On-scene Investigation / Vehicle to Vehicle
Dynamic Science, Inc. / Case Number: DS01-003
2000 Ford Taurus
California
December, 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.
DS01-003		

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 case vehicle was equipped with an Advanced Occupant Protection System. The collision occurred in southern California in December, 2000 at 0525 hours. The collision occurred at a T-intersection of a state route and a private roadway. The state route is a north/southbound rural highway consisting of five lanes. It is a straight asphalt surface with a slight upward grade. The north-south state route was uncontrolled, and the speed limit for the north-south roadway was 89 km/h (55 mph). The east-west private roadway was controlled by a stop sign for westbound traffic. It was dark but there were street lights present. It was foggy with 45.7 m (150 ft) visibility, and the roadway surface was wet. The case vehicle, a 2000 Ford Taurus LX 4-door driven by a restrained 30-year-old male was northbound in the left lane. There were two additional occupants in the case vehicle. The front right seat was occupied by a restrained 39-year-old male. The 2nd left seat was occupied by a 48-year-old male. The other vehicle, a 1997 Chevrolet S-10 utility vehicle driven by a police reported restrained 52-year-old male, was attempting a left turn to head south. The fog appears to have played a role in the collision. The driver of the case vehicle indicated to the police that it was very foggy and hard to see. The Chevrolet was initially stopped at the intersection. Once the driver of the Chevrolet thought it was clear to proceed, he accelerated and entered the intersection, directly in the path of the case vehicle. The driver of the case vehicle was unable to take any evasive action and the front of the case vehicle stuck the left front of the Chevrolet. On impact, both front air bags in the case vehicle deployed. After impact, the case vehicle rotated counterclockwise and came to final rest in the southbound travel lanes heading northwest. The Chevrolet rotated clockwise and came to final rest in the northbound travel lanes heading northeast.

The driver of the case vehicle sustained minor abrasions to his hands. The front right occupant in the case vehicle sustained "complaint of pain" type injuries consisting of facial and nose pain. The 2nd left occupant in the case vehicle did not report injuries to the police. Both injured occupants indicated to the police that they would seek their own medical attention. The driver of the Chevrolet did not report any injuries to the police.

Both vehicles were towed from the scene, and the case vehicle was subsequently declared a total loss by the insurance company.

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: DS01-003

TABLE OF CONTENTS

BACKGROUND:

Description:	This Advanced Occupant Protection Systems case was reported to the NHTSA by Dynamic Science, Inc. on February 7, 2001. NHTSA assigned the case to Dynamic Science on February 8, 2001.
Investigation Type:	On-scene
Crash Location:	California
Crash Date:	December, 2000
Notification Date:	February 7, 2001
Field Work Completed:	February 8, 2001

SUMMARY:

The collision occurred in southern California in December, 2000 at 0525 hours. The collision occurred at a T-intersection of a state route and a private roadway. The state route is a north/southbound rural highway consisting of five lanes. It is a straight and asphalt surface with a slight upward grade. The north-south state route was uncontrolled, and the speed limit for the north-south roadway was 89 km/h (55 mph). The east-west private roadway was controlled by a stop sign for westbound traffic. It was dark but there were street lights present. It was foggy with 45.7 m (150 ft) visibility, and the roadway surface was wet.

The case vehicle, a 2000 Ford Taurus LX 4-door driven by a restrained 30-year-old male (145 cm-67 in./84 kg-185 lbs) was northbound in the left lane at or near the 89 km/h (55 mph) speed limit. There were two additional occupants in the case vehicle. The front right seat was occupied by a restrained 39-year-old male. The 2nd left seat was occupied by a 48-year-old male.

Figure 1. Approach to area of impact, case vehicle

Figure 2. Final rest, case vehicle

The other vehicle, a 1997 Chevrolet S-10 utility vehicle driven by a police reported restrained 52-year-old male, was attempting a left turn to head south at a speed calculated at 19.9 km/h (12.4 mph).

