

On-scene Investigation / Vehicle to Vehicle  
Dynamic Science, Inc. / Case Number: DS01-009  
2000 Ford Taurus SE  
Texas  
December, 2000

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

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

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16. Abstract  <p>This case was initiated because the case vehicle was equipped with an Advanced Occupant Protection System (AOPS) and an Electronic Data Recorder (EDR). The case vehicle, a 2000 Ford Taurus SE driven by 56-year-old female (170 cm/67 in, 81 kg/180 lbs), was traveling westbound. The vehicle had been purchased 12 days earlier. The other vehicle, a 1999 Mazda Protege driven by a 19-year-old male, was traveling eastbound and slowing down to turn left into a private driveway. The front right seat of the Mazda was occupied by a 12-year-old male. The third vehicle, a 2000 Chevrolet Astro Van driven by 22-year-old male, was traveling eastbound directly behind the Mazda. As the Mazda slowed to make the left turn, the Chevrolet was unable to stop and struck the back of the Mazda. The Chevrolet was equipped with dual frontal air bags and they deployed. The collision pushed the Mazda into the westbound lane and into the path of the case vehicle. The front of the case (11FYEW2) vehicle struck the right side (02RFEW3) of the Mazda. On impact, the frontal air bags in the case vehicle and the Mazda deployed. After impact, the case vehicle rotated slightly clockwise and the Mazda rotated counterclockwise. There was a second impact with the left side (03LZEW2) of the case vehicle side-slapping the rear right of the Mazda. All three vehicles were towed from the scene.</p> <p>The driver of the case vehicle sustained a sternal fracture and contusions to her shoulder, chest, and abdomen. All the injuries were related to seat belt usage. She was unaware of what occurred during the crash. Her first memory was paramedics assisting her out of the passenger side door. She was transported to a local hospital by ground ambulance and stayed in the hospital for two days. She is self-employed and was out of work for approximately one month.</p>					
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**Dynamic Science, Inc.**  
**Accident Investigation**  
**Case Number: DS01-009**

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**BACKGROUND:**

Description: This Advanced Occupant Protection Systems case was reported to the NHTSA by DSI on April 08, 2001. The case was assigned to DSI on April 10, 2001. An on-site investigation was conducted and all field work was completed on May 4, 2001.

Investigation Type: On-scene  
 Crash Location: Texas  
 Crash Date: December, 2000  
 Notification Date: April 10, 2001  
 Field Work Completed: May 4, 2001

**SUMMARY:**

This three vehicle, rear-end and angle type crash, occurred in December, 2000 at 1520 hours on a two lane US highway. At the area of impact, the highway is a divided, two lane, asphalt roadway. The westbound roadway has a positive 1.6% grade and the eastbound roadway a negative 3% grade. The posted speed limit is 113 km/h (70 mph).

The case vehicle, a 2000 Ford Taurus SE driven by 56-year-old female (170 cm/67 in, 82 kg/180 lbs), was traveling westbound. The vehicle had been purchased 12 days earlier. The other vehicle, a 1999 Mazda Protege driven by a 19-year-old male, was traveling eastbound and slowing down to turn left into a private driveway. The front right seat of the Mazda was occupied by a 12-year-old male. The third vehicle, a 2000 Chevrolet Astro Van driven by 22-year-old male, was traveling eastbound directly behind the Mazda.



**Figure 1.** Approach to impact area for case vehicle--facing west.

As the Mazda slowed to make the left turn, the Chevrolet was unable to stop and struck the back of the Mazda. The Chevrolet was equipped with dual frontal air bags and they deployed. The collision redirected the Mazda into the westbound lane and into the path of the case vehicle. The front of the case (11FYEW2) vehicle struck the right side (02RFEW3) of the Mazda. On impact, the frontal air bags in the case vehicle and the Mazda deployed. The case vehicle sustained a total delta v of 32.6 km/h (20.3 mph), a longitudinal delta v of -31.5 km/h (-19.6 mph), and a latitudinal delta v of 8.4 km/h (5.2 mph)<sup>1</sup>. The Mazda sustained a delta v of 41.1 km/h (25.5 mph), a longitudinal delta v of -20.6 km/h (-12.8 mph), and a latitudinal delta v of -35.6 km/h (-22.1 mph). The WinSmash results fit the collision model, but appear slightly low for both vehicles.

