On-scene Advanced Occupant Protection Systems Investigation
Dynamic Science, Inc. / Case Number: DS00-011
2000 Mercury Sable LS
Texas
May, 2000

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no responsibility for the contents or use thereof.

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the National Highway Traffic Safety Administration.

The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points be coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety systems.

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient Catalog No.
DS00-011		

4. Title and Subtitle	5. Report Date
In-Depth Accident Investigation	
	6. Performing Organization Report No.

7. Author(s)	8. Performing Organization Report No.
Dynamic Science, Inc.	

9. Performing Organization name and Address	10. Work Unit No. (TRAIS)
Dynamic Science, Inc. 530 College Parkway, Ste. K Annapolis, MD 21401	11. Contract or Grant no. DTNH22-94-D-27058

12. Sponsoring Agency Name and Address	13. Type of report and period Covered [Report Month, Year]
U.S. Dept. of Transportation (NRD-32) National Highway Traffic Safety Administration 400 7th Street, SW Washington, DC 20590	14. Sponsoring Agency Code

15. Supplemental Notes

16. Abstract

This case was initiated because the vehicle was equipped with advanced occupant protection systems. This single vehicle collision occurred in the state of Texas in May, 2000 at 2155 hours. The collision occurred at a “L” type intersection. As the southbound street ends, there is a street that intersects and forms a L-intersection towards the east, so southbound traffic can turn left. The uncontrolled north-south roadway is a two way, two lane, undivided, dry, straight and level asphalt roadway. The police report indicates the street was dark and unlighted. The speed limit is 56 km/h (35 mph).

The case vehicle is a 2000 Mercury Sable LS four-door sedan driven southbound by a restrained 39-year-old female (162.6 cm-64 in/61 kg-135 lbs). As the case vehicle came to the L-intersection, it continued going straight rather than turning left onto the adjacent roadway. The police report indicates that the case vehicle departed the roadway and fell into the creek. The physical evidence on the vehicle indicates that it struck a concrete pole with its front left bumper corner. Since the crash scene has been altered recently, it appears more likely that the object struck by the case vehicle no longer exists at this location. On impact with the concrete pole, both front air bags deployed. The case vehicle came to final rest off the paved roadway and facing south on the dirt field. The case vehicle sustained moderate damage to the front bumper, hood, grille area and left front fender. Induced contact damage produced buckling of the driver door. The case vehicle was towed from the scene, and was subsequently declared a total loss by the insurance company.

The driver of the case vehicle did not report any injuries to police at the time of the crash and she was not transported for medical treatment. The driver indicated that she sustained chest and back pain–muscle strains, and that sought treatment the following day.

The Delta V for the case vehicle was computed, using WinSmash, as a total Delta v of 23.0 km/h (14.3 mph), a longitudinal Delta v of -23.0 km/h (-14.3 mph) and a latitudinal Delta v of 0 km/h (0 mph). This is a borderline reconstruction, but the results appear reasonable. The downloaded Electronic Data Recorder (EDR) data indicates a cumulative longitudinal Delta v of -26.0 km/h (-16.2 mph) and a cumulative lateral Delta v of 4.8 km/h (3.0 mph) at the 78 ms mark. The EDR report is included as an attachment to this report. The case vehicle was assigned a Collision Deformation Classification (CDC) of 12FLEN2 and a Principle Direction of Force (PDOF) of 0 degrees. The combined direct and induced damage width was 148 cm (58 in) [CRASH L = 148 cm (58 in)], and the maximum crush depth was 28 cm (11 in) located at C_2.

This vehicle was equipped with an advanced occupant protection system. The system consists of a Restraint Control Module (RCM) dual stage front air bags, seat belt pretensioners, load limiters, seat track sensors, and seat belt latch usage detectors. The system is controlled by the RCM. The primary function of the RCM is to control the deployment of the occupant protection systems. The system records longitudinal and lateral acceleration. Data related to the driver and passenger air bag deployment include: 78 milliseconds of crash pulse, deployment strategy of the dual-stage air bag system, seat belt latch use, pretensioner operation, and driver seat track location.