Figure 3. Front view, case vehicle

The fog appears to have played a role in the collision. The driver of the case vehicle indicated to the police that it was very foggy and hard to see. The Chevrolet was initially stopped at the intersection. Once the driver of the Chevrolet thought it was clear to proceed, he accelerated and entered the intersection, directly in the path of the case vehicle. The driver of the case vehicle was unable to take any evasive action and the front of the case vehicle stuck the left front of the Chevrolet.

Figure 4. Right side, case vehicle

On impact, both front air bags in the case vehicle deployed. The case vehicle sustained a longitudinal delta v of -33.8 km/h (-21.0 mph) and a lateral delta v of -19.5 km/h (-12.1 mph)[1]. The Electronic Data Recorder showed a longitudinal delta v of -37.1 km/h (-23.1 mph) and a lateral delta v of -25.2 km/h (-15.7 mph) at the 78 ms mark.

After impact, the case vehicle rotated counterclockwise and came to final rest in the southbound travel lanes heading northwest. The Chevrolet rotated clockwise and came to final rest in the northbound travel lanes heading northeast.

The driver of the case vehicle sustained minor abrasions to his hands. The front right occupant in the case vehicle sustained "complaint of pain" type injuries consisting of facial and nose pain. The 2nd left occupant in the case vehicle did not report injuries to the police. Both injured occupants indicated to the police that they would seek their own medical attention.

[1]Calculated using WinSmash 2.06 and NCAP derived stiffness values.

The driver of the Chevrolet did not report any injuries to the police.

Both vehicles were towed from the scene, and the case vehicle was subsequently declared a total loss by the insurance company.

