TRANSPORTATION SCIENCES
CRASH RESEARCH SECTION

Veridian Engineering
Buffalo, New York 14225

ADVANCED OCCUPANT PROTECTION SYSTEM STUDY
2000 FORD TAURUS INVESTIGATION

VERIDIAN CASE NO. 2000 12-093G

LOCATION - MICHIGAN

CRASH DATE - JUNE 2000

Contract No. DTNH22-94-07058

Prepared for:

U.S. Department of Transportation
National Highway Traffic Safety Administration
Washington, DC 20590

DISCLAIMER

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

TECHNICAL REPORT STANDARD TITLE PAGE

1. *Report No.* 2000 12-093G	2. *Government Accession No.*	3. *Recipient's Catalog No.*	
		4. Weights	
5. *Title and Subtitle* Advanced Occupant Protection System Study Vehicle -2000 Ford Taurus Location - Michigan		6. *Report Date*: August 2000	
		7. *Performing Organization Code*	
8. *Author(s)* Crash Data Research Center		9. *Performing Organization Report No.*	
10. *Performing Organization Name and Address* Transportation Sciences Crash Data Research Center Veridian Engineering P.O. Box 400 Buffalo, New York 14225		11. *Work Unit No.* CO1115 0285-(0000-9999)	
		12. *Contract or Grant No.* DTNH22-94-D-07058	
13. *Sponsoring Agency Name and Address* U.S. Department of Transportation National Highway Traffic Safety Administration Washington, DC 20590		14. *Type of Report and Period Covered* Technical Report Crash Date: June 2000	
		15. *Sponsoring Agency Code*	
16. *Supplementary Notes*:			

17. *Abstract*

This on-site investigation focused on the performance of the redesigned occupant protection system in the 2000 Ford Taurus. The occupant protection system was a total redesign from earlier model years. The protection system consisted of an integrated use of 3-point lap and shoulder belts, pre-tensioners, seat position sensing and dual-stage air bag inflation. The driver and front right passenger air bags were designed to deploy at different thresholds of crash severity dependant on restraint use and seat position.

In the subject crash, the 2000 Ford Taurus was the striking vehicle in a front-to-rear two vehicle crash that involved a stopped 1999 Ford Expedition. The 37 year old male driver of the Ford was restrained at the time of the crash by the vehicle's 3-point lap and shoulder belt and was the vehicle's sole occupant. The seat belt pre-tensioner and frontal air bags in the Ford Taurus deployed as a result of the crash. The police report indicated the driver had a complaint of pain, but was not visibly injured. He was not transported to a medical facility.

This crash was identified by National Automotive Sampling System PSU 12 and was subsequently selected for investigation in the NASS system. This crash report was forwarded to the Special Crash Investigations team at Veridian Engineering on June 16, 2000. The Crash Investigations Division of the National Highway Traffic Safety Administration (NHTSA) was informed of the crash by the Veridian SCI and NHTSA subsequently assigned a joint investigation of the subject crash. Specifically, the SCI team was assigned the task of inspecting the Ford Taurus and downloading the crash data stored in the vehicle's Restraint Control Module as part of the Advanced Occupant Protection System Study.

18. *Key Words* Personal Protection System Air bag deployment Pre-tensioner 3-point restraint		19. *Distribution Statement* General Public	
20. *Security Classif. (of this report)* Unclassified	21. *Security Classif. (of this page)* Unclassified	22. *No. of Pages* 11	23. *Price*

TABLE OF CONTENTS

ADVANCED OCCUPANT PROTECTION SYSTEM STUDY
2000 FORD TAURUS
VERIDIAN CASE NO: 2000-12-093G
LOCATION: MICHIGAN
CRASH DATE: JUNE, 2000

BACKGROUND

This on-site investigation focused on the performance of the redesigned occupant protection system in the 2000 Ford Taurus. The occupant protection system was a total redesign from earlier model years. The protection system consisted of an integrated use of 3-point lap and shoulder belts, pre-tensioners, seat position sensing and dual-stage air bag inflation. The driver and front right passenger air bags were designed to deploy at different thresholds of crash severity dependant on restraint use and seat position.

In the subject crash, the 2000 Ford Taurus was the striking vehicle in a front-to-rear two vehicle crash that involved a stopped 1999 Ford Expedition. The 37 year old male driver of the Ford was restrained at the time of the crash by the vehicle's 3-point lap and shoulder belt and was the vehicle's sole occupant. The seat belt pre-tensioner and frontal air bags in the Ford Taurus deployed as a result of the crash. The police report indicated the driver had a complaint of pain, but was not visibly injured. He was not transported to a medical facility.

