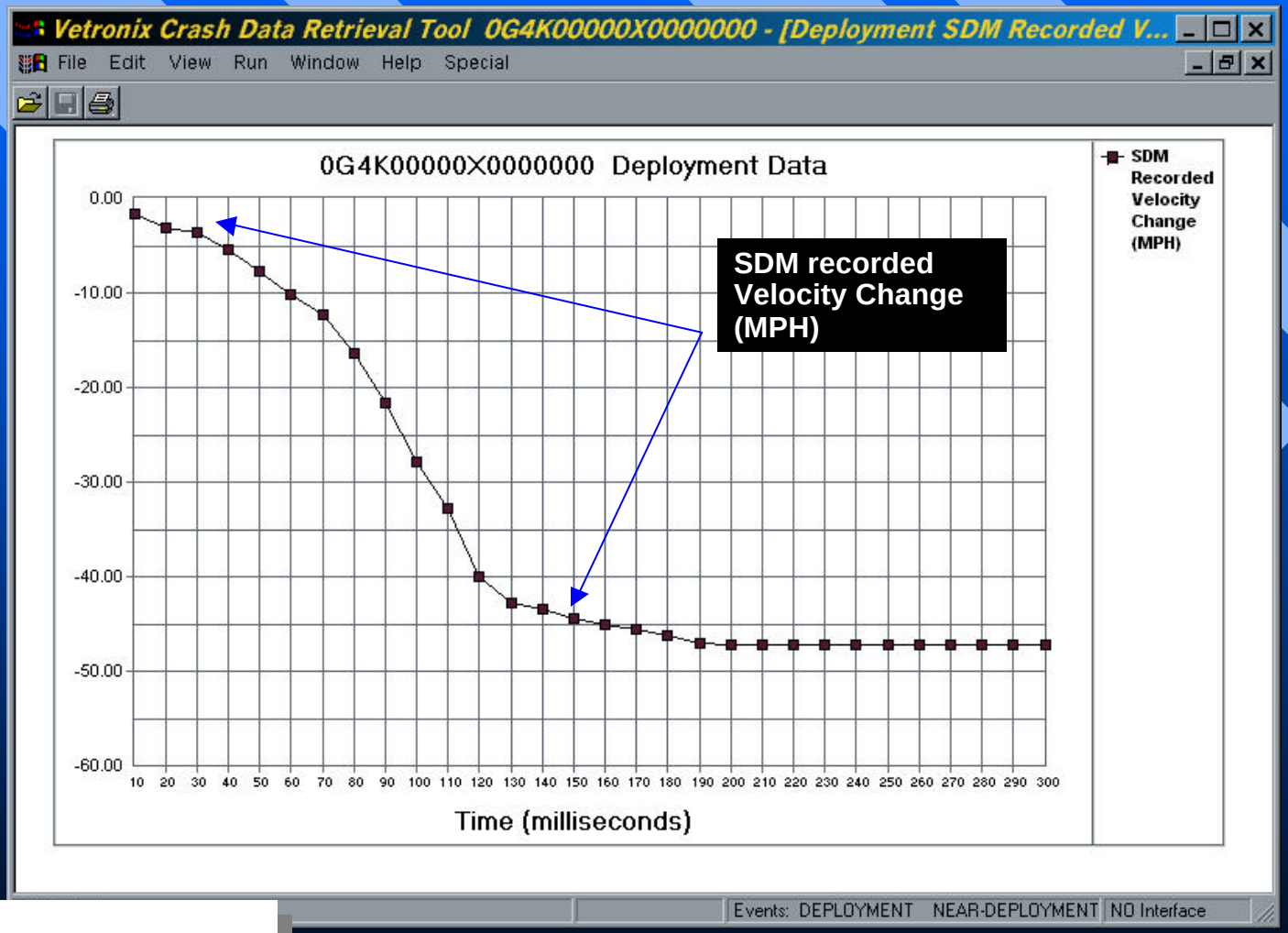
Brake Switch Status (On or Off)



Vetronix CORPORATION

Post-Crash Graph

GM Air Bag Module



Vetronix CORPORATION

Data Summary Table

GM Air Bag Module

Vetronix Crash Data Retrieval Tool 0G4K00000X0000000 - [Deployment Data Summary]

File Edit View Run Window Help Special

0G4K00000X0000000 System Status At Deployment	
SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	UNBUCKLED
Passenger Front Air Bag Suppression Switch Circuit Status	ON
Ignition Cycles At Deployment	187
Ignition Cycles At Investigation	213

PRE-CRASH DATA			Electronic Data Validity Check Status = VALID	
Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status
-5	57	4032	100	OFF
-4	65	4160	70	OFF
-3	62	2304	2	ON
-2	55	1088	2	ON
-1	47	896	2	ON

Time (Milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Recorded Velocity Change (MPH)	-1.54	-3.07	-3.51	-5.27	-7.68	-10.09	-12.29	-16.24	-21.50	-27.86	-32.69	-39.93	-42.78	-43.44	-44.32

Time (Milliseconds)	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
Recorded Velocity Change (MPH)	-44.98	-45.42	-46.07	-46.95	-47.17	-47.17	-47.17	-47.17	-47.17	-47.17	-47.17	-47.17	-47.17	-47.17	-47.17

Time From Algorithm Enable To Deployment Command (msec)	18.75
Time from Near Deployment to Deployment (sec)	N/A

File loaded | Events: DEPLOYMENT NEAR-DEPLOYMENT | NO Interface

Vetronix CORPORATION

Real World Data

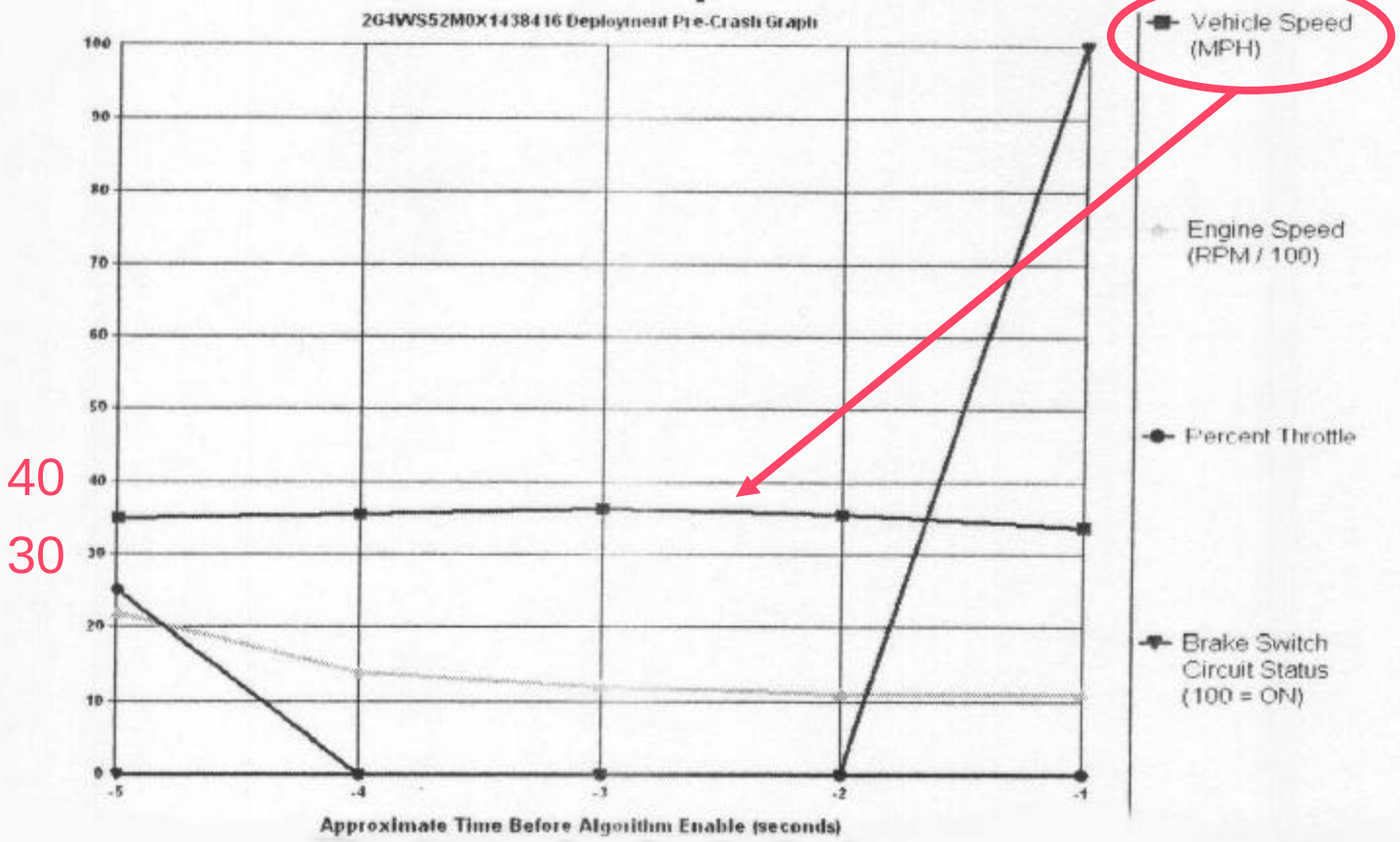
- 2 Staged Crashes – CDR Training Purpose - CSI Collision Safety Institute
- 4 Actual Crashes – Correlation of Physical Evidence Speed and EDR – CIT State Crash Investigation Team

