

**TRANSPORTATION SCIENCES  
CRASH DATA RESEARCH CENTER**

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**ADVANCED OCCUPANT PROTECTION SYSTEM STUDY  
2001 FORD TAURUS INVESTIGATION**

**VERIDIAN CASE NO. CA01-037**

**LOCATION - NEW YORK**

**CRASH DATE - JUNE 2001**

**Contract No. DTNH22-94-07058**

**Prepared for:**

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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 of the involved vehicle(s) or their safety systems.

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<p>16. <i>Supplementary Notes:</i> On-site investigation of a 2001 Ford Taurus equipped with an Advanced Occupant Protection System.</p>			
<p>17. <i>Abstract</i></p> <p>This on-site investigation focused on the fatal injury mechanism of the female driver and the performance of the Advanced Occupant Protection System (AOPS) in the 2001 Ford Taurus. The AOPS consisted of 3-point lap and shoulder belts with load limiter retractors, seat belt buckle pretensioners, seat position sensing and dual-stage frontal air bags. The driver and front right passenger air bags were designed to deploy at different thresholds based on crash severity, restraint use, and seat position. The subject 2001 Ford Taurus was involved in a roadside departure and subsequent left side impact with a tree. The 20 year old female driver and 14 year old female front right passenger were both restrained by the vehicle's 3-point lap and shoulder belt at the time of the crash. The force of the crash caused the front seat belt pretensioners to fire and the frontal air bag for the driver to deploy. The driver sustained a fatal closed head injury as a result of head contact to the tree. The front right passenger only sustained a minor abrasion and a sprained finger in the event.</p> <p>The crash was identified through a local media search conducted by the Special Crash Investigations Team at Veridian Engineering. Veridian SCI informed the Crash Investigations Division of the National Highway Traffic Safety Administration (NHTSA) of the crash on July 02, 2001. NHTSA subsequently assigned an on-site crash investigation the same day, as part of the Advanced Occupant Protection System Study. The vehicle was located in a local tow yard and was available for inspection. The crash data stored in the vehicle's Restraint Control Module was downloaded as a supplement to the crash investigation.</p>			
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**ADVANCED OCCUPANT PROTECTION SYSTEM STUDY  
2001 FORD TAURUS**

**VERIDIAN CASE NO: CA01-037**

**LOCATION: NEW YORK**

**CRASH DATE: JUNE, 2001**

***BACKGROUND***

This on-site investigation focused on the fatal injury mechanism of the female driver and the performance of the Advanced Occupant Protection System (AOPS) in the 2001 Ford Taurus. The AOPS consisted of 3-point lap and shoulder belts with load limiter retractors, seat belt buckle pretensioners, seat position sensing and dual-stage frontal air bags. The driver and front right passenger air bags were designed to deploy at different thresholds based on crash severity, restraint use, and seat position. The Taurus was not equipped with side-impact air bags. The subject 2001 Ford Taurus was involved in a roadside departure and subsequent left side impact with a tree. The 20 year old female driver and 14 year old female front right passenger were both restrained by the vehicle's 3-point lap and shoulder belt systems at the time of the crash. The force of the crash caused the front seat belt pretensioners to fire and the frontal air bag for the driver to deploy. The driver sustained a fatal closed head injury as a result of head contact to the tree. The front right passenger sustained a minor abrasion and a sprained finger in the event.

The crash was identified through a local media search conducted by the Special Crash Investigations Team at Veridian Engineering. Veridian SCI informed the Crash Investigations Division of the National Highway Traffic Safety Administration (NHTSA) of the crash on July 02, 2001. NHTSA subsequently assigned an on-site crash investigation the same day, as part of the Advanced Occupant Protection System Study. The vehicle was located in a local tow yard and was available for inspection. The crash data stored in the vehicle's Restraint Control Module was downloaded as a supplement to the crash investigation.