This crash was identified by National Automotive Sampling System PSU 12 and was subsequently selected for investigation in the NASS system. This crash report was forwarded to the Special Crash Investigations team at Veridian Engineering on June 16, 2000. The Crash Investigations Division of the National Highway Traffic Safety Administration (NHTSA) was informed of the crash by the Veridian SCI and NHTSA subsequently assigned a joint investigation of the subject crash. Specifically, the SCI team was assigned the task of inspecting the Ford Taurus and downloading the crash data stored in the vehicle's Restraint Control Module as part of the Advanced Occupant Protection System Study.

SUMMARY

Crash Site

This two-vehicle crash occurred during the morning hours of June, 2000. It was daylight at the time of the crash and the weather was not a factor. The road surface was dry. At the scene, the primary roadway was configured with four lanes, north/south in direction. A two lane east/west road intersected from the west, forming a 3-leg intersection. The intersection was controlled by a stop sign for eastbound traffic. The primary roadway was straight with a negative grade (>2%) at the intersection. The primary roadway's east shoulder was an open area free of obstructions. The speed limit in the area of the crash was 89 km/h (55 mph). **Figure 1** is a northbound trajectory view approaching the intersection and point of impact. **Figure 2** is a look back view from the area of final rest toward the intersection.

Figure 1: Northbound pre-crash trajectory view.

Figure 2: Look back from the area of final rest toward the intersection.

Pre-crash

The 1999 Ford Expedition was stopped in the inboard (left) northbound lane at the 3-leg intersection waiting for southbound traffic to clear. It was the driver's intention to turn left onto the intersecting roadway. The vehicle was driven by a 36 year old restrained female. A 4 year old male was seated in a right rear of the vehicle. In her interview, the driver reported the child was restrained by the lap belt with the shoulder belt positioned under his arm.

The 2000 Ford Taurus was northbound in the inboard (left) lane driven by a 37 year old restrained male. He was the vehicle's sole occupant. As the Taurus crested the hill south of the intersection, the driver saw and recognized the stopped Ford Expedition late in the pre-crash sequence. The driver braked and steered clockwise (right), however, he was not able to avoid the impact.

Crash

The crash occurred when the front plane of the Ford Taurus impacted and under-rode the back plane of the Ford Expedition in a 12/6 o'clock impact configuration. The force of the impact deployed the Taurus's left pre-tensioner and frontal air bags. The magnitude of the underride was moderate. During the impact sequence, the front structural third of the Taurus drove underneath the Ford Expedition and lifted its rear axle off the ground. Damages to the hood and forward body structures on the Taurus extended rearward 123 cm (48 in) from the front plane. The Expedition's rear bumper contacted and fractured the windshield of the Taurus at maximum engagement.

The northeastward momentum of the Ford Taurus displaced both vehicles forward and to the right. The vehicle's crossed into the outboard (right) lane and off the right side of the roadway during disengagement. The Ford Expedition came to rest off the east shoulder facing northeast approximately 36 m (120 ft) northeast of the impact. After separation, the Ford Taurus began to rotate clockwise . It came to rest off the east shoulder facing southeast, approximately 32 m (105 ft) northeast of the point of impact.

Post-crash

Both vehicles sustained disabling damage and had to be towed. None of the occupants in the crash required medical transport nor follow-up medical treatment. In his interview, the driver of the Ford Taurus did report he sustained seat belt related contusions (AIS 1) to his left shoulder and right hip. The driver of the Ford Expedition reported that neither she nor her son were injured.