Scene Diagram

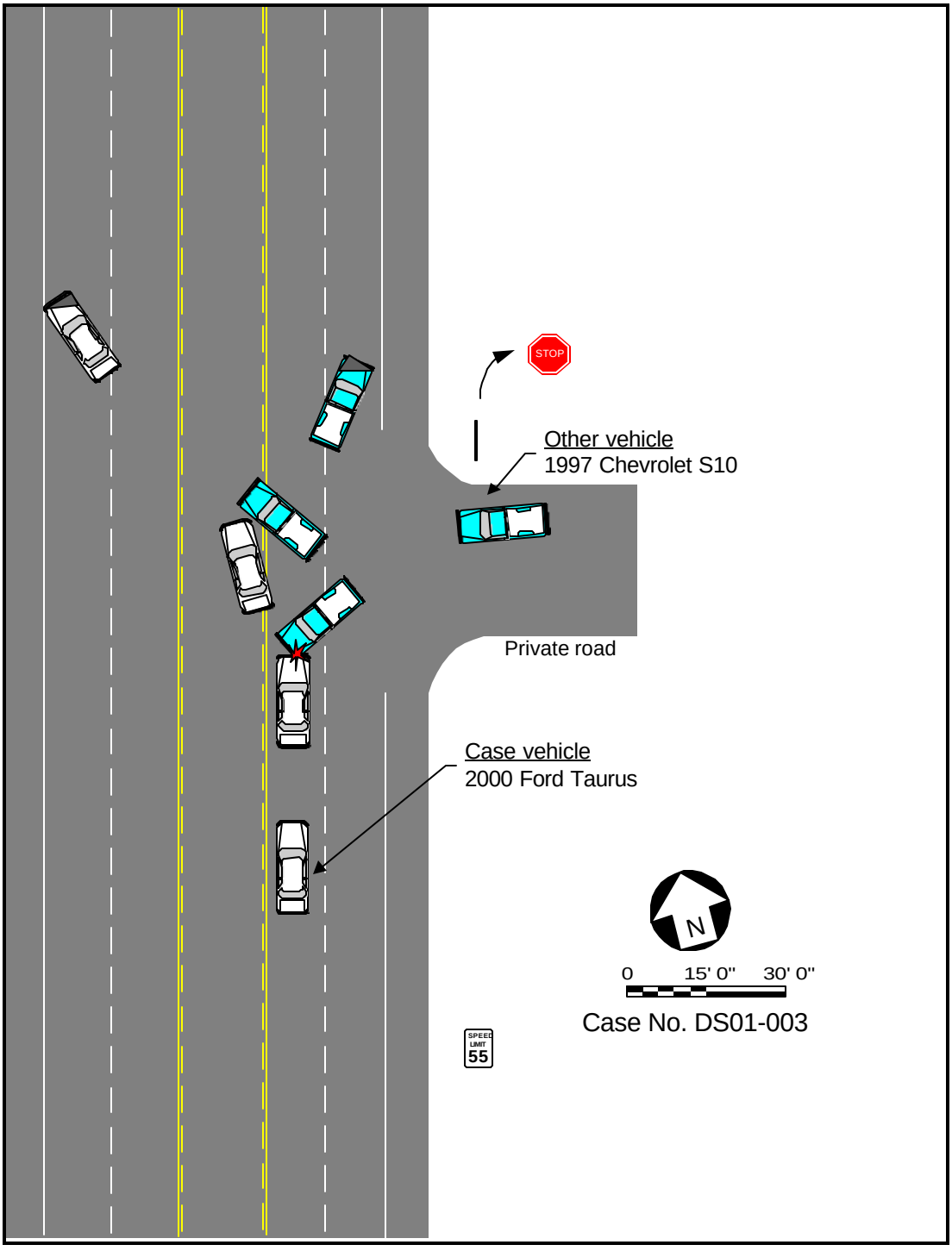


Figure 5. Scene diagram

COLLISION MEASUREMENTS						
Reference point:	North road edge					
Reference line:	East road edge (V2) / West road edge (V1)					
Data Point	**Distance and Direction from RP**			**Distance and Direction from RL**		
	ft	m	d	ft	m	d
Scrapes/POI	31	9.4	S	27	8.2	W
Other vehicle - Chevrolet S10						
ERR	9	2.7	N	15	4.6	W
ERF	17	5.2	N	12	3.7	W
Case vehicle - Ford Taurus						
ERR	25	7.6	N	20	6.1	E
ERF	33	10.1	N	14	4.3	E
Northbound grade						
2.3% @ 200 ft. south of RP						
1.9% @ 100 ft. south of RP						
2.1% @ RP						
Acceleration (field test)						
9 mph - normal acceleration						
11 mph - fast acceleration						

DETAILED INFORMATION

Vehicles

Case vehicle

Description:	2000 Ford Taurus LX 4-door	
VIN:	1FAFP52UXYGxxxxxx	
Odometer:	24,526 km (15,240 miles)	
Engine:	3.0L 6 cyl	
Reported Defects:	None	
Cargo:	None	
Damage Description:	Moderate to major damage to front right. Wheelbase shortened by 12.5 cm (4.9 in.) on right side. Right door bowed outward.	
CDC:	01FZEW1	
Delta V:	Total	39.0 km/h (24.2 mph)
	Longitudinal	-33.8 km/h (-21.0 mph)
	Latitudinal	-19.5 km/h (-12.1 mph)
	Energy	25,483 joules (18,795 ft-lbs)

Figure 6. Front, case vehicle

Figure 7. Right side, case vehicle

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, 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 accerleration. Data related to the driver and passenger air bag deployment include: 80 milliseconds of crash pulse, deployment strategy of the dual-stage air bag system, seat belt latch use, pretensioner operation, and driver seat track location.

On impact, both front air bags in the case vehicle deployed. The case vehicle sustained a longitudinal delta v of -33.8 km/h (-21.0 mph) and a lateral delta v of -19.5 km/h (-12.1 mph). The Electronic Data Recorder showed a longitudinal delta v of -37.1 km/h (-23.1 mph) and a lateral delta v of -25.2 km/h (-15.7 mph) at the 78 ms mark. The pulse was leveling off at this point.