***SUMMARY***

***Crash Site***

This single vehicle run-off-road/fixed object crash occurred during the evening hours of June, 2001. It was daylight at the time of the crash and the weather was not a factor. The road surface was dry. The subject roadway was a north/south two-lane asphalt road in a rural setting. There was a right curve for northbound traffic. The radius of curvature, near the point of impact, measured approximately 274 m (900 ft). The west road shoulder was grass, measured approximately 1.5 m (5.0 ft) in width and was approximately level. The shoulder then tapered into a 1 m (3 ft) deep ditch that ran parallel to the road. The ditch was centered 2.7 m (90 ft) from the north road edge. A 25 cm (10 in) diameter hardwood tree was growing in the ditch and was the point of impact. The unposted speed limit was 89 km/h (55 mph). **Figure 1** is a northbound trajectory view of the roadway.



**Figure 1:** Trajectory view of the Ford Taurus.

### *Pre-crash*

The 2001 Ford Taurus was northbound driven by a 20 year old restrained female. Her sister, a 14 year old restrained female, was the front right passenger. Reportedly, the driver had picked-up the passenger in a near-by town and they were returning to their home. As the vehicle approached the right curve, the Taurus encountered a deer in the road. The deer probably came from the driver's left and ran into the left front fender of the vehicle. This damage would have been masked by the subsequent impact with the tree. The deer was found on the west shoulder approximately 47 m (154 ft) south of the point of impact. The startled driver reacted to the sudden deer encounter by steering counterclockwise (left) and then braking. The Ford departed the west side of the road evidenced by the tire marks depicted in **Figure 2**. The left front tire left the road approximately 27 m (88 ft) south of the point of impact. A skid mark attributed to the Ford's right front tire began 21 m (70 ft) south of the point of impact. During the vehicle's initial off-road trajectory, the driver steered back clockwise (right) in an effort to regain the road. The rear tires of the Ford lost traction and the vehicle began to rotate clockwise. The vehicle traveled along the west road shoulder and ditch line for a distance of approximately 27 m (88 ft) to impact with a 25 cm (10 in) diameter tree. **Figure 3** depicts the vehicle's off-road clockwise yawing trajectory. The Ford had rotated approximately 20 degrees clockwise at impact.