17. Key Words	18. Distribution Statement		
Air bag, deployment, advanced, AOPS			
19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No of pages	22. Price

Dynamic Science, Inc.
Accident Investigation
Case Number: DS00-011

TABLE OF CONTENTS

BACKGROUND:

Description:	This Advanced Occupant Protection Systems (AOPS) case was reported to the NHTSA by Dynamic Science, Inc. on August 14, 2000. The NHTSA assigned the case to DSI on that same day.
Investigation Type:	On-scene
Crash Location:	Texas
Crash Date:	May, 2000
Notification Date:	August 14, 2000
Field Work Completed:	August 15, 2000

SUMMARY:

This single vehicle collision occurred in the state of Texas in May, 2000 at 2155 hours. The collision occurred at a “L” type intersection. As the street ends there is an intersecting roadway which intersects and forms a L-intersection towards the east, so southbound traffic can turn left. At the time of the scene inspection there were traffic barricades with traffic attenuators (barrels) where the southbound roadway came to a dead end. There were flashing strobes at the top of the barriers. The roadway had been recently paved. The police report does not indicate that there was any road construction taking place at the time of the collision. The uncontrolled north-south roadway is a two way, two lane, undivided, dry, straight and level asphalt roadway. The police report indicates the street was dark and unlighted. The speed limit is 56 km/h (35 mph).

The case vehicle is a 2000 Mercury Sable LS

Figure 1. Direction of travel towards impact (south).

Figure 2. Traffic barriers

four-door sedan driven by a restrained[1] 39-year-
old female (163 cm-64 in/61 kg-135 lbs), traveling southbound.

As the case vehicle came to the end, it continued going straight rather than turning left onto the adjacent roadway. The police report indicates that the case vehicle departed the roadway and fell into the creek. The physical evidence on the vehicle indicates that it struck a concrete pole with its front left bumper corner. Since the crash scene has been altered recently, it appears that the object struck by the case vehicle no longer exists at this location. On impact with the concrete pole, both front air bags deployed.

The case vehicle came to final rest in a dry creek bed off the paved roadway and facing south on the dirt field. The case vehicle sustained moderate damage to the front bumper, hood, grille area and left front fender. Induced contact damage produced buckling of the driver door. The case vehicle was towed from the scene, and was subsequently declared a total loss by the insurance company.

The driver of the case vehicle did not report any injuries to police at the time of the crash and she was not transported for medical treatment. The driver indicated that she sustained chest and back pain–muscle strain, and that she had sought treatment the following day at a hospital.

The Delta V for the case vehicle was computed, using WinSmash, as a total Delta v of 23.0 km/h (14.3 mph), a longitudinal Delta v of -23.0 km/h (-14.3 mph) and a latitudinal Delta v of 0 km/h (0 mph). This is a borderline reconstruction, but the results appear reasonable. The downloaded EDR data indicates a cumulative longitudinal Delta v of -26.0 km/h (-16.2 mph) and a cumulative lateral Delta v of 4.8 km/h (3.0 mph) at the 78 ms mark. The EDR report is included as an attachment to this report. The case vehicle was assigned a Collision Deformation Classification of 12FLEN2 and a PDOF of 0 degrees. The combined direct and induced damage width was 148 cm (58.3 in) [CRASH L = 148 cm (58 in)], and the maximum crush depth was 28 cm (11 in) located at C_2.

The case vehicle is equipped with beige leather-covered bucket seat in the outboard front seating positions and a leather-covered bench seat in the rear. The front left seat back was reclined rearward at a 22 degrees angle from vertical and the seat was adjusted to between middle and rear most track position. This seat position was equipped with a manual lap and shoulder belt and emergency locking retractor (ELR). The front right seat back was reclined rearward at an 18 degree angle vertical and the seat was adjusted to the rear most track position. This seat position was equipped with a manual lap and shoulder belt and a switchable retractor in ELR mode.