The EDR report further indicates that:

1. This was a first stage deployment.
2. The driver's seat was not in the forward position.
3. The left front and right front seat buckles were engaged.
4. The time from algorithm wake-up to pretensioner was 14 milliseconds
5. The time from algorithm wake-up to first stage - belted was 21 milliseconds.

The case vehicle was equipped with frontal air bags mounted in the steering wheel and top mounted in the instrument panel of the front right seat position. The module cover opened in an "H" configuration. There were no indications of any damage to the covers. There were blood splatters on the air bag face. The single flap cover for the passenger frontal air bag did not sustain any damage. There were blood spots on the face and left side of the air bag.

The case vehicle was also equipped with seat belt pretensioners at the front left and front right seating positions. The pretensioner barrels were checked and measured 6.7 cm (2.6 in.) at the front left seating position and 5.9 cm (2.3 in) at the front right seating position. This indicated that both pretensioners had deployed.

Other vehicle

Description:	1997 Chevrolet S10 pickup	
VIN:	Unknown	
Odometer:	Unknown	
Engine:	Unknown	
Reported Defects:	None noted	
Cargo:	Unknown	
Damage Description:	Police indicate “major” damage to left side and front. Vehicle towed from the scene due to damage.	
Impact Speed:	19.9 km/h (12.4 mph)[2]	
CDC:	Unknown	
Delta V:	Total	48.9 km/h (30.4 mph)
	Longitudinal	-40.1 km/h (-24.9 mph)
	Latitudinal	28.1km/h (17.4 mph)
	Energy	306,800 joules (226,284 ft-lbs.)

[2]Calculation using an acceleration rate of 4 ft/sec/sec

Occupants

Case vehicle	Occupant 1	Occupant 2	Occupant 3
Age/Sex:	30/Male	39/Male	48/Male
Seated Position:	Front left	Front right	Rear left
Seat Type:	Fabric covered bucket seat--adjusted to between the middle and rear most track position	Fabric covered bucket seat--adjusted to the rear most track position	Fabric covered bench seat
Height:	145 cm (67 in.)	Unknown	Unknown
Weight:	84 kg (185 lbs)	Unknown	Unknown
Occupation:	Unknown	Unknown	Unknown
Pre-existing Medical Condition:	None noted	None noted	None noted
Alcohol/Drug Involvement:	None	NA	NA
Driving Experience:	Presumed to be greater than 10 years	NA	NA
Body Posture:	Normal, upright	Normal, upright	Normal, upright
Hand Position:	Unknown	Unknown	Unknown
Foot Position:	Right foot on brake, left on floor	Unknown	Unknown
Restraint Usage:	Lap and shoulder belt used	Lap and shoulder belt used	Lap and shoulder belt used
Air bag:	Steering wheel mounted air bag deployed	Top mounted instrument panel passenger air bag deployed	NA

Other vehicle

Age/Sex:	52/Male
Seated Position:	Front left
Seat Type:	Unknown
Height:	173 cm (68 in.)
Weight:	68 kg (150 lbs.)
Occupation:	Unknown
Pre-existing Medical Condition:	None noted
Alcohol/Drug Involvement:	None
Driving Experience:	Unknown, presumed to be greater than 20 years
Body Posture:	Unknown
Hand Position:	Unknown
Foot Position:	Unknown
Restraint Usage:	Lap and shoulder belt used per police report

Injuries and Injury Mechanisms

Case vehicle

	INJURY	OIC CODE	ICD-9	SOURCE
Driver:	Minor abrasions to hands	790202.1,3	913.0	Air bag
Front right occupant:	Complained of facial and nose pain	Not codeable		
Rear right occupant:	No reported injuries			

Other vehicle

	INJURY	OIC CODE	ICD-9	SOURCE
Driver:	No reported injuries			

Occupant Kinematics

The 30-year-old male driver of the case vehicle was seated in a normal, upright fashion in the fabric-covered bucket seat. He was wearing the available lap and shoulder belt. The EDR showed that the seat buckle was engaged. The anchorage was adjusted to the mid position. The seat was adjusted to between the middle and rear most track position. At impact, the driver responded to the 30 degree direction of force by moving forward and to the right. He loaded the lap and shoulder belt as the pretensioners fired. Both knees contacted the lower instrument panel–deforming it. His right foot deformed the gas pedal to the right. The driver engaged the deployed air bag with his head and torso. As he loaded the bag and the steering wheel, the steering column shear capsules were stroked 0.2 cm (0.08 in) on the right and 0.7 cm (0.3 in) on the left. It seems likely that the air bag contacted both of his hands–causing the bilateral abrasions.