**Figure 2:** Trajectory view at the point of road side departure.

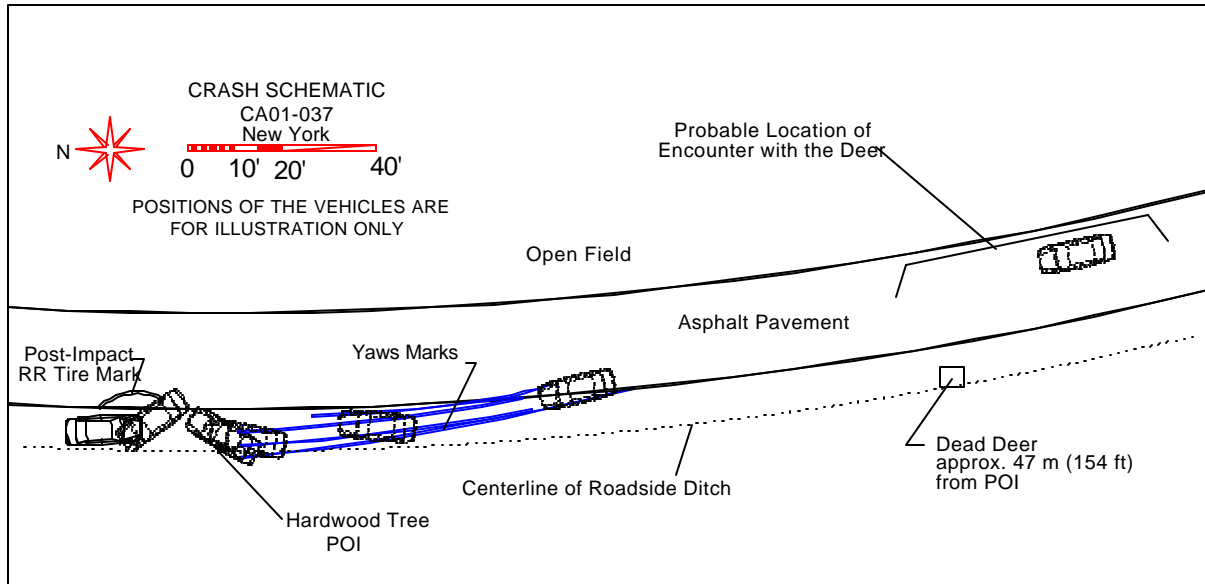


**Figure 3:** Yaw marks leading to the point of impact.

### ***Crash***

**Figure 4** is a schematic of the crash sequence. The front aspect of the vehicle's left side impacted the tree in a sideswiping orientation. The direct contact began approximately at the left front axle location and engagement with the tree continued along the vehicle's left side during its northward trajectory. The maximum engagement with the tree occurred at the left B-Pillar location. The vertical measurement of the direct contact to the tree measured 147 cm (58 in). The nature and dynamics of this prolonged sideswiping impact was not suitable for analysis via the WINSMASH model. The estimated delta V of the impact was 19 to 29 km/h (12 to 18 mph).

The impact with the tree stopped the vehicle's clockwise rotation and caused the vehicle to rotate counterclockwise during the separation phase of the impact. A yaw mark caused by the right rear tire during this rotation is depicted in the background of Figure 3. The Ford rotated approximately 180 degrees and came to rest facing south approximately 8 m (25 ft) north of the tree.



**Figure 4:** Crash schematic.

### ***Post-crash***

Following the crash, the right front passenger turned off the ignition, exited the vehicle through the right front door and ran to a nearby house for assistance. The police were notified of the crash via the 911 system and the police and ambulance personnel were dispatched to the scene. The police and the ambulance arrived on-scene 9 minutes after crash notification. The driver of the vehicle was unresponsive and had to be extricated from the vehicle. Resuscitative measures were applied and the driver was transported to the emergency room of a local hospital. The ambulance arrived at the hospital 53 minutes after crash notification. Efforts to revive the driver proved unsuccessful and she was pronounced dead 75 minutes post crash.

The 14 year old front right passenger was transported to the emergency room as a precaution and for observation. She sustained a sprained index finger and a small abrasion to the left knee. She was treated and released several hours later.

### ***2001 FORD TAURUS***

The 2001 Ford Taurus was identified by the Vehicle Identification Number (VIN): 1FAFP53U81A (production sequence deleted). The vehicle's power train consisted of a 3.0 liter, V-6 engine linked to a 4-speed automatic overdrive transmission. The vehicle was equipped with 4-wheel disc anti-lock brakes. The cloth trimmed interior was equipped with a power package that included power steering, brakes, windows, door locks, mirrors and a power driver seat. The driver seat was equipped with a seat track position sensor. The driver's foot controls were not adjustable. The manual restraint system consisted of 3-point lap and shoulder belts for the five seat positions. The front restraints were equipped with buckle pretensioners. The vehicle was also equipped with frontal air bags for the driver and front right passenger. The 4-door sedan was manufactured in September 2000. The odometer read 12,701 km (7,892 miles) at the time of the inspection.

#### ***Exterior Damage***

**Figures 5 and 6** are the front and left side views of the vehicle's damage. The combined length of the direct and induced left side damage measured 267 cm (105 in). The direct contact damage began on the left front fender, 30 cm (12 in) forward of the left front axle, and ended on the aft aspect of the left rear door, 39.4 cm (15.5 in) forward of the left rear axle. The crush profile measured along the trim elevation was as follows: C1=5.3 cm (2.1 in), C2=25.7 cm (10.1 in), C3=25.4 cm (10.0 in), C4=13.7 cm (5.4 in), C5=7.1 cm (2.8 in), C6=0. The impact shifted the left front and rear doors rearward into the B-pillar and C-pillar, respectively. Both left doors were jammed shut. The hinges of the left front door were cut during the extrication process and the door was opened rearward. The right side doors were operational.