AOPS Discussion

This vehicle was equipped with an advanced occupant protection system. The system consists of a Restraint Control Module (RCM) dual stage front air bags, seat belt pretensioners, load limiters, seat track sensors, and seat belt latch usage detectors. The system is controlled by the RCM. The primary function of the RCM is to control the deployment of the occupant protection systems.

[1] EDR report indicates that the driver seat buckle was “engaged”.

The system records longitudinal and lateral acceleration. Data related to the driver and passenger air bag deployment include: 78 milliseconds of crash pulse, deployment strategy of the dual-stage air bag system, seat belt latch use, pretensioner operation, and driver seat track location.

The EDR report further indicates that:

1. This was a first stage only deployment. The second stage was disposed.
2. The driver's seat was not in the forward position.
3. The left front seat buckle was engaged; the front right seat buckle was not engaged.
4. The time from algorithm wake-up to pretensioner deployment attempt was 7 milliseconds.
4. The time from algorithm wake-up to first stage - belted was 22 milliseconds.

The case vehicle was equipped with a driver's frontal air bag and a top-mount front right passenger's air bag. The driver's air bag was circular and measured 44 cm (17.3 in.) in diameter. It was equipped with two tethers and two vent ports. The dual module covers opened in an "H" configuration. There were no indications of any damage to driver's air bag or the module covers. The front right passenger's air bag was rectangular and measured 40 cm (15.7 in) high by 58 cm (22.8 in) wide. It was equipped with two vent ports and did not have any internal tether straps. On the face of the air bag there were vinyl transfers to the membrane from expansion within the module. The single flap module cover opened properly and was not damaged.

Both front seat positions of the case vehicle were equipped with seat belt pretensioners. The pretensioner barrels were checked and measured. The driver's barrel measured 4.0 cm (1.6 in.), indicating that it had deployed. The front right barrel measured 10.8 cm (4.3 in.), indicating it had not deployed.

The case vehicle was also equipped with adjustable foot controls. The longitudinal distance between the toe pan and the back of the brake pedal was measured at 15.5 cm (6.1 in).