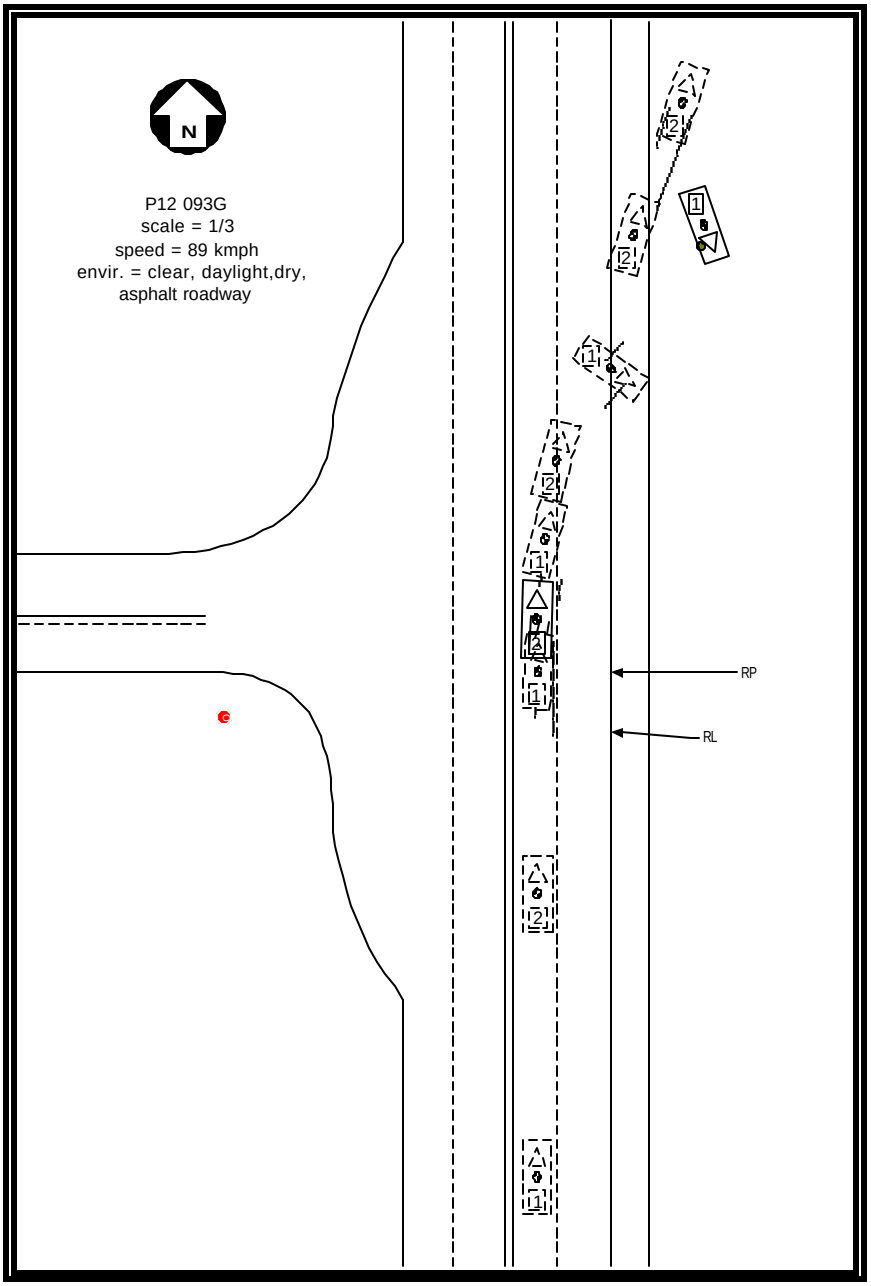


Figure 3: Crash schematic

2000 FORD TAURUS

The 2000 Ford Taurus was identified by the Vehicle Identification Number (VIN): 1FAFP53Z9YG (production sequence deleted). The vehicle's power train consisted of a 3.0 liter, V-6 engine linked to a 4-speed automatic transmission. The engine was configured with the "flexible fuel" option. The odometer read 7,821 km (4860 miles) at inspection.

Exterior Damage

Figures 4 and 5 are the left front and front views of the Taurus, respectively. The front plane sustained direct and induced damage that extended across the entire 157 cm (62 in) end width of the vehicle. The damage was biased to the vehicle's left side as a result of the pre-crash right steering maneuver. The direct contact damage began 47.0 cm (18.5 in) right of center and extended 119.0 cm (44.5 in) to the left front bumper corner. The crush profile measured on the bumper reinforcement bar was as follows: C1=5 cm (2 in), C2=10 cm (3.9 in), C3=12 cm (4.7 in), C4=13 cm (5.1 in), C5=10 cm (3.9 in), C6=0. The bumper reinforcement had rotated clockwise during the under-ride (when viewed from the left end) and indicated the direct bumper to bumper contact at impact was minimal.

Figure 4: Left front view of the Taurus.

Figure 5: Front view of the Taurus.