The force of the crash caused approximately 30 cm (12 in) of lateral intrusion measured at the B-pillar. The interior B-pillar to B-pillar dimension measured 102 cm (40 in). The direct contact with the tree deformed and creased the left aspect of the roof into a vertical section. The exterior lateral dimension of the direct roof to tree contact measured 30 cm (12 in) at the A-pillar. The top aspect of the left A-pillar deformed vertically downward approximately 13 cm (5 in). The left side windows were closed at the time of the crash and disintegrated upon impact. The left side of the windshield was fractured by direct contact. There was no change in the wheelbase dimensions. The Collision Deformation Classification (CDC) was 11-LYAW-3. The nature and dynamics of this prolonged side-swiping impact was not suitable for analysis via the WINSMASH model. The delta V of this moderate severity crash was approximately 19 to 29 km/h (12 to 18 mph) based on SCI experience.





Figure 5: Ford Taurus front view.



Figure 6: Left side view.

### *Advanced Occupant Protection System*

The Advanced Occupant Protection System in the 2001 Ford Taurus, designated by the manufacturer as the Personal Safety System (PSS), was a total redesign from earlier model years. The AOPS consisted of the integrated use of manual 3-point lap and shoulder belts with load limiting retractors, buckle pre-tensioners, driver seat position sensing and dual-stage frontal air bag inflation. The driver and front right passenger air bags were designed to deploy at different thresholds of crash severity dependent on restraint use and seat position. The Restraint Control Module (RCM) located on the vehicle's centerline, under the instrument panel, monitored and controlled the deployment of the vehicle's safety systems. The RCM was capable of recording data related to the crash event. The crash data was downloaded in the field during the SCI inspection. This data was then electronically forwarded to the Safety Office of the Ford Motor Company for analysis. The results of the downloaded data are included as **Attachment A** at the end of this report.

The RCM data indicated the driver and front right belt systems were buckled at the time of the crash and the buckle pre-tensioners fired 222 milliseconds after algorithm initiation.. The driver seat was adjusted to a "forward position" (measured as 9.1 cm (3.6 in) rear of full forward) and the driver air bag was also commanded to deploy at 222 milliseconds. The front right passenger air bag did not deploy. The AOPS control logic lowered the deployment threshold for the driver to the unrestrained condition when the driver seat was adjusted to the "forward track position". The restrained passenger air bag was still at the higher deployment threshold and deployment was not warranted.

The RCM recorded the crash acceleration pulse for a duration of 78 milliseconds and calculated a delta V curve for that time frame. The 78 millisecond longitudinal delta V recorded by the RCM was approximately -10.9 km/h (-6.8 mph). The 78 millisecond lateral delta V was approximately 12.5 km/h (7.8 mph). Analysis of the acceleration pulse and velocity curves indicated that only a portion of this long duration crash event was recorded. The acceleration traces were still active and the velocity curves were still rising at the termination of the recording.

### *Interior Damage*

The Taurus was equipped with 3-point lap and shoulder belt systems in the front outboard seat positions. The front seat belt systems consisted of a continuous loop lap and shoulder belt webbing with a sliding latch plate. The vehicle sensitive/load limiting retractors were located in the base of the B-pillars. The front restraints were also equipped with buckle mounted pre-tensioners. The restraint's D-rings were adjustable. The rear seat was equipped with 3-point lap and shoulder restraints for all three seat positions.

Upon inspection, the driver's restraint webbing was extended from the retractor and locked in place due to the deformation, **Figure 7**. The left front D-ring was adjusted to the lowest position and the webbing was gathered in the D-ring's corner from loading. Historical usage evidence was identified on the latch plate consistent with the age of the vehicle. The driver's buckle pretensioner had fired. The post-crash measurement of the pretensioner's piston barrel was 41 mm (1.6 in). The pre-crash specification of the barrel length measured 110 mm (4.3 in), therefore the fired pre-tensioner removed 69 mm (2.7 in) of slack from the belt system. All the evidence identified during the inspection indicated the driver was properly restrained at the time of the crash.



**Figure 7:** Driver's restraint system.

The front right restraint webbing was stowed and operational upon inspection. The webbing and latch plate exhibited historical evidence similar in nature to the driver's restraint. The right buckle pretensioner had fired. The piston barrel measured 56 mm (2.2 in). This measurement indicated approximately 54 mm (2.1 in) of slack was removed by the fired pretensioner. All the evidence identified during the inspection indicated the front right passenger was restrained during the crash.