Scene Diagram

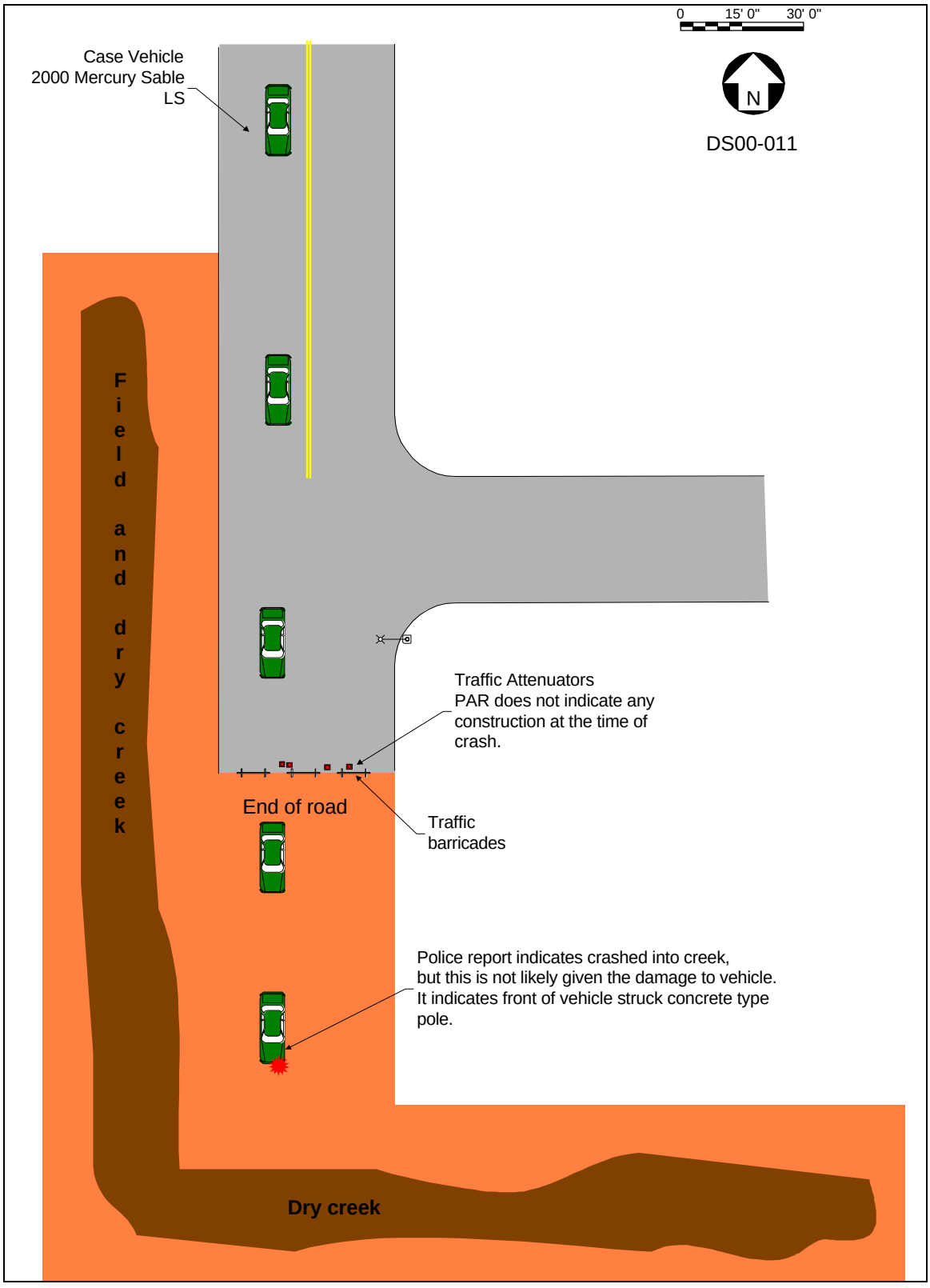


Figure 3. Scene diagram

DETAILED INFORMATION

Vehicles

Case vehicle

Description:	2000 Mercury Sable LS 4-door	
VIN:	1MEFM55S9YGxxxxxx	
Odometer:	8,431 km (5,239 miles)	
Engine:	3.0L 6 cyl	
Reported Defects:	None	
Cargo:	None	
Damage Description:	Moderate damage to front left. The front left door frame had induced damage.	
CDC:	12FLEN2	
Delta V:	Total	23.0 km/h (14.3 mph)
	Longitudinal	-23.0 km/h (-14.3 mph)
	Latitudinal	0.0 km/h (0.0 mph)
	Energy	36,446 joules (26,881 ft-lbs)

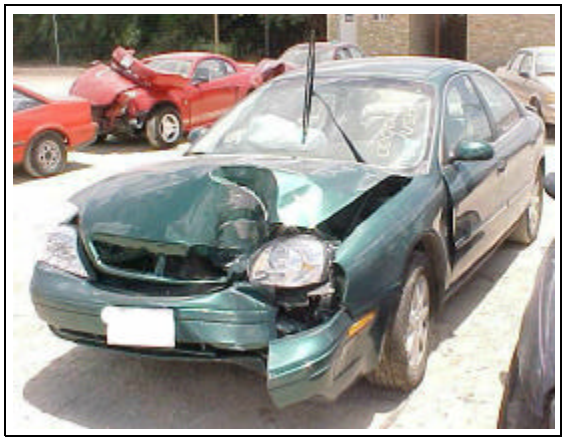


Figure 4. Exterior front damage to case vehicle

Occupants

Case vehicle	Occupant 1
Age/Sex:	39/Female
Seated Position:	Front left
Seat Type:	Leather-covered bucket seat. Seat adjusted to between middle and rear most track position.
Height:	163 cm (64 in.)
Weight:	61 kg (135 lbs)
Occupation:	House cleaner
Pre-existing Medical Condition:	None noted
Alcohol/Drug Involvement:	None
Driving Experience:	Presumed to be greater than 20 years
Body Posture:	Assumed normal, upright
Hand Position:	Unknown
Foot Position:	Unknown, assumed left foot on floorboard and right foot on gas pedal
Restraint Usage:	Lap and shoulder belt used
Air bag:	Steering wheel mounted air bag deployed
Pretensioner:	Equipped with a pretensioner at the belt buckle-pretensioner fired