After impact, the case vehicle rotated slightly clockwise and the Mazda rotated counterclockwise. There was a second impact with the left side (09LZEW2) of the case vehicle side-slapping the rear right of the Mazda.

All three vehicles were towed from the scene.

The data was downloaded from the Restraint Control Module memory of the case vehicle and the file was emailed to Ford. The results are included as an attachment to this report.



**Figure 2.** Exterior damage to case vehicle.



**Figure 3.** Exterior damage to Mazda.

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<sup>1</sup>Calculated using the Winsmash 1.2.1 and stiffness values for the case vehicle calculated using NCAP crash data. CDC for the Mazda estimated from insurance photographs.

The driver of the case vehicle sustained a sternal fracture and contusions to her shoulder, chest, and abdomen. All the injuries were related to seat belt usage. She was unaware of what occurred during the crash. Her first memory was paramedics assisting her out of the passenger side door. She was transported to a local hospital by ground ambulance and stayed in the hospital for two days. She is self-employed and was out of work for approximately one month.



**Figure 4.** Exterior damage to Chevrolet.

The police report indicates that the three occupants of the other vehicles sustained "B, non-incapacitating" type injuries and were transported to a local hospital for treatment.

# Scene Diagram

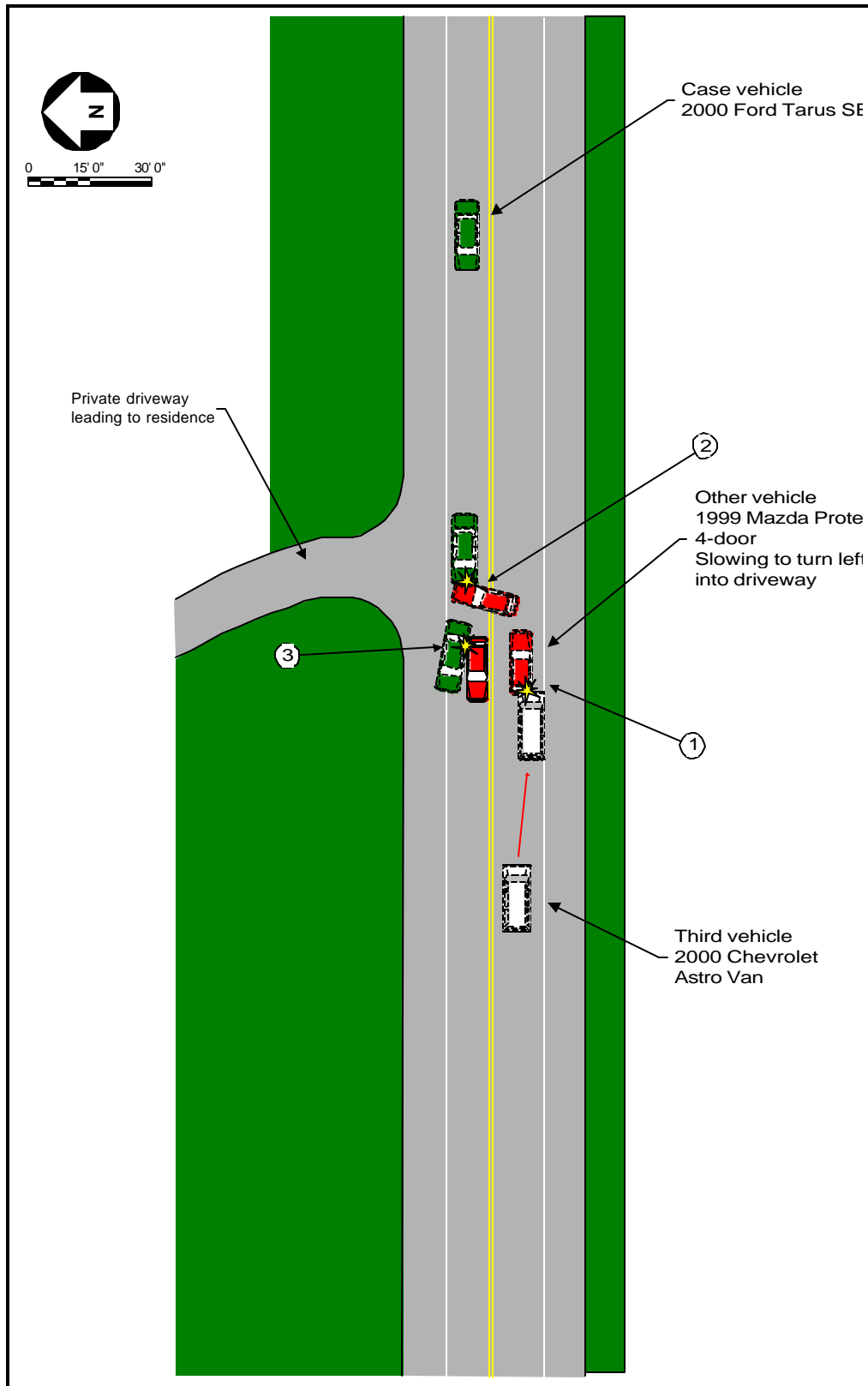


Figure 6. Scene diagram



**DETAILED INFORMATION****Vehicles**Case vehicle

Description:	2000 Ford Taurus SE	
VIN:	1FAFP56S7YAxxxxxx	
Odometer:	18,364 km (11,411 miles)	
Engine:	3.0 L 6 cyl	
Reported Defects:	None	
Cargo:	None	
Damage Description:	Major front end damage, left door frame displaced, contact damage to left side from side slap impact, toe pan intrusion. Vehicle declared a total loss by insurance company.	
CDC:	Event 2, Impact 1: 11FYEW2 Event 3, Impact 2: 09LZEW2	
Delta V (Impact 1):	Total	32.6 km/h (20.3 mph)
	Longitudinal	-31.5 km/h (-19.6 mph)
	Latitudinal	8.4 km/h (5.2 mph)
	Energy	182,468 joules (134,607 ft-lbs)
Delta V (Impact 2):	Total	7.7 km/h (4.8 mph)
	Longitudinal	0 km/h (0 mph)
	Latitudinal	7.7 km/h (4.8 mph)
	Energy	6,626 joules (4,888 ft-lbs)