CSI Staged Crash #1

- 1999 Buick Century (Bullet Vehicle)
- 1992 Toyota Tercel
- Head-on Impact
- Timer Impact Speed = 34.09 mph
- RADAR Speed = 35 mph
- EDR = 34 mph at –1 sec.

Staged Crash #1

CPC Crash #3 – SDM "pre-crash"



CPC Crash #3 - SDM data

Staged Crash #1

2G4WS52M0X1438416 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	884
Time Between Non-Deployment And Deployment Events (sec)	N/A

Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Adjusted Algorithm Velocity Change	-0.53	-2.94	-5.35	-7.33	-9.74	-12.16	-13.69	-12.60	-7.99	-2.95	-2.29	-2.51	N/A	N/A	N/A

PRE-CRASH DATA

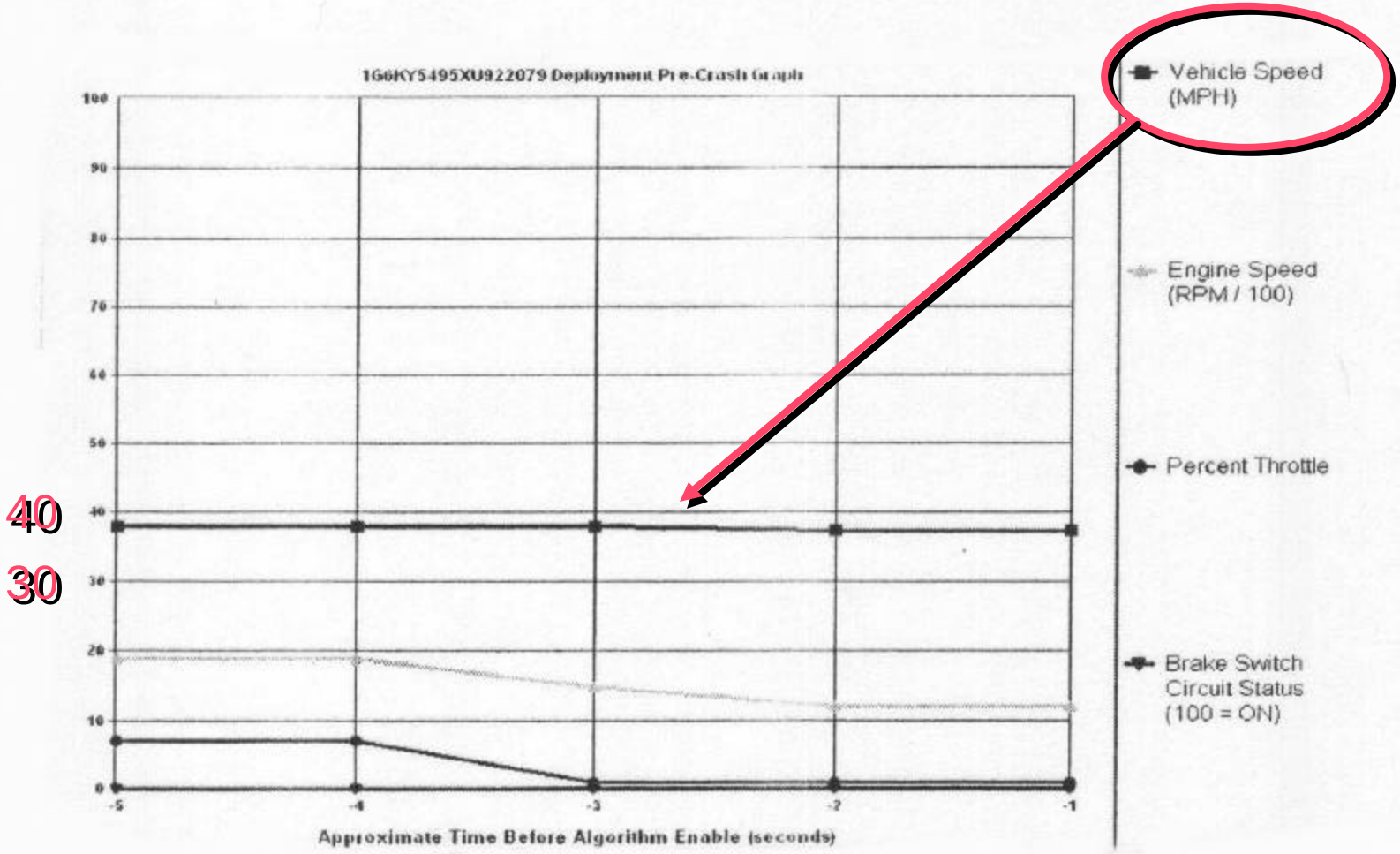
Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status
-5	35	2240	25	OFF
-4	35	1408	0	OFF
-3	36	1152	0	OFF
-2	35	1088	0	OFF
-1	34	1088	0	ON

Staged Crash # 2

- Late Model Cadillac Seville (Bullet)
- Late Model Pontiac Transport
- Side Impact Collision
- Actual Cadillac Crash Speed = 37 mph