Figure 8. Driver position, case vehicle

Figure 9. Load marks to driver's seat belt

Figure 10. Load marks to front right passenger seat belt

The 39-year-old male front right passenger was seated in a normal, upright fashion in the fabric-covered bucket seat. He was wearing the available lap and shoulder belt. The EDR showed that the seat buckle was engaged. The anchorage was adjusted to the full up position. The seat was adjusted to the rear most track position. At impact, this occupant responded to the 30 degree direction of force by moving forward and to the right. He loaded the lap and shoulder belt. It appears that his legs engaged the glove box, causing some deformation. As the impact continued, he rode down the impact–causing a depression in the front right seat. He engaged the air bag with his face–causing some pain but no injuries. He rebounded backward and deformed the seat back rearward.

Figure 11. Ride-down pattern in front right seat

The 48-year-old male rear left passenger was seated in a normal, upright fashion in the fabric-covered bench seat. He was wearing the available lap and shoulder belt. At impact, the driver responded to the 30 degree direction of force by moving forward and to the right. He loaded the lap and shoulder belt. He did not report any injuries.

Figure 12. Rear right seating position

Attachment 1. EDR report

Investigation Data

File Name:	DS01003.tex	File Save Date:	16-Feb-2001
File Read-out Date:	N/A	Report Date:	19-Feb-2001
Report Version:	1.6		

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:	14
Time From Algorithm Wakeup to First Stage - Unbelted:	14
Time From Algorithm Wakeup to First Stage - Belted:	21
Time From Algorithm Wakeup to Second Stage:	0

Restraint System Status

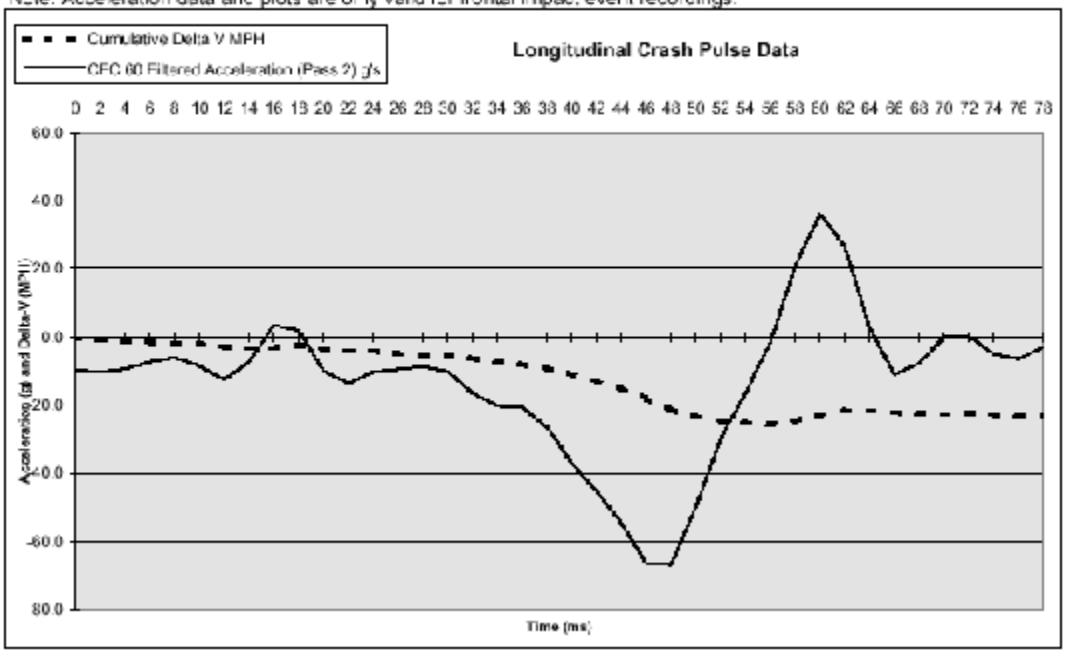
Driver Seat Belt Buckle:	Engaged
Passenger Seat Belt Buckle:	Engaged
Driver Seat Track In Forward Position:	No
Passenger Seat Weight Switch Position:	N/A