**Figure 7.** Front left, 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 engagement 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 engagement, pretensioner operation, and driver seat track location.

At the first impact the case vehicle sustained a total  $\Delta v$  of 32.6 km/h (20.3 mph), longitudinal  $\Delta v$  of -31.5 km/h (-19.6 mph), and a latitudinal  $\Delta v$  of 8.4 km/h (5.2 mph) as computed by WinSmash. The downloaded Electronic Data Recorder (EDR) data indicates a cumulative longitudinal  $\Delta v$  of 40.7 km/h (-25.3 mph) and a cumulative lateral  $\Delta v$  of 12.4 km/h (7.7 mph) at the 78 ms mark. The EDR report is included as an attachment to this report.

The EDR report further indicates that:

1. This was a second stage deployment.
2. The driver's seat was not in the forward position.
3. The left front buckle was engaged, the right was not.
4. The time from algorithm wake-up to pretensioner fire was 5 milliseconds.
5. The time from algorithm wake-up to first stage deployment was 8 milliseconds.
6. The time from algorithm wake-up to second stage deployment was 12 milliseconds.

According to Ford, there were two unusually high spikes in the data output that may have been influenced in some way by the subsequent side-slap impact.

Both front seat positions of the case vehicle were equipped with seat belt pretensioners. The pretensioner barrels were measured. The driver's pretensioner measured 4.1 cm (1.6 in.), indicating that it had fired. The passenger's pretensioner measured 10.6 cm (4.2 in.), indicating that it had not fired. The right shear capsule stroke measured 0.5 cm (0.2 in.) and 1.9 cm (0.8 in.) to the left shear capsule. The steering column breakaway coupling was intact.

The case vehicle was equipped with a driver's and front right passenger's air bags. The driver's steering wheel mounted air bag was circular and measured 43 cm (16.9 in.) in diameter. It was equipped with two tethers and two vent ports. The vent holes were at the 11 and 1 o'clock positions. There was a red smear, likely lipstick, on the center of the driver's air bag. The dual module covers opened in a typical "H" configuration. There were no indications of damage to the covers. The front right passenger's top mounted air bag was rectangular and measured 56 cm (22 in.) by 46 cm (18.1 in.). It was equipped with two vent ports and did not have any tethers. On the face of the air bag there was cover-related scuffing. The single flap module cover did not sustain any damage.