Staged Crash # 2

Pre Crash data - Cadillac



Seville Data Summary

Staged Crash # 2

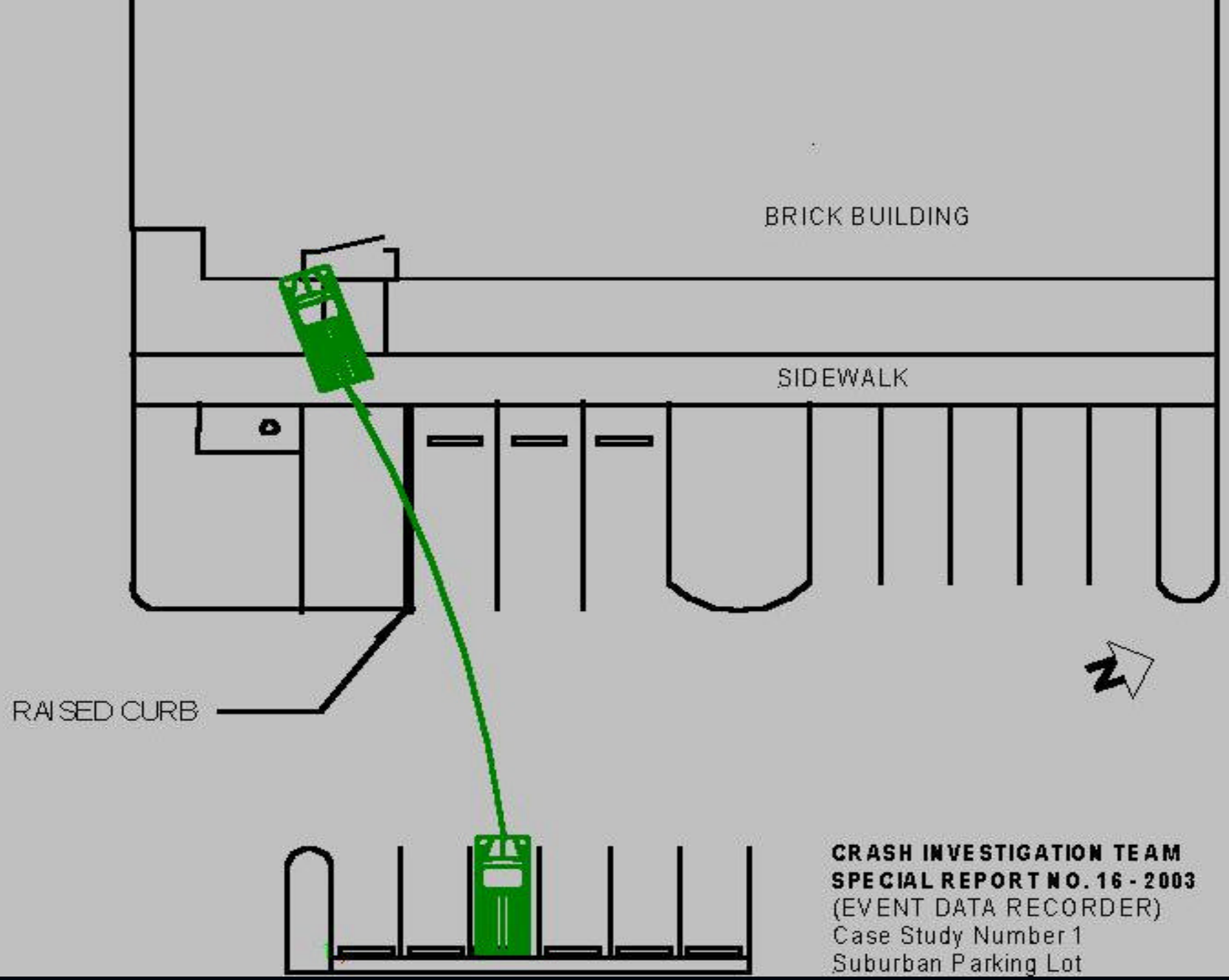
1G6KY5495XU922079 System Status At Deployment	
SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	BUCKLED
Ignition Cycles At Deployment	660
Ignition Cycles At Investigation	694
Time From Algorithm Enable to Deployment Command Criteria Met (msec)	16.25
Time Between Non-Deployment And Deployment Events (sec)	N/A

Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Recorded Velocity Change (MPH)	-1.54	-3.07	-4.83	-7.24	-10.09	-13.16	-16.24	-18.65	-19.53	-19.75	-19.75	-19.75	-19.75	-19.75	-19.53
Time (milliseconds)	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
Recorded Velocity Change (MPH)	-19.31	-19.31	-19.31	-19.31	-19.53	-19.75	-19.75	-19.53	-19.53	-19.31	-19.31	-19.31	-19.31	-19.31	-19.31

PRE-CRASH DATA				
Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status
-5	38	1856	7	OFF
-4	38	1856	7	OFF
-3	38	1472	1	OFF
-2	37	1152	1	OFF
-1	37	1152	1	OFF

CIT Crash # 1

- 2002 Chevrolet S-10 Pickup Truck
- Single Vehicle
- Fixed Object
- Frontal Impact
- Public Parking Lot/Brick Building
- Sudden Acceleration Claim



CRASH INVESTIGATION TEAM
SPECIAL REPORT NO. 16 - 2003
(EVENT DATA RECORDER)
Case Study Number 1
Suburban Parking Lot

2002 Chevrolet
S-10 Pickup

Struck Corner of
Building
Entranceway

CHEVROLET

Pickup Parked

2 Inches of
Crush Exterior
Crumbled
Interior Wall

Crash Reconstruction

Physical Evidence:

- 17 inches of crush on pickup
- Rapid acceleration from known distance to fixed object
- No pre-impact skid marks

Speed Determination Techniques:

- Conservation of Energy
- Acceleration/Distance Analysis

Calculated Speed

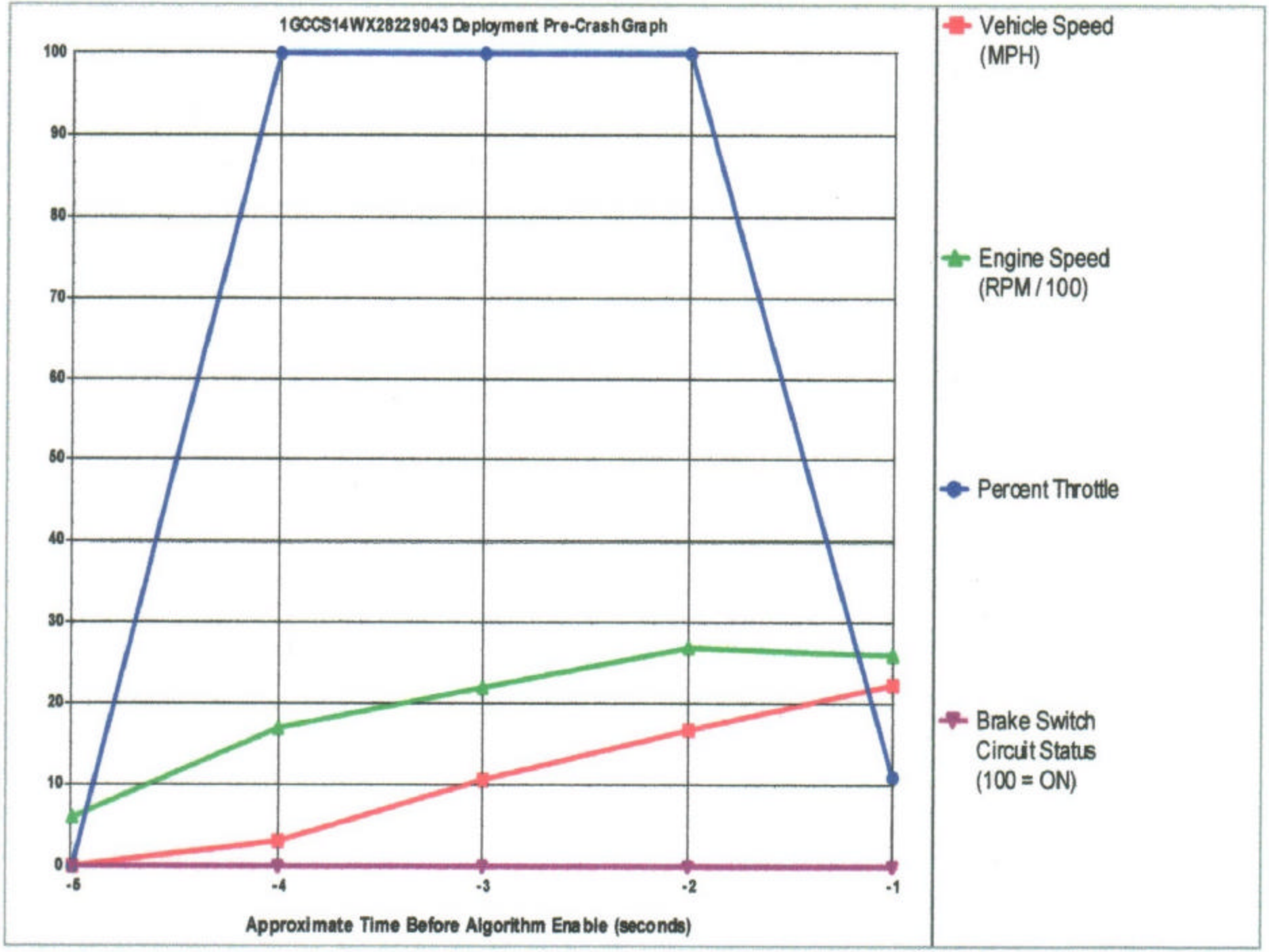
Using the two techniques mentioned:

Crush Analysis &

Acceleration Analysis

A speed range of 18 – 21 mph was calculated.