The driver seat was adjusted to a forward position and could not be moved due to the vehicle's deformation. Measurements taken from an exemplar vehicle indicated the seat was positioned 9.1 cm (3.6 in) rear of full forward. The forward position of the seat was recognized by the RCM, as noted above. The horizontal distance between the center of the steering wheel and the seat back measured 66 cm (26 in). The inboard aspect of the seat was in-contact with the center console indicating the seat had shifted to the right approximately 5 cm (2 in) during the crash sequence. The intruding left B-pillar was in direct contact with the outboard aspect of the seat back and was also in contact with the left aspect of the head restraint, **Figure 8**. During the crash sequence, the left side of the roof deformed and rolled down into a vertical section. **Figure 9** is an interior view of the deformed roof and headliner. The vertical height of the deformed headliner was 30 cm (12 in). There was no evidence of occupant contact to the headliner.



**Figure 8:** View of direct contact between the left B-pillar and driver's head restraint.



**Figure 9:** Interior view of the deformed headliner.

The front right seat was adjusted in a mid-track position. Exemplar measurements determined the seat was positioned 14.2 cm (5.6 in) rear of full forward. This seat could not be moved at the time of the inspection due to floor pan deformation. Therefore, the seat was still adjusted to its at-crash seat track position.

The 4-spoke adjustable steering wheel rim was adjusted to a center position. There was no rim deformation. The steering wheel was turned approximately 120 degrees counterclockwise. Inspection of the steering column shear capsules determined there was approximately 6.3 mm (0.25 in) of left shear capsule separation. This separation was directly related to the exterior crash forces; not driver loading. The bend bracket supporting the mid-aspect of the steering column and the shear coupling on the lower aspect of the column were not damaged and intact.

**Figure 10** is a view of the Taurus's front interior. The driver air bag module was designed in the typical manner in the center of the steering wheel. The driver air bag had deployed from the H-configuration module cover flaps. The cover flaps opened along the designated tear seams. The height of the upper and lower flaps measured 6.4 cm (2.5 in) and 4.6 cm (1.8 in), respectively. The width of the flaps measured 17.2 cm (6.8 in). The deployed driver air bag measured 53 cm (21 in) in diameter. It was tethered by four straps sewn to the face of the bag. The bag was vented by two 2.9 cm (1.1 in) ports located in the 10/2 o'clock position of the back side of the bag. There was no evidence of occupant contact to the air bag. A small blood spatter was observed on the face of the bag in the 3 o'clock sector and was a post-crash artifact. The face of the air bag membrane was lacerated by the disintegrated side glazing. The laceration measured approximately 1 cm (0.4 in) in diameter. The following nomenclature identified the air bag: P5206000-00E TXM002651803

The front right passenger air bag module was a top mount design located in the right aspect of the instrument panel. The severity of the crash was below the threshold required for deployment of this supplemental restraint, given the belted condition of the right passenger.



Figure 10: Front interior view.

***OCCUPANT DEMOGRAPHICS***

	<b>Driver</b>	<b>Front right passenger</b>
Age/Sex:	20 year old/Female	14 year old/Female
Height:	173 cm (68 in)	157 cm (62 in)
Weight:	66 kg (145 lb)	57 kg (125 lb)
Restraint Use:	3-point lap and shoulder	3-point lap and shoulder
Usage Source:	SCI inspection, RCM	SCI inspection, RCM
Medical Treatment:	Transported and pronounced dead upon arrival	Treated and released

***DRIVER INJURY***

<b><i>Driver's Injuries</i></b>	<b><i>Injury Severity (AIS 2000)</i></b>	<b><i>Injury Mechanism</i></b>
Fracture of the right temporal bone and posterior middle fossa	Serious (150200.3,8)	Direct head contact to the tree
Brain is covered bilaterally by a heavy film of subdural hemorrhage	Critical (140654.5,3)	Direct head contact to the tree