Other vehicle (Mazda)

Description:	1999 Mazda Protege	
VIN:	JM1BJ2228X0xxxxxx	
Odometer:	Unknown	
Engine:	1.6 L	
Reported Defects:	None noted	
Cargo:	Unknown	
Damage Description:	Major damage to rear end and right front. Vehicle towed from scene and later declared a total loss.	
CDC:	Event 1, Impact 1: Unknown Event 2, Impact 2: 02RFEW3 Event 3, Impact 3: Unknown	
Delta V (Impact 2):	Total	41.1 km/h (25.5 mph)
	Longitudinal	-20.6 km/h (-12.8 mph)
	Latitudinal	-35.6 km/h (-22.1 mph)
	Energy	24,189 joules (17,852 ft-lbs)



**Figure 8.** Right rear, other vehicle (Mazda)



**Figure 9.** Right front, other vehicle (Mazda)



**Figure 10.** Interior view, other vehicle (Mazda)

Other vehicle (Chevrolet)

Description: 2000 Chevrolet Astro Van 4 x 2  
 VIN: 1GCDM19W0YBxxxxxx  
 Odometer: Unknown  
 Engine: 4.L V6  
 Reported Defects: None noted  
 Cargo: Unknown  
 Damage Description: Moderate damage to bumper, grille, hood.  
 Vehicle towed from scene and later declared a total loss.  
 CDC: Event 1, Impact 1: 12FYEW1  
 Delta V: Total Unknown  
 Longitudinal Unknown  
 Latitudinal Unknown  
 Energy Unknown



**Figure 11.** Front right, other vehicle (Chevrolet)



**Figure 12.** Interior view, other vehicle (Chevrolet)

**Occupants**

<u>Case vehicle</u>	Occupant 1
Age/Sex:	56/Female
Seated Position:	Front left
Seat Type:	Fabric covered bucket seat. Adjusted to mid-track position.
Height:	170 cm (67 in)
Weight:	82 kg (180 lbs)
Occupation:	Self-employed, social worker
Pre-existing Medical Condition:	None noted
Alcohol/Drug Involvement:	None
Driving Experience:	Approximately 35 years
Body Posture:	Normal, upright
Hand Position:	Unknown
Foot Position:	Right foot on accelerator, left on floor
Restraint Usage:	Lap and shoulder belt available, used
Air bag:	Steering wheel mounted air bag, deployed



Other vehicle (Mazda)

Age/Sex:	19/Male	12/Male
Seated Position:	Front left	Front right
Seat Type:	Bucket	Bucket
Height:	Unknown	Unknown
Weight:	Unknown	Unknown
Occupation:	Student	Student
Pre-existing Medical Condition:	None noted	None noted
Alcohol/Drug Involvement:	None	None
Driving Experience:	Unknown	NA
Body Posture:	Unknown	Unknown
Hand Position:	Unknown	Unknown
Foot Position:	Unknown	Unknown
Restraint Usage:	Lap and shoulder belt used, per police report	Lap and shoulder belt used, per police report

Other vehicle (Chevrolet)

Age/Sex:	22/Male
Seated Position:	Front left
Seat Type:	Pedestal style bucket seat
Height:	Unknown
Weight:	Unknown
Occupation:	Wheel repairman
Pre-existing Medical Condition:	None noted
Alcohol/Drug Involvement:	None
Driving Experience:	Unknown
Body Posture:	Unknown
Hand Position:	Unknown
Foot Position:	Unknown
Restraint Usage:	Lap and shoulder belt used, per police report
Air bag:	Steering wheel mounted air bag, deployed

**Injuries and Injury Mechanisms**

## Case vehicle

	<u>INJURY</u>	<u>OIC CODE</u>	<u>ICD-9</u>	<u>SOURCE</u>
Driver:	Contusion, left shoulder	790402.1,2	923.0	Seat belt
	Contusion, left chest	490402.1,2	922.1	Seat belt
	Contusion, abdomen	590402.1,4	922.2	Seat belt
	Sternal fracture	450804.2,4	807.2	Seat belt
	Possible heart injury <sup>2</sup>	NA	NA	

## Other vehicle (Mazda)

	<u>INJURY</u>	<u>OIC CODE</u>	<u>ICD-9</u>	<u>SOURCE</u>
Driver:	“B” - non incapacitating injury			
Front right occupant	“B” - non incapacitating injury			

## Other vehicle (Chevrolet)

	<u>INJURY</u>	<u>OIC CODE</u>	<u>ICD-9</u>	<u>SOURCE</u>
Driver:	“B” - non incapacitating injury			

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<sup>2</sup>Driver was told by doctors in hospital that she had an irregular heartbeat and that it was probably related to the crash.