EDR Parameters


1GCCS14WX28229043 Deployment Pre-Crash Graph
100
90
80
70
60
50
40
30
20
10
0
-5
-4
-3
-2
-1
Approximate Time Before Algorithm Enable (seconds)
Vehicle Speed (MPH)
Engine Speed (RPM / 100)
Percent Throttle
Brake Switch Circuit Status (100 = ON)

Vetronix

CDR CRASH DATA RETRIEVAL SYSTEM

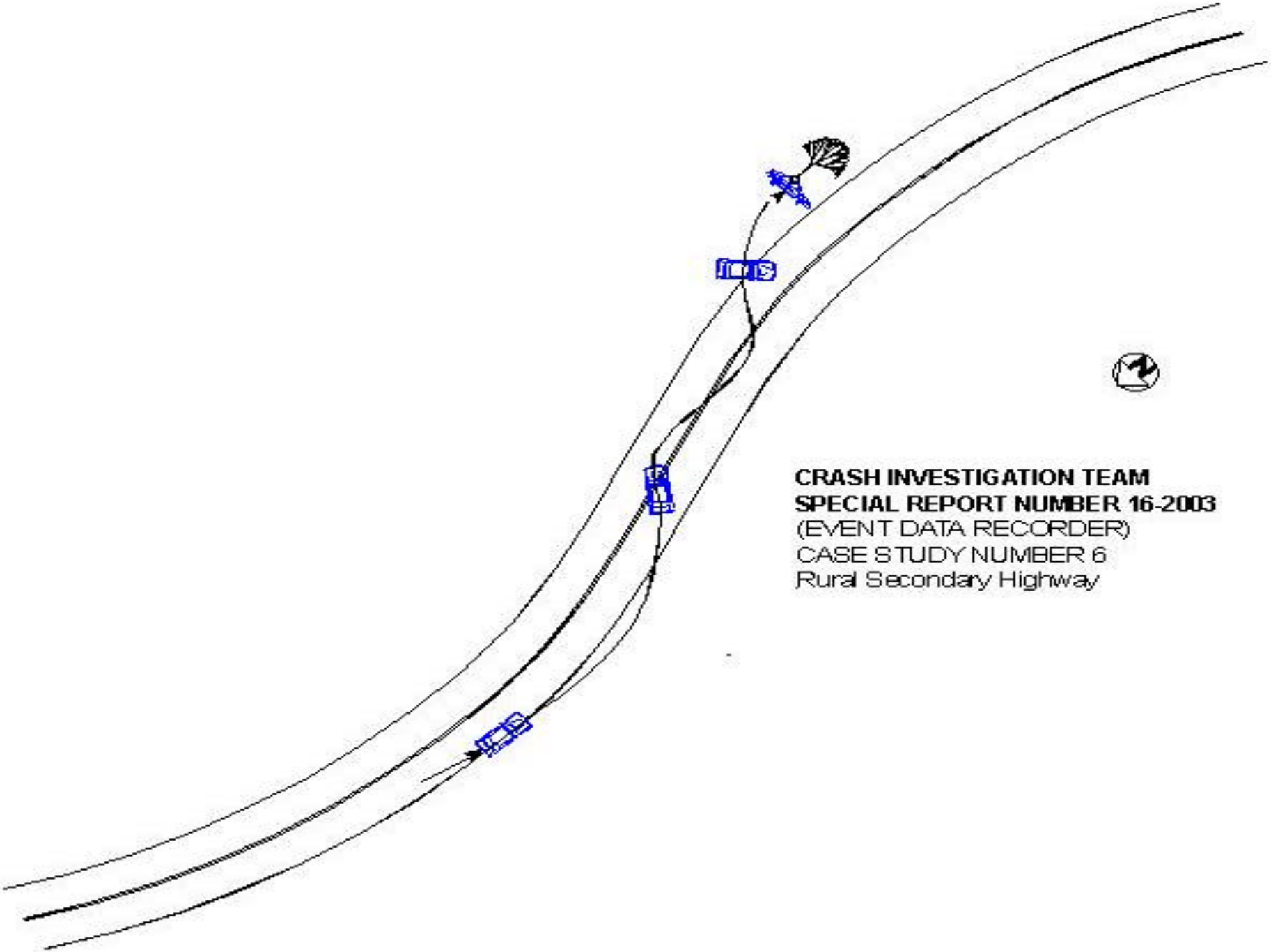
System Status At Deployment

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

CIT Crash # 2

- 2001 Chevrolet Cavalier Z-24
- Single Vehicle
- Fixed Object
- Side Impact
- Struck Tree After Sliding Broadside
- 2 Fatalities



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

2001 Chevrolet Cavalier Z-24

Struck Trees after Sliding Broadside

Path of Cavalier
Initially Left Roadway
Yaw Marks

U-HAUL

Crash Reconstruction

Physical Evidence:

- Right side of vehicle traveled on grassy shoulder for 100 ft.
- Driver abruptly re-entered the roadway and over-steered a second time and began to yaw
- Vehicle side slipped on pavement 125 feet
- Vehicle slide 110 ft. in the wet soil then began to tip over before striking tree

Crash Reconstruction

Speed Determination Techniques:

- Speed from Yaw marks
- Calculated from two different locations within the front tire mark
- Measurements made about 220 feet from impact after deceleration

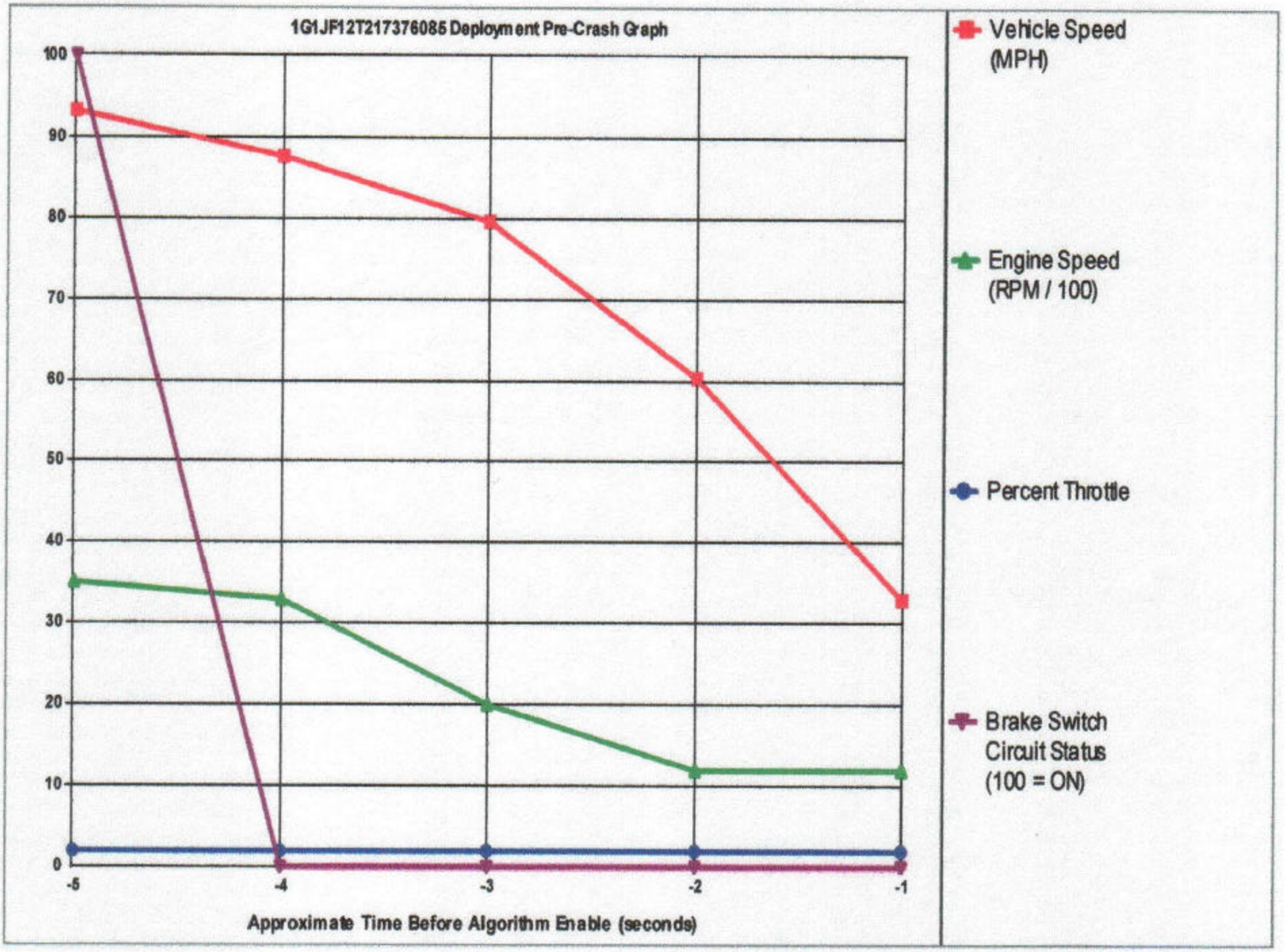
Calculated Speed

Using the technique mentioned:

Yaw Mark Analysis

The vehicle was traveling at a minimum of 70 mph (after some deceleration). And due to subsequent side slip the vehicle continued to decelerate before impacting the tree.