Extensive contusion of the posterior left temporal zone in a 2 x 5 cm (1 x 2 in) area, contusions on the convexity of the left parietal zone and contusion over the left superior frontal cortex	Critical (140618.5,2)	Direct head contact to the tree
Subarachnoid hemorrhage present over the convexity of the right and left hemispheres	Serious (140684.3,1) (140684.3,2)	Direct head contact to the tree
Petechial hemorrhages in the right side of the mid-brain	Critical (140210.5,8)	Direct head contact to the tree
Contusion of the mid-brain	Critical (140204.5,8)	Direct head contact to the tree
Blood in the apex of the left ventricle	Severe (140678.4,2)	Direct head contact to the tree
Dicing-type superficial lacerations on the left side of the face	Minor (290602.1,2)	Disintegrated left front window glazing
Oval contusion at the base of the neck	Minor (390402.1,9)	Left D-ring, probable (Note, the injury's aspect was not specified in the medical record. The location of the injury was most probably at the junction with the left shoulder - consistent with intrusion.)
6.4 mm (0.25 in) lung laceration deep in the fissure in the apex of the right middle lobe in about a 5 cm (2 in) area of hemorrhage into the adjacent parenchyma	Serious (441430.3,1)	Inertial contact to the seat belt webbing
5 cm (2 in) laceration of the liver on the back of the left lobe and partial stripping of the capsule in a 8 x 5 cm (3 x 2 in) area with some superficial laceration on the front of the left lobe	Moderate (541822.2,1)	Inertial contact to the seat belt webbing

Extensive contusion, abrasion and superficial laceration over the left shoulder and lateral upper arm	Minor (790202.1,2) (790402.1,2) (790602.1,2)	Disintegrated left front window glazing backed up by the tree
Multiple contusions on the anterior right thigh at the mid-level in a 13 cm (5 in) zone	Minor (890402.1,1)	Steering wheel rim
Multiple contusions medially and laterally on the left thigh and knee	Minor (890402.1,2)	Intruding left front door panel

*Note: the above injuries were identified in the driver's autopsy record.*

### **DRIVER KINEMATICS**

Immediately prior to the crash, the restrained driver was seated in an upright posture with her seat adjusted to a forward position. She reacted to the sudden encounter with a deer by steering counterclockwise and in the process lost directional control of the vehicle. The Taurus crossed the center of the road and departed the left side of the road. The driver attempted to correct the vehicle's errant trajectory of the steering back clockwise. During the process of this counter steer, the Taurus began yawing clockwise. The Taurus traveled approximately 27 m (88 ft) along the road and ditch line to a sideswiping-type impact with a tree.

The sideswiping impact with the tree created a long duration crash pulse. The magnitude of the crash deceleration during the early stages of the event was relatively low and then rapidly ramped up as the vehicle's interaction with the tree maximized in the later stages of the crash. The restrained driver responded to the 11 o'clock direction of the impact force by moving slightly forward and left into close proximity to the door and window glazing. Near the time of maximum engagement, the pretensioner and driver air bag deployed. The pretensioner deployment removed some of the slack from the belt system and helped to maintain the driver's upright posture.

The driver's head and neck flexed forward and left in response to the impact force. Coincident to this kinematic pattern, the left front glazing disintegrated and the left front door was intruding into the driver's occupant space. Both of these components were backed-up by the tree. The left side of the driver's face, her left upper arm and shoulder sustained lacerations, abrasions and contusions from contact with the disintegrated glazing. The driver sustained a fatal brain injury and skull fracture as a result of direct contact to the tree. The left B-pillar intruded laterally approximately 30 cm (12 in) and contacted the head restraint. It was probable the intruding left D-ring contacted the driver's neck resulting in the oval contusion. The D-ring had a contoured trim cover and was located in the general area to cause that injury. Several strands of hair were captured between the B-pillar and head restraint positioning the head in this region as well. The driver's torso loaded the pretensioned seat belt as a result of her forward trajectory.

This loading resulted in the liver and lung lacerations. The intruding left door contacted the driver’s left flank resulting in the left lower extremity contusions. The right lower extremity contusions resulted from contact with the lower sector of the steering wheel rim. It was probable the driver had little interaction with the deployed driver air bag. No evidence of direct contact was identified.