## Occupant Kinematics

The 56-year-old female (170 cm/67 in, 82 kg/180 lbs) driver of the case vehicle was seated in a normal, upright fashion. She was wearing prescription sunglasses. She was using the available lap and shoulder belt. The upper anchorage adjustment was in the mid position. The fabric-covered bucket seat was adjusted to the rear most track position, and the seat back angle was adjusted to a rearward reclined position of 16E. At impact, the restrained driver responded to the 340E direction of force by moving forward and to the left. She engaged the pretensioned seatbelt with her chest, shoulder, and abdomen—causing the sternal fracture and torso contusions. Her face contacted the deployed air bag and her legs struck the instrument panel causing damage to the rigid plastic cover and slight deformation to the knee bolster; neither contact caused any injuries. As the vehicle sideslapped the other vehicle, the driver responded to the 270E by moving to the left and engaging the door side panel. No injuries were sustained as a result of this contact. Both the brake and gas pedals were displaced laterally. The brake was displaced to the left—which is consistent with the driver's movement during the side slap. The accelerator was displaced to the right. This was possibly due to from kinematic motion to the right from the spinout and side slap.



Figure 13. Driver's seated position

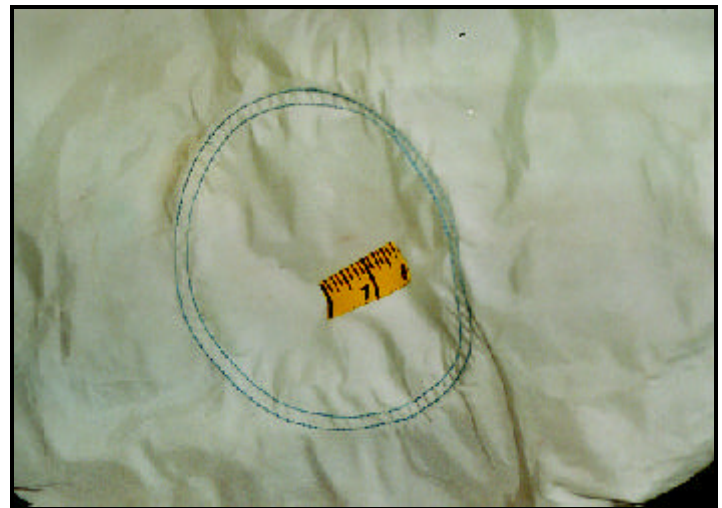
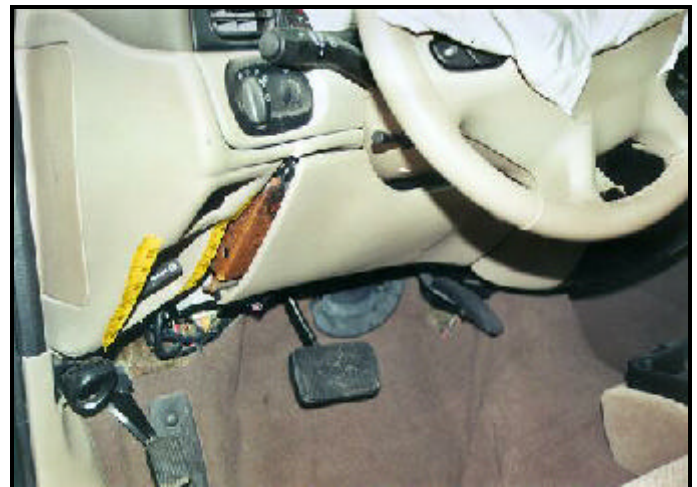


Figure 14. Lipstick contact to driver's air bag



**Figure 15.** Seat belt loading marks on driver's belt



**Figure 16.** Knee contacts to lower instrument panel, lateral displacement of foot controls

Attachment 1. EDR report

*Preliminary  
Crash Severity Data  
Integrity under review.*

2000 Taurus/Sable EDR Report - Summary Page

**Investigation Data**

File Name:	ds01-009.hex	File Save Date:	14-May-2001
File Read-out Date:	N/A	Report Date:	16-May-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:	5
Time From Algorithm Wakeup to First Stage - Unbelted:	8
Time From Algorithm Wakeup to First Stage - Belted:	8
Time From Algorithm Wakeup to Second Stage:	12