EDR Parameters


1G1JF12T217376085 Deployment Pre-Crash Graph
100
90
80
70
60
50
40
30
20
10
0
-5
-4
-3
-2
-1
Approximate Time Before Algorithm Enable (seconds)
Vehicle Speed (MPH)
Engine Speed (RPM / 100)
Percent Throttle
Brake Switch Circuit Status (100 = ON)

Vetronix

CDR CRASH DATA RETRIEVAL

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

Issue Discovered In This Case

2000 and 2002

Chevrolet Cavalier Z24

2.4L Engine

Manual Transmission

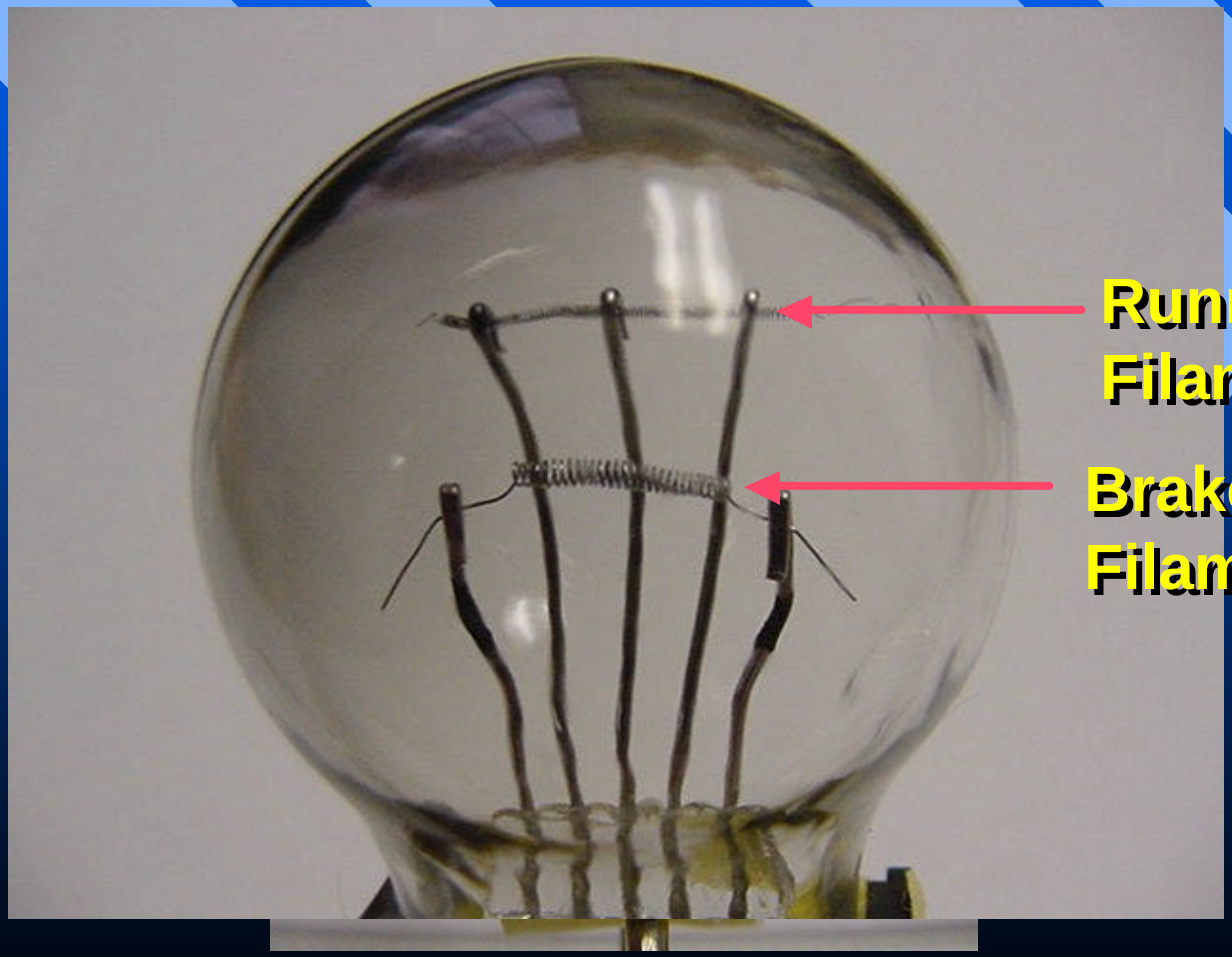
Brake Switch Status

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

When the EDR indicates the brakes are **ON** they are **OFF** and when **OFF** they are **ON**