***FRONT RIGHT PASSENGER INJURY***

<b>Injury</b>	<b>Severity (AIS 98 update)</b>	<b>Injury Mechanism</b>
Sprained right index finger	Minor (750402.1,1)	Unknown
Left knee abrasion	Minor (890202.1,2)	Unknown

*Note: The above injuries were listed in the police narrative of the crash.*

***FRONT RIGHT PASSENGER KINEMATICS***

Immediately prior to the crash, the restrained front right passenger was seated in an upright posture with her seat adjusted in a mid-track position. Reportedly, she was looking down and not paying attention to the roadway. After the driver initiated the avoidance maneuvers, she looked up and probably reached and braced herself on the vehicle’s interior. She maintained an upright posture throughout the crash event as a consequence of her use of the 3-point manual restraint and the effectiveness of the pretensioner deployment. She did not have significant contact with any interior component of the driver. The exact source of her injuries could not be identified.



## ATTACHMENT A

2000 Taurus/Sable EDR Report - Summary Page		
<b>Investigation Data</b>		
File Name:	cd01-037.hex	File Save Date: 10-Jul-2001
File Read-out Date:	N/A	Report Date: 10-Jul-2001
Report Version:	1.6	
<b>EDR Control Module Data</b>		
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	
<b>Algorithm Times</b> <small>Actual initiation depends on restraint system status (below)</small>		
		ms
Time From Algorithm Wakeup to Pretensioner:	222	
Time From Algorithm Wakeup to First Stage - Unbelted:	222	
Time From Algorithm Wakeup to First Stage - Belted:	0	
Time From Algorithm Wakeup to Second Stage:	0	
<b>Restraint System Status</b>		
Driver Seat Belt Buckle:	Engaged	
Passenger Seat Belt Buckle:	Engaged	
Driver Seat Track In Forward Position:	Yes	
Passenger Seat Weight Switch Position:	N/A	
<b>Deployment Initiation Attempt Times</b>		
	Driver	Passenger
Time From Algorithm Wakeup to Pretensioner Deployment Attempt:	222	222
Time From Algorithm Wakeup to First Stage Deployment Attempt:	222	Not Deployed
Time From Algorithm Wakeup to Second Stage Deployment Attempt:	Disposal	Not Deployed

Figure 11: Restraint Control Module Summary Page.