*← Fast Decisions  
Imply High  
Severity*

**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**

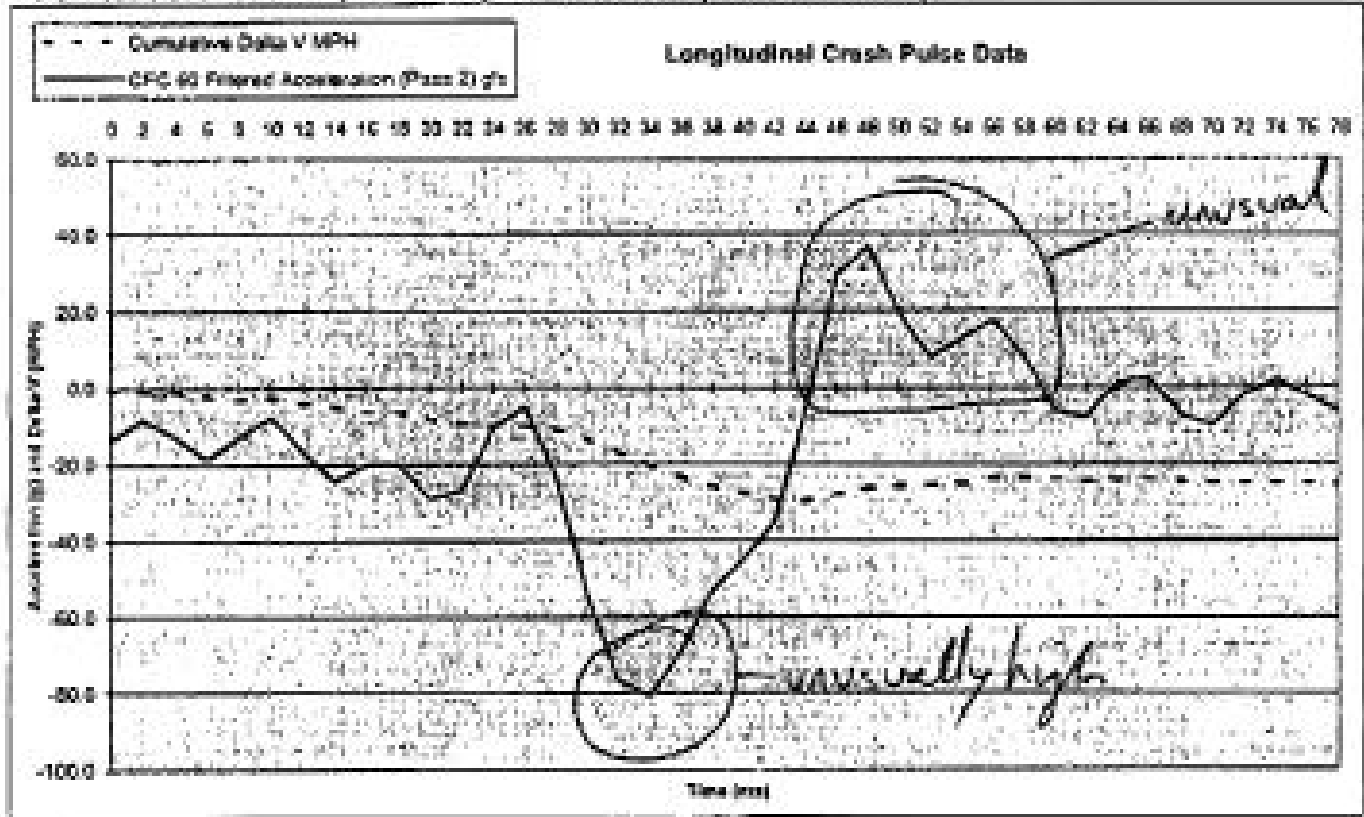
	Driver	Passenger
Time From Algorithm Wakeup to Pretensioner Deployment Attempt:	5	Unbelted
Time From Algorithm Wakeup to First Stage Deployment Attempt:	8	8
Time From Algorithm Wakeup to Second Stage Deployment Attempt:	12	12

0

Longitudinal Cumulative Delta-V

Time (ms)	0	10	20	30	40	50	60	70	78
Delta-V (MPH)	-6.4	-9.3	-9.3	-12.4	-17.3	-22.7	-22.7	-22.3	-15.3

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)	0.0	+8.2	8.3	1.2	6.6	5.6	8.3	7.8	5.9

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