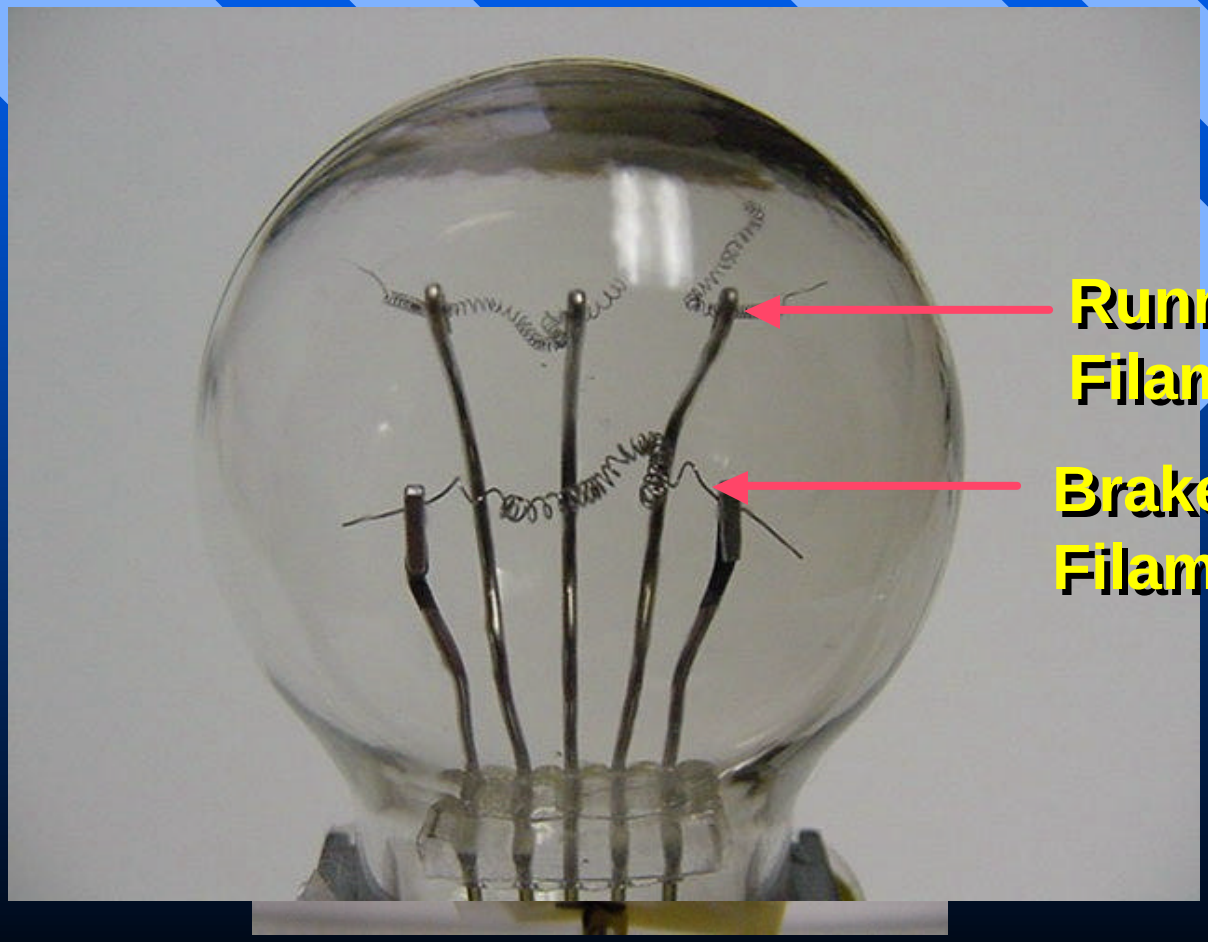
Follow-up Investigation

Normal Filament



Follow-up Investigation

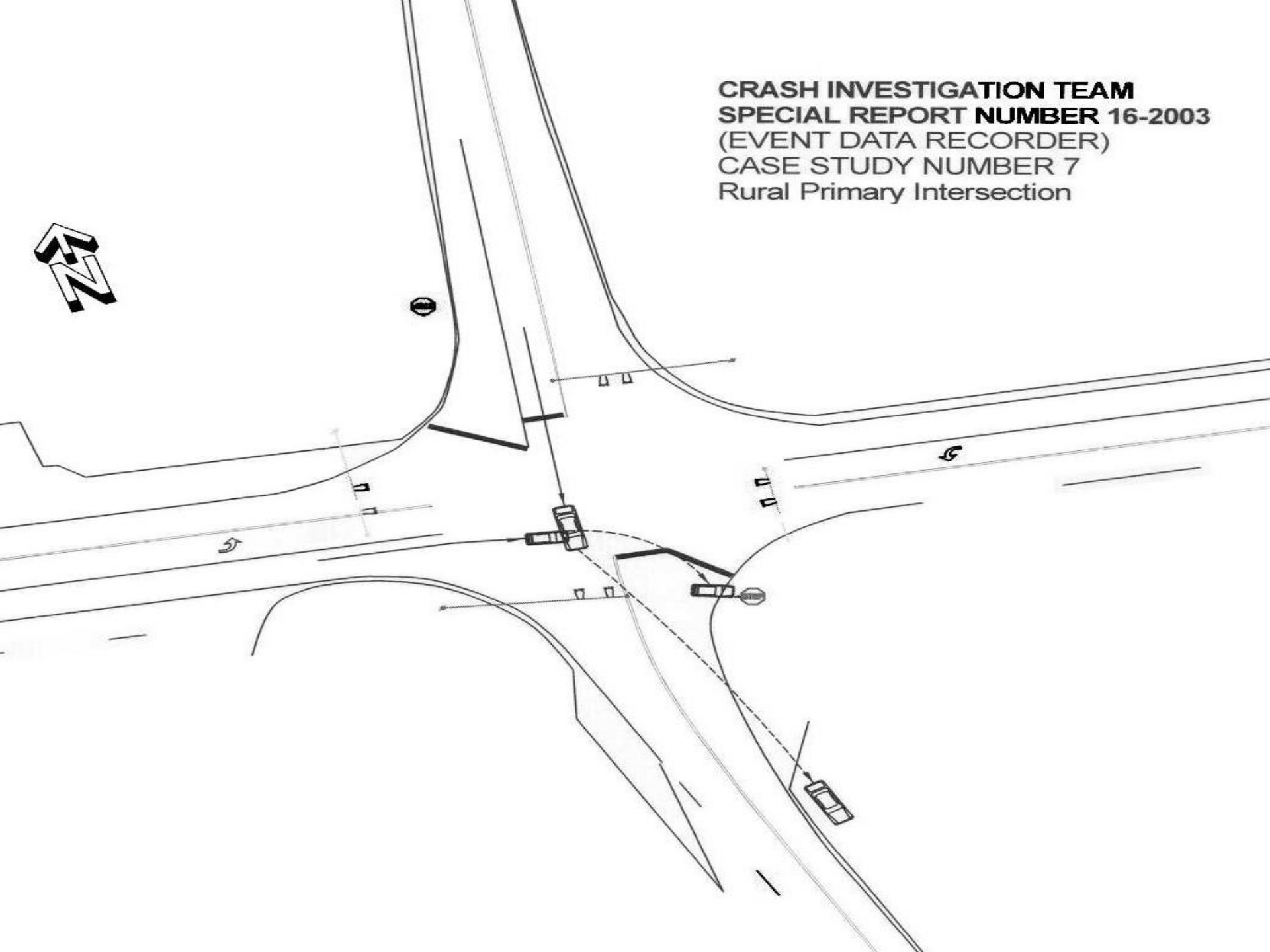
Hot Shock!



CIT Crash # 3

- 2000 Cadillac Seville (EDR)
- 1998 Ford Escort
- Two Vehicles
- Angle Collision
- Failure to Stop at Intersection
- 2 Fatalities

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



2000 Cadillac Seville

Struck on Right Passenger Door

1998 Ford Escort

Striking Vehicle

Visual Clutter
Oversized Stop Sign
CITGO
STOP

Note Stop Bars
Scuff Marks From Cadillac
Skid Marks From Escort

Crash Reconstruction

Physical Evidence:

- Escort Skidded 36 ft. to impact
- Escort rotated clockwise 340º and came to rest about 50 feet from impact.
- Escort sustained about 20 in. of collapse
- Cadillac initially pushed 10 ft. east
- Cadillac final rest was 137 ft. south of impact
- Cadillac sustained about 18 in. of collapse

Crash Reconstruction

Speed Determination Techniques:

- Speed from Skid Marks
- Conservation of Linear Momentum

Calculated Speed

Using the techniques mentioned:

Skid Mark Analysis & Conservation of Linear Momentum

The Escort was traveling approximately 49 mph at impact.

The Cadillac was traveling approximately 37 mph at impact.