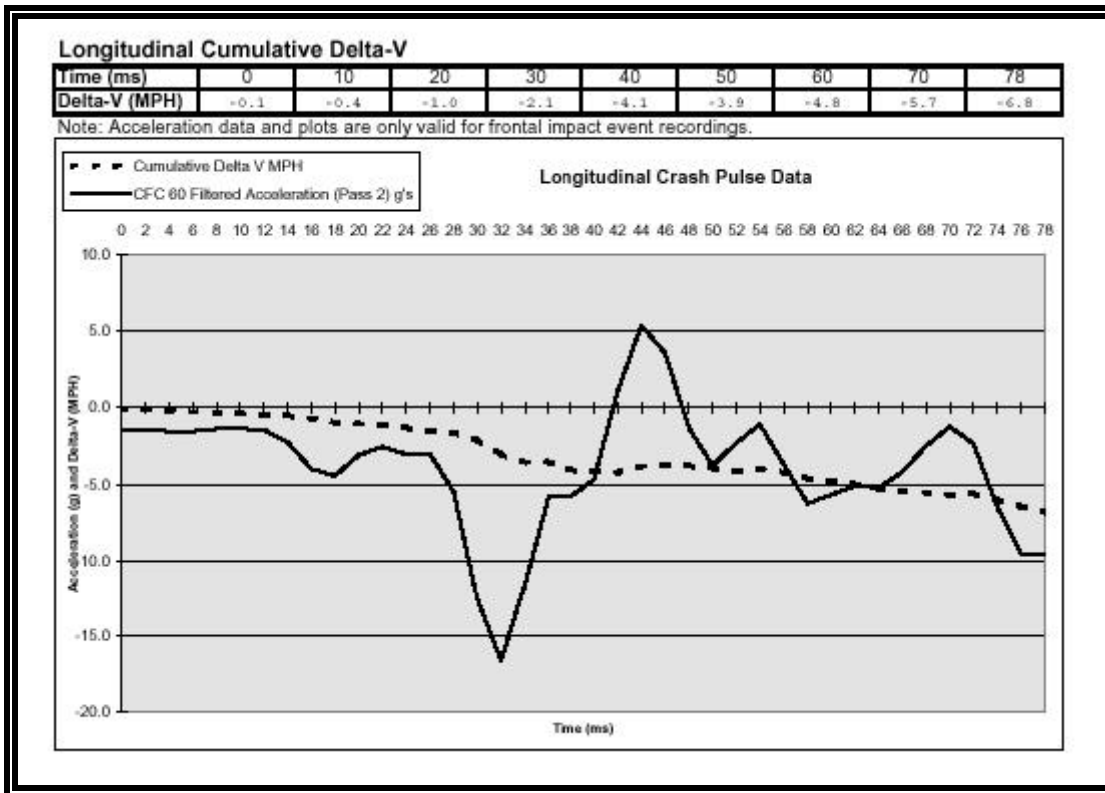


Figure 12: Longitudinal delta V.

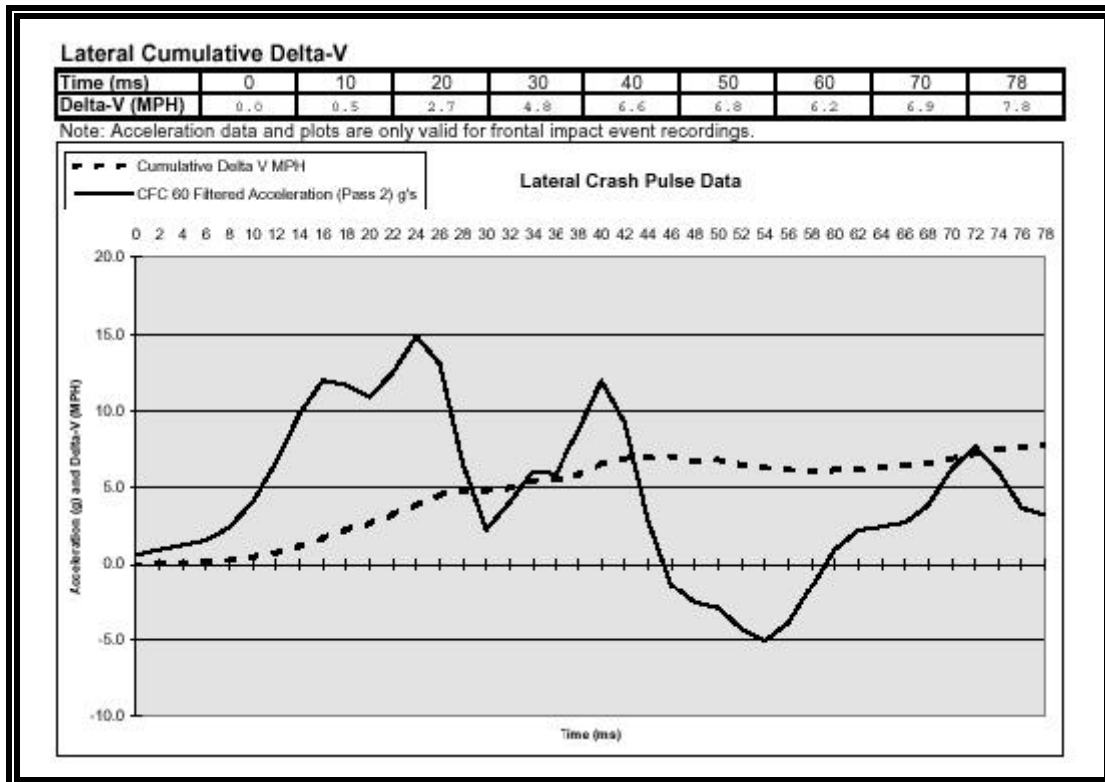


Figure 13: Lateral delta V.