Injuries and Injury Mechanisms

Case vehicle

	INJURY	OIC CODE	ICD-9	SOURCE
Driver:	Upper back muscle strain	640478.1, 7	847.1	Possibly seat back
	Unknown chest injury—complained of pain	415099.7, 0	959.1	Air bag

Occupant Kinematics

The 39-year-old female driver of the case vehicle was seated in a normal, upright fashion in the leather-covered bucket seat. She was wearing the available lap and shoulder safety belt; the pretensioner had deployed. The EDR showed that the seat buckle was engaged. The anchorage was adjusted to the full up position. The seat was adjusted to between the middle and rear most track position. At impact, the driver initiated a forward trajectory in response to the 12 o'clock impact force, and she loaded the lap and shoulder safety belt as the pretensioners fired. The driver engaged the deployed air bag in some fashion with her torso although there was no evidence of contact. She did complain of pain and an unknown type injury to her chest. As she contacted the air bag, the steering column shear capsules were not stroked. She rebounded backward and possibly struck the seat back.

Figure 5. Driver's seat area.

Figure 6. Deployed driver's air bag.

Attachment 1. EDR report

2000 Taurus/Sable EDR Report - Summary Page

Investigation Data

File Name:	ds00-011.hex	**File Save Date:**	17-Aug-2000
File Read-out Date:	N/A	**Report Date:**	20-Oct-2000
Report Version:	1.4		

EDR Control Module Data

Data Validity Check:	Valid	**EDR Model Version:**	141
Time From Side Safing Decision to Left (Driver) Side Bag Deployment:			Not Deployed
Time From Side Safing Decision to Right (Passenger) Side Bag Deployment:			Not Deployed
Passenger Airbag Switch Position During Event:			N/A
Diagnostic Codes Active When Event Occurred:			0

Algorithm Times Actual initiation depends on restraint system status (below).	**ms**
Time From Algorithm Wakeup to Pretensioner:	7
Time From Algorithm Wakeup to First Stage - Unbelted:	10
Time From Algorithm Wakeup to First Stage - Belted:	22
Time From Algorithm Wakeup to Second Stage:	0

Restraint System Status

Driver Seat Belt Buckle:	Engaged
Passenger Seat Belt Buckle:	Not Engaged
Driver Seat Track In Forward Position:	No
Passenger Seat Weight Switch Position:	N/A

Deployment Initiation Attempt Times	**Driver**	**Passenger**
Time From Algorithm Wakeup to Pretensioner Deployment Attempt:	7	Unbelted
Time From Algorithm Wakeup to First Stage Deployment Attempt:	22	22
Time From Algorithm Wakeup to Second Stage Deployment Attempt:	Disposal	Disposal