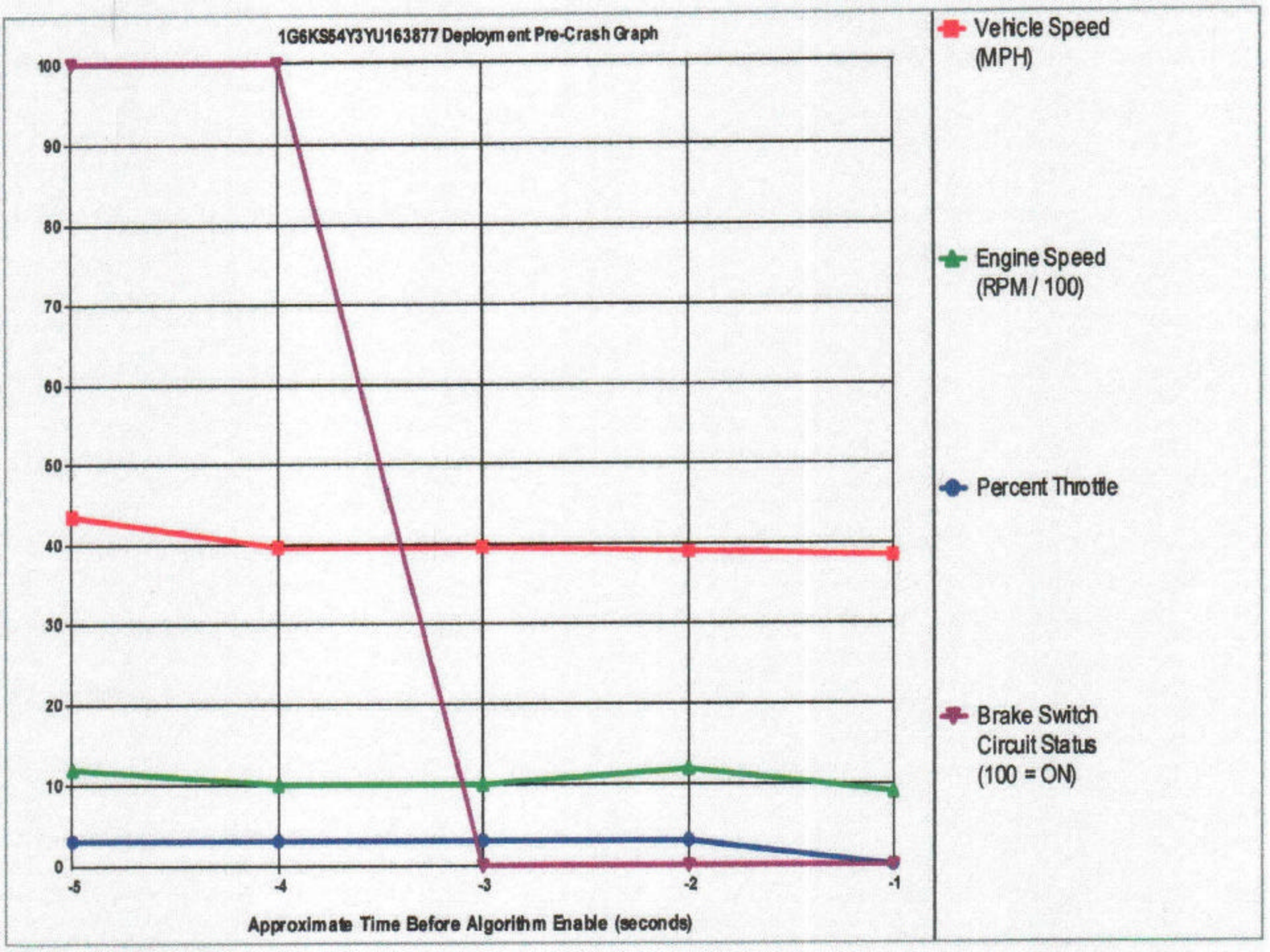
Calculated Speed

Using the techniques mentioned:

Skid Mark Analysis & Conservation of Linear Momentum

The Escorts pre-impact skid mark speed was 29 mph, combined with its speed at impact (49 mph) results in a minimum speed estimate of 57 mph (55 speed limit) prior to skidding.

EDR Parameters


1G6KS54Y3YU163877 Deployment Pre-Crash Graph
100
90
80
70
60
50
40
30
20
10
0
-5
-4
-3
-2
-1
Approximate Time Before Algorithm Enable (seconds)
Vehicle Speed (MPH)
Engine Speed (RPM / 100)
Percent Throttle
Brake Switch Circuit Status (100 = ON)

Vetronix

CDR CRASH DATA RETRIEVAL SYSTEM

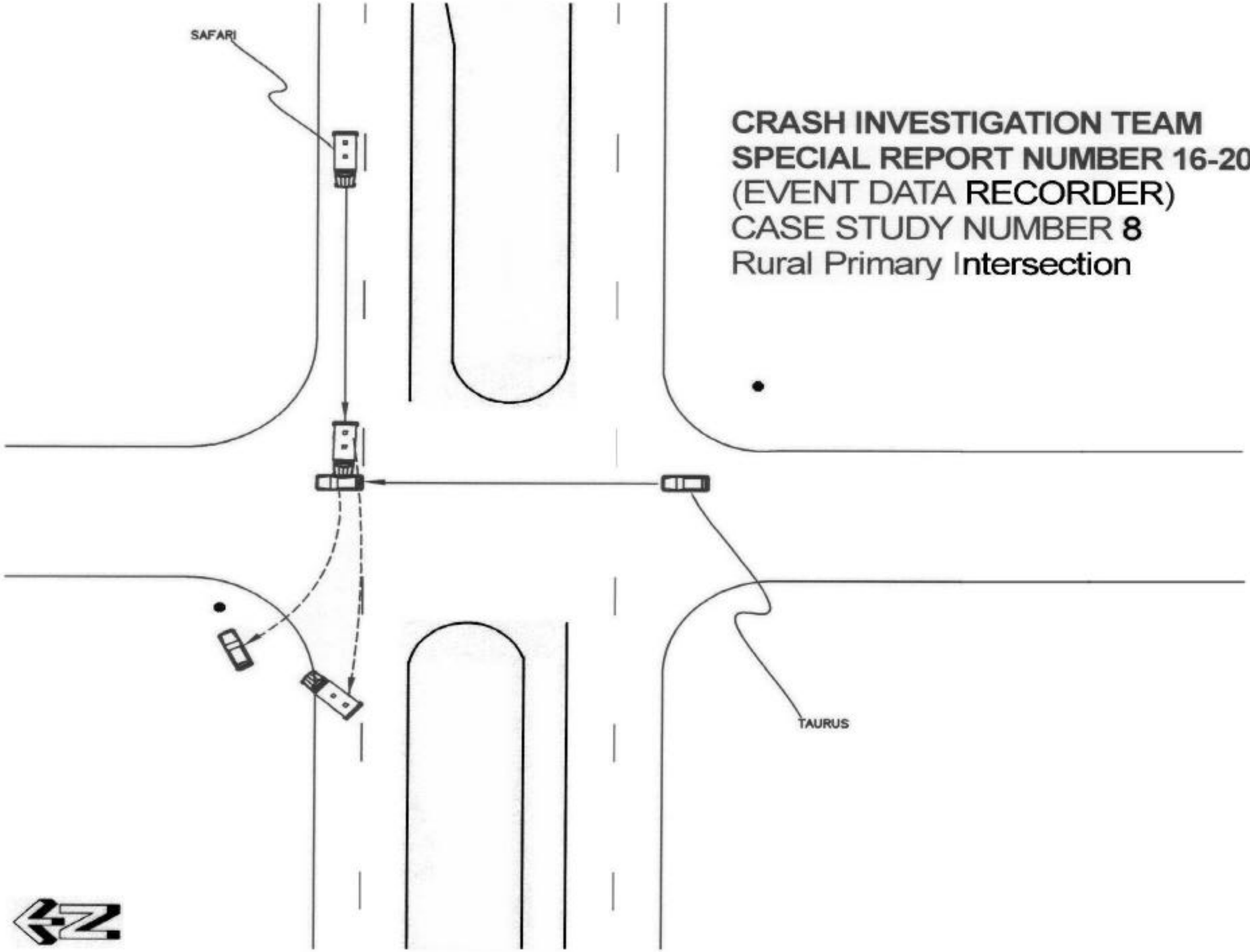
System Status At Deployment

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

CIT Crash # 4

- 2001 GMC Safari Van (EDR)
- 2003 Ford Taurus (Non Readable EDR)
- Two Vehicles
- Angle Collision
- Failure to Stop at Intersection
- 1 Fatalities