The direct contact damage due to the under-ride extended rearward onto the hood and left front fender. The damage was comprised of longitudinal scraping and scratches caused by the rear bumper and undercarriage of the Expedition. The damage on the surface on the hood extended rearward 122 cm (48 in) from the front of the Taurus. The hood was buckled and had shifted rearward fracturing the lower aspect of the windshield. The exterior surface of the windshield was fractured directly in front of the driver's position by contact from the Expedition's rear bumper. (Note, this windshield fracture was inaccurately attributed to an interior occupant contact in the NASS file). The left fender was buckled and crushed down during the under-ride. The left front door had shifted rearward, overlapping the left rear door at the B-pillar. All the doors remained operational. The left wheelbase was foreshortened approximately 2.5 cm (1.0 in). The Collision Deformation Classification (CDC) was 12-FDEW-01. The

Damage Only Algorithm of the WINSMASH model calculated a total delta V of 35.0 km/h (21.7 mph) for the Taurus in this impact. The longitudinal and lateral components were -35.0 km/h (-21.7 mph) and 0 km/h, respectively. The calculated Barrier Equivalent Speed was 18.9 km/h (11.7 mph). The results of the WINSMASH reconstruction appeared reasonable.

Occupant Protection System

The occupant protection system in the 2000 Ford Taurus, designated by the manufacturer as the Personal Protection System (PPS), was a total redesign from earlier model years. The protection system consisted of the integrated use of manual 3-point lap and shoulder belts, pre-tensioners, seat position sensing and dual-stage air bag inflation. The driver and front right passenger air bags were designed to deploy at different thresholds of crash severity dependant 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. It was not possible to field download the RCM due to damages to the vehicle's electrical system. Permission was obtained and the RCM was removed from the vehicle. The RCM was sent 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 data indicated the left restraint was buckled, the left pre-tensioner fired 8 ms after event detection and a stage 1 air bag deployment was commanded at 21 ms. The 80 millisecond longitudinal delta V was approximately 32 km/h (20 mph) and still rising. It should be noted that this was not the total delta V of the impact, only the recorded delta V at that time interval. The typical duration of a vehicle-to-vehicle impact of this nature is greater than 150 milliseconds.

Figure 6 is a left interior view of the front occupant compartment. The electrically adjustable driver's seat was adjusted to a full rear position at inspection. This was the at-crash adjustment of the seat as the seat track could not have been altered due to damage to the vehicle's electrical system. The horizontal distance between the center hub of the steering wheel and seat back measured 66 cm (26 in). The seat back was reclined 17 degrees aft of vertical. The foot controls were not adjustable.

Figure 6: Left interior view of the Taurus.

The vehicle 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/energy management retractors were located in the base of the B-pillars. The front restraints were also equipped with buckle mounted pretensioners. The driver's pre-tensioner fired as a result of the crash, **Figure 7**. The post-crash measurement of the pre-tensioner's piston was 57.2 mm (2.25 in). The front right seat belt pretensioner did not fire, (as reported in the NASS file).

Figure 7: View of the left inboard buckle anchor.

The restraint's upper anchorages (D-rings) were adjustable. The left front D-ring was adjusted to the full up position. Inspection of the surface of the D-ring identified an abrasion across the full width of its friction surface. Upon inspection, the driver's restraint webbing was stowed in the retractor and operational. After extending webbing and buckling the latch plate, evidence of use in the crash was identified near the latch plate. The webbing appeared stressed and was "waffled". This belt evidence measured 5 cm (2 in) in length and began 80.8 cm (31.8 in) above the outboard anchor. Additional belt evidence was identified 13 cm (5 in) above the outboard anchor. This belt evidence consisted of a 1 cm (0.5 in) abrasion from contact with the aft aspect of the vinyl trim structure surrounding the seat cushion. A corresponding abrasion was identified on the vinyl trim.

There was no intrusion or interior damage related to the exterior forces of the crash. The driver knee bolster was not deformed, however two areas of contact were identified. The surface of the panel was scuffed from minor contact by the driver's lower extremities. The left scuff measured 2.0 cm (0.8 in) in diameter and was located 3.8 cm (1.5 in) left of the steering column centerline and 42.7 cm (16.8 in) above the floor. The right contact measured 3.8 cm x 5.0 cm (1.5 in x 2.5 in), width by height, and was located 5.0 cm (2 in) right of the steering column centerline, 43.7 cm (17.2 in) above the floor. These contacts were not noted by the NASS researcher.