Deployment Initiation Attempt Times	Driver	Passenger
Time From Algorithm Wakeup to Pretensioner Deployment Attempt:	14	14
Time From Algorithm Wakeup to First Stage Deployment Attempt:	21	21
Time From Algorithm Wakeup to Second Stage Deployment Attempt:	Disposal	Disposal

Longitudinal Cumulative Delta-V

Time (ms)	0	10	20	30	40	50	60	70	78
Delta-V (MPH)	-0.4	-2.0	-3.6	-6.5	-13.3	-23.2	-23.0	-22.6	-23.1

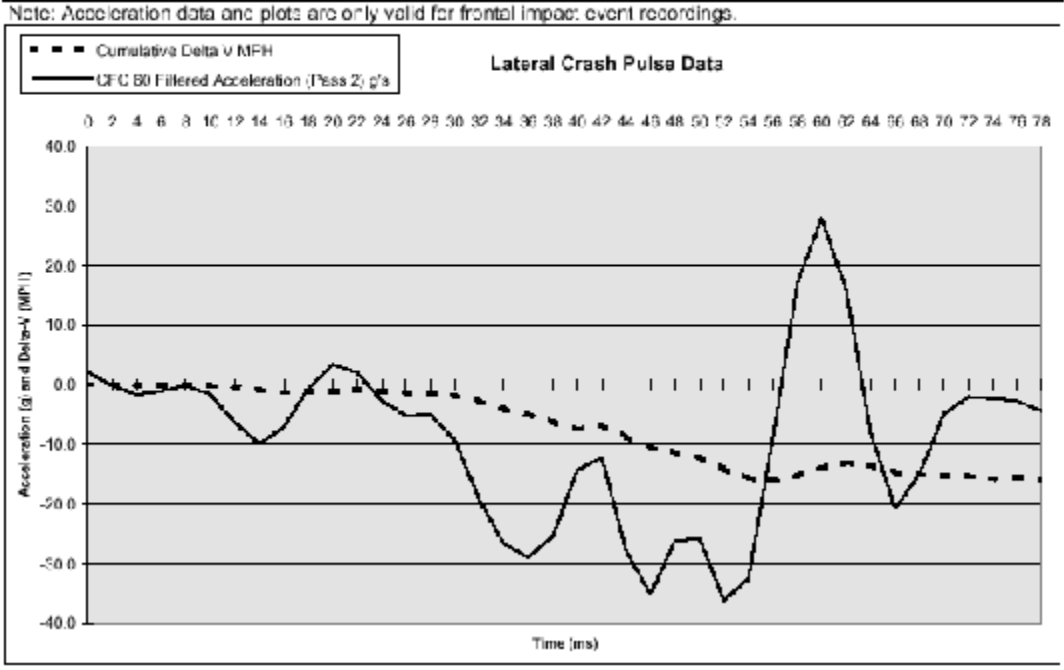
Note: Acceleration data and plots are only valid for frontal impact event recordings.



Lateral Cumulative Delta-V

Time (ms)	0	10	20	30	40	50	60	70	78
Delta-V (MPH)	0.1	-0.1	-1.1	-1.8	-7.4	-12.2	-15.5	-15.3	-15.7

Note: Acceleration data and plots are only valid for frontal impact event recordings.