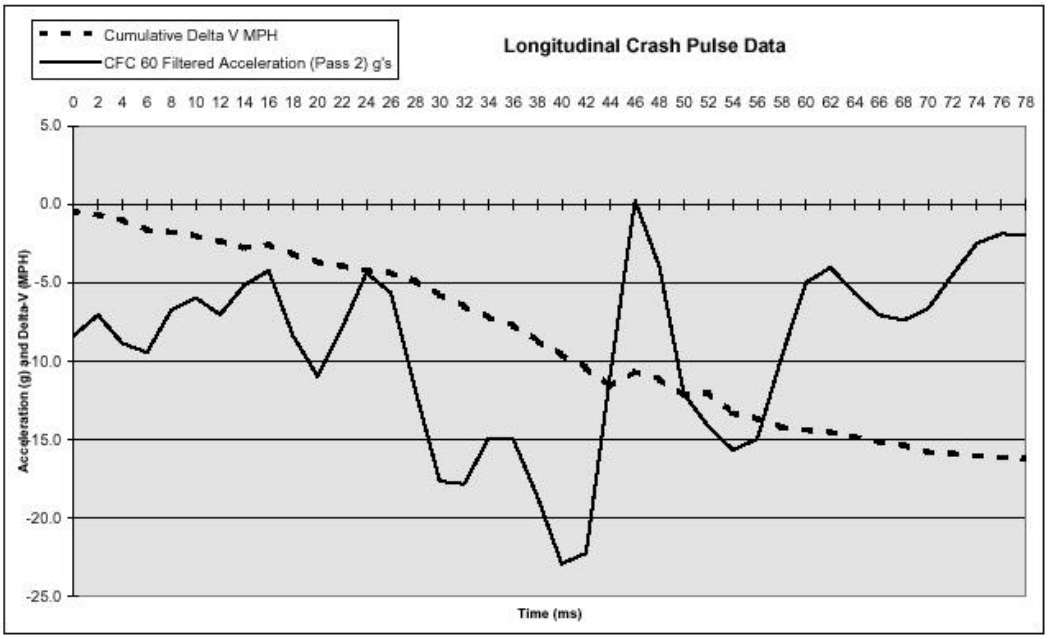
Notes

1. Read-out date is set by the PC interface tool.
2. Features and data parameters which are not available on the module are marked "N/A".
3. CFC 60 is a Butterworth 4-pole phaseless digital filter. (See SAE J211 Part 1 Appendix C dated March 1995.)
4. Total and maximum Delta-V results are not available from truncated/incomplete crash pulses.
5. Algorithm wakeup (0 ms) is not the first moment of vehicle contact or impact.
6. The Excel "Analysis ToolPak" Add-in must be enabled for this spreadsheet to operate properly.

2000 Taurus/Sable EDR Report - Charts

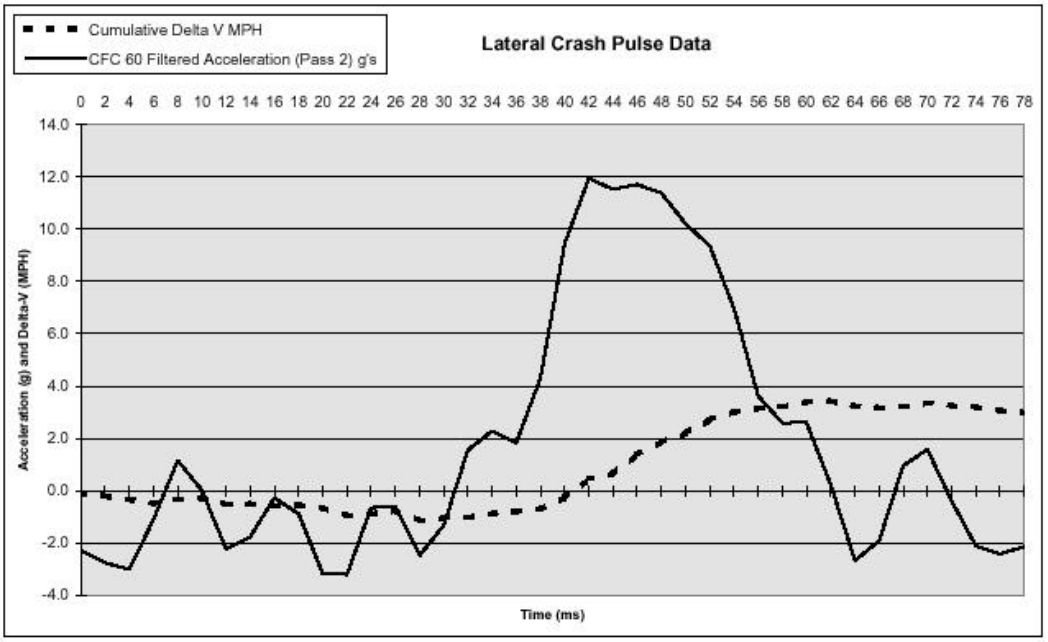
Longitudinal Cumulative Delta-V

Time (ms)	0	10	20	30	40	50	60	70	78
Delta-V (MPH)	-0.5	-2.0	-3.7	-5.8	-9.6	-12.2	-14.4	-15.8	-16.2