The steering wheel rim angle was adjustable. It had a 4-notch adjustment and was positioned one notch below the full-up position. There was no rim deformation and the steering column showed no signs of loading. There was no movement of the shear capsules and the bend bracket was undeformed. The shear plate on the lower aspect of the column was intact.

The driver air bag, **Figure 8**, was located in the typical configuration in the center hub of the steering wheel. It had deployed as designed from the H-configuration module. The width of the module cover flaps measured 16.5 cm (6.5 in). The height of the upper and lower flaps measured 7.5 cm (3.0 in) and 5.0 cm (2.0 in), respectively. There was no contact evidence to the cover flap. The bag measured 50 cm (20 in) in its deflated state. It was vented by two ports located in the 11/1 o'clock sectors on the back side of the

bag. The port diameter measured 2.5 cm (1.0 in). The bag was tethered by two straps. The straps measured 11.4 cm (4.5 in) in width. Black vinyl scuffs from deployment contact with the cover flaps was dispersed over the 2 to 6 o'clock sectors on the face of the air bag. The 2 to 4 o'clock sectors on the back side of the bag were scuffed from steering wheel rim contact. There was no direct evidence of driver contact on the air bag. The following nomenclature identified the driver air bag and was located in its 12 o'clock sector:

P5206000-00D
TXM000560163

The front right passenger air bag, **Figure 9**, was a top-mount design housed in the right aspect of the instrument panel. The module cover flap was vinyl and measured 27.9 cm x 14.0 cm (11.0 in x 5.5 in), width by depth. The face of the passenger air bag measured 55.9 cm x 30.5 cm (22.0 in x 12.0 in). The bag extended rearward from the module 40.6 cm (16 in) in its deflated state. The bag was vented by two ports measuring 4.6 cm (1.8 in) in diameter. The ports were symmetrically located on the side panels of the bag. The only contact evidence on the face of the bag consisted of a 20 cm x 30 cm (8 in x 12 in) area of patterned vinyl transfers. This transfers were the result of contact with the aft edge of the air bag module during the deployment sequence.

Figure 8: Driver air bag.

Figure 9: Front right passenger air bag.

1999 FORD EXPEDITION

The 1999 Ford Expedition was identified by a Vehicle Identification Number (VIN): 1FMPU18L2XL (production sequence deleted). The utility vehicle's power train was equipped with a 5.4 liter, V-8 engine linked to a 4 speed automatic transmission. It was equipped with 4-wheel drive. The digital electronic odometer could not be read during the NASS inspection. The vehicle was equipped with a Supplemental Restraint System that consisted of driver and front right passenger air bags. The SRS did not deploy in the rear-end collision.

Exterior damage

Figures 10 and 11 are the rear and right side views of the Ford Expedition, respectively. The back plane of the Expedition sustained a combination of direct contact and induced damages that extended across the entire 178 cm (70 in) end width. The damage was biased to the right side as a result of the Taurus's pre-crash steering maneuver. The direct contact damage width measured 131 cm (52 in). The direct contact began 43 cm (17 in) left of center and extended to the right rear bumper corner. The crush profile measured at the rear bumper elevation was as follows: C1=47 cm (18 in), C2=52 cm (20 in), C3=62 cm (24 in), C4=64 cm (25 in), C5=64 cm (25 in), C6=64 cm (25 in). The rear bumper rotated down as a result of the under-ride. The rear hatch was jammed shut by the deformation and the backlight disintegrated during the impact. Both rear quarterpanels were buckled and deformed forward. The induced damages extended along the sides of the vehicle's to the rear doors. The left and right wheelbase was foreshortened 1 cm (0.5 in) and 8 cm (3 in), respectively.

The Collision Deformation Classification was 06-BDEW-03. The total delta V of the Expedition calculated by the Damage Only Algorithm of the WINSMASH model was 24.9 km/h (15.5 mph). The longitudinal and lateral components were -24.8 km/h (-15.4 mph) and 2.2 km/h (1.3 mph), respectively. The calculated Barrier Equivalent Speed was 35.5 km/h (22.1 mph). These results appeared reasonable based on SCI experience.

Figure 10: Rear view of the Ford Expedition.

Figure 11: Right side view of the Expedition.

OCCUPANT DEMOGRAPHICS

2000 Ford Taurus

Age/Sex:	37 year old/male driver
Height:	190 cm (75 in)
Weight:	118 kg (260 lb)
Restraint Use:	3 point lap and shoulder
Usage Source:	SCI inspection/Restraint