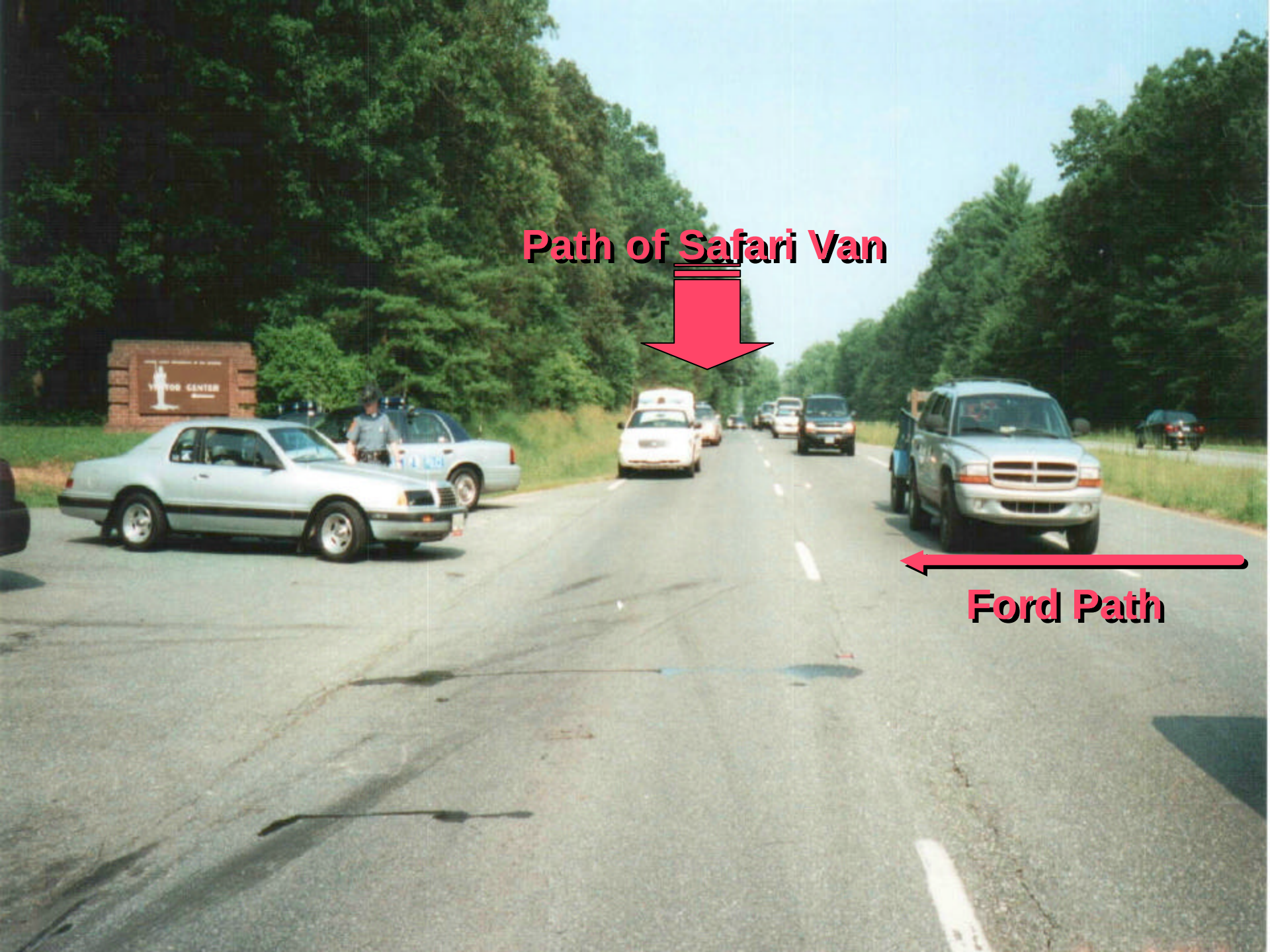
CRASH INVESTIGATION TEAM
SPECIAL REPORT NUMBER 16-2003
(EVENT DATA RECORDER)
CASE STUDY NUMBER **8**
Rural Primary Intersection

2003 Ford Taurus

Struck on Right Rear Passenger Door

2001 GMC Safari Van

Striking vehicle


Path of Safari Van
Ford Path

Crash Reconstruction

Physical Evidence:

- No evasive action by the Taurus driver
- Taurus rotated nearly 75º and came to rest about 50 feet from impact
- Taurus sustained about 13 in. of collapse
- Safari rotated about 125º and came to rest about 55 feet from impact
- Safari sustained about 13 in. of collapse
- Safari left no pre-impact skid marks

Crash Reconstruction

Speed Determination Techniques:

- Conservation of Energy
- Conservation of Linear Momentum
- Acceleration/Deceleration Analysis

Calculated Speed

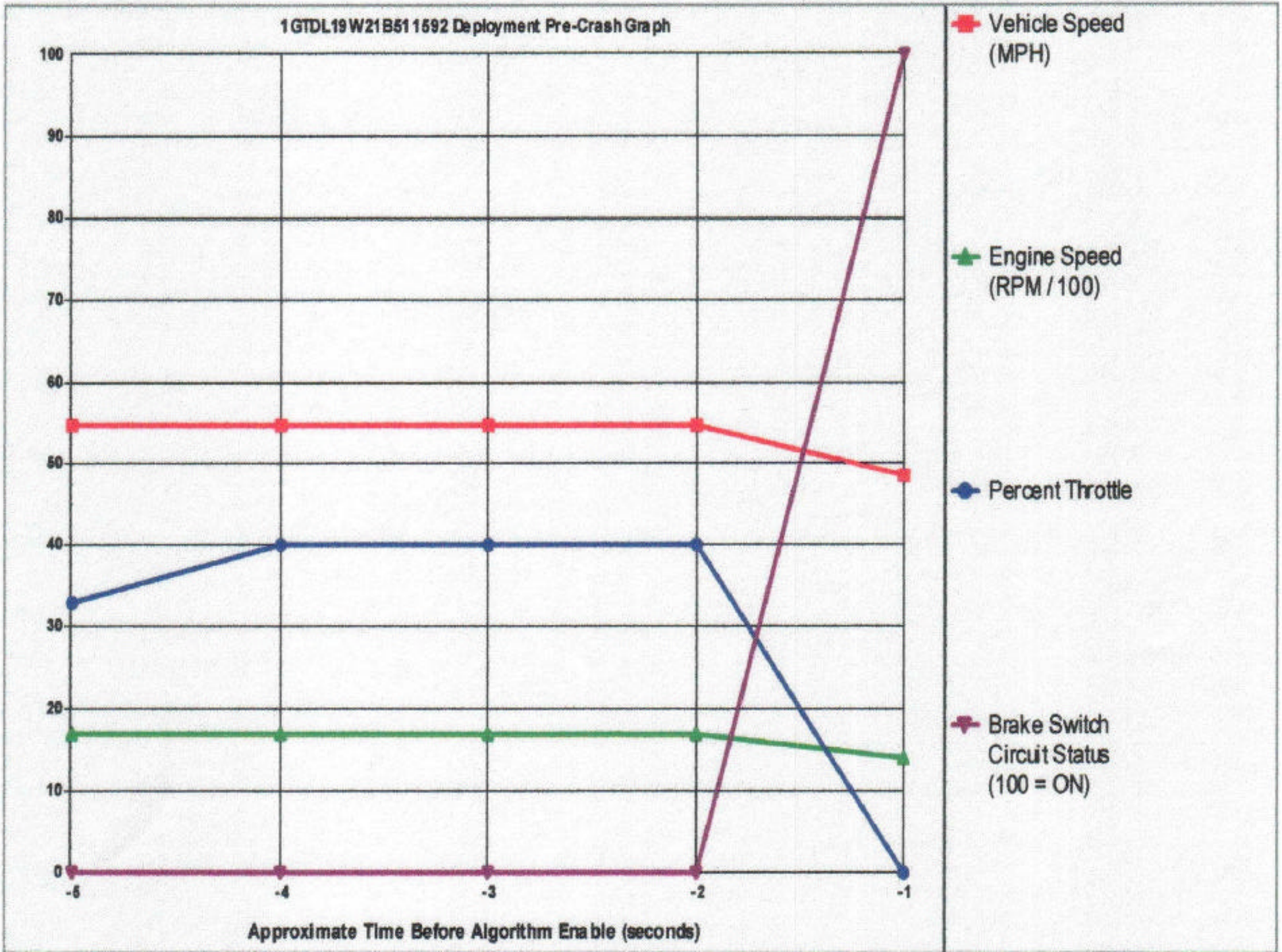
Using the techniques mentioned:

Conservation of Momentum and Energy & Acceleration Analysis

The Safari was traveling approximately 45 mph at impact

The Taurus was traveling approximately 17 mph at impact

EDR Parameters


1GTDL19W21B511592 Deployment Pre-Crash Graph
100
90
80
70
60
50
40
30
20
10
0
-5
-4
-3
-2
-1
Approximate Time Before Algorithm Enable (seconds)
Vehicle Speed (MPH)
Engine Speed (RPM / 100)
Percent Throttle
Brake Switch Circuit Status (100 = ON)

Vetronix

CDR CRASH DATA RETRIEVAL SYSTEM

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

EDR Analysis Summary

- Generally the data recorded by the EDR was consistent with physical evidence observed and each reconstruction analysis
- There are crash situations which may make the EDR data inconsistent with physical evidence e.g., vehicle goes airborne, wheel breaks from the axle. In these cases if the accelerator is continuously applied there may be spikes in rpm’s and speed

Will This Tool Replace the Crash Reconstructionist?

- The EDR is a tool to be used by the reconstructionist *not a replacement*
- The EDR Supplements good investigative and analytical procedures
- The EDR doesn't stand alone in many "real world" events
  - Full analysis of the crash still required

Any Questions?