Lateral Cumulative Delta-V

Time (ms)	0	10	20	30	40	50	60	70	78
Delta-V (MPH)	-0.1	-0.3	-0.7	-1.0	-0.3	2.2	3.4	3.4	3.0



File Name: ds00-011.hex

2000 Taurus/Sable EDR Report - Memory Dump

Hexidecimal Module Memory Dump

Address	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F
0800	0F	4A	40	76	14	FB	FF	FF	FF	FF	0E	24	0F	2D	3A	4C
0810	C8	FF	00	FF	52	60	52	60	60	52	E3	20	3C	78	D6	A0
0820	08	03	28	37	5F	0F	0F	0A	F5	0A	B7	84	A1	5E	D5	AA
0830	03	0C	1B	1E	00	FF	3C	3C	80	06	28	64	64	00	0C	01
0840	5A	96	50	FF	FF	FF	EF	DF	D5	E7	FF	72	4E	13	25	B1
0850	EC	14	09	0F	01	FF	FF	88	7F	FF	CD	44	08	FF	FF	95
0860	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF
0870	05	37	EF	19	61	00	8F	FF	59	46	31	41	00	02	FF	1C
0880	17	FF	00	02	FF	80	09	FF	80	0A	FF	80	0F	FF	80	FF
0890	13	FF	80	2B	FF	80	35	FF	80	38	FF	80	FF	FF	00	FF
08A0	04	86	88	00	00	08	20	01	00	00	FF	FF	FF	FF	FF	FF
08B0	02	FF	81	38	00	8D	FF	FF	FF	FF	FF	FF	13	01	C1	45
08C0	FF	24	24	C1	8E	53	01	C1	90	51	00	00	56	89	FF	FE
08D0	01	0E	0C	80	02	58	16	87	1F	BE	01	0A	00	8C	01	04
08E0	00	F0	01	36	00	A0	01	54	00	3F	02	30	02	C7	02	8A
08F0	05	14	07	08	01	2C	03	CA	04	CE	06	40	73	33	00	A0
0900	3F	FF	00	03	00	4B	01	CC	00	03	0F	FF	00	14	00	78
0910	00	A0	00	6E	0A	16	FF	01	00	00	00	7F	0F	0C	0F	02
0920	03	5A	32	46	05	50	02	02	FA	1E	08	0C	0A	1C	02	23
0930	09	06	28	32	16	20	16	1F	5F	FF	FF	02	FF	FF	FF	11
0940	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF
0950	0A	00	16	00	07	00	00	06	00	00	06	11	07	20	20	28
0960	07	08	0D	14	07	13	02	00	00	00	0A	16	1B	0F	10	0A
0970	00	00	6F	90	A4	82	B4	9F	99	72	5A	5A	BB	92	D9	77
0980	B8	D7	DE	D5	D1	DB	82	9B	D0	A5	74	96	BC	8E	92	BE
0990	BD	C6	BC	B2	CE	CE	9C	B8	BE	AE	B8	AE	B2	B9	BA	8F
09A0	9C	93	88	9E	99	94	91	AD	88	8D	99	97	9D	8D	7C	82
09B0	85	8C	77	7C	7D	6F	CF	8D	76	AC	68	94	8B	9C	9E	96
09C0	95	9A	90	A0	9D	A1	A0	7D	7E	7C	7B	8A	83	77	84	7E
09D0	83	7D	75	84	88	71	87	82	89	86	86	96	A3	8B	A3	98
09E0	91	9A	8F	89	84	8B	84	78	80	83	89	7D	80	7C	7E	00
09F0	00	00	00	00	00	00	00	FF	FF	8B	00	FF	FF	FF	FF	04

File name: ds00-011.hex