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	03	24	0F	2D	3A	4C
0810	C8	FF	C0	FF	52	60	52	60	60	52	B3	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	1D	1E	0C	FF	3C	3C	00	06	23	64	64	00	0C	01
0840	5A	96	50	FF	FF	FF	EF	DF	D5	E7	F7	72	4E	13	25	B1
0850	EC	14	C9	0F	01	FF	FF	88	7F	FF	CD	44	08	FF	FF	95
0860	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	F7	FF	FF	FF	FF	FF
0870	05	39	60	EC	62	00	8F	FF	59	46	31	41	00	02	FF	13
0880	38	FF	80	02	FF	80	13	FF	80	12	F7	80	2B	FF	80	FF
0890	2D	FF	80	09	FF	80	0A	FF	80	0F	F7	80	35	FF	80	FF
08A0	44	86	8C	00	00	28	20	01	00	00	F7	FF	FF	FF	FF	FF
08B0	02	FF	81	38	00	8D	01	FF	FF	FF	F7	FF	34	01	D0	BF
08C0	FF	23	C1	D0	BF	54	01	D0	BF	51	00	89	60	34	FF	FE
08D0	01	0E	CC	00	02	50	1C	07	1F	DE	01	0A	00	3C	01	04
08E0	00	F0	C1	3C	0C	A0	01	54	00	3F	02	30	02	27	02	0A
08F0	05	14	C7	08	01	2C	03	CA	04	CE	06	40	73	33	00	A0
0900	3F	FF	C0	03	0C	4B	01	CC	00	03	07	FF	00	14	00	78
0910	00	A0	C0	6E	0A	16	FF	01	00	00	00	7F	0F	3C	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	F7	02	FF	FF	FF	11
0940	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	F7	FF	FF	FF	FF	FF
0950	0E	00	15	00	0E	00	00	04	00	00	07	08	0A	07	17	24
0960	06	07	0B	0B	0B	11	05	11	00	00	09	15	1B	05	0B	13
0970	00	00	9C	D0	9E	81	B3	C1	A0	6B	B3	6D	AB	87	92	90
0980	80	65	5D	E5	AC	5D	7B	C6	88	A9	E1	AF	98	DA	C5	BB
0990	A6	B6	AC	AE	C0	B2	9A	C5	CA	BD	83	99	B9	A9	AB	8C
09A0	87	8C	92	88	A0	75	92	9C	C3	68	88	9B	79	90	93	77
09B0	6F	7C	6D	4C	42	3B	1A	04	4E	56	90	83	D0	E9	DE	94
09C0	89	91	9A	AB	89	90	9C	87	80	7C	81	7F	7F	78	68	71
09D0	87	80	8E	77	74	78	75	57	43	57	47	4B	9E	29	2F	5E
09E0	57	2B	3B	77	A0	BA	AC	68	50	69	79	82	6E	8A	76	00
09F0	00	00	C0	00	0C	00	00	FF	FF	BE	00	FF	FF	FF	FF	04

Attachment 2. Calculations

CASE NUMBER: ds01-003

Comments: Chevy S-10 accelerating into roadway

*** * END VEL W/ A RATE, I VEL, DISTANCE * ***

$Ve = \sqrt{Vi^2 + 2 \times a \times D}$

$Ve = \sqrt{0.00^2 + 2 \times 4.00 \times 41.00}$

$Ve = \sqrt{0.00 + 328.00}$

$Ve = \sqrt{328.00}$

$Ve = 18.11$

Ve = Ending Velocity in FPS.
Vi = Initial Velocity in FPS.
a = Acceleration in FPS².
D = The Distance in Feet.
2 = A Constant.

INPUTS:	
The Initial Vel in FPS is:	0.00
The Acceleration Rate is:	4.00
The Distance in Feet is:	41.00

RESULTS:	
The Ending Vel in FPS is:	18.11

Printed: 5/31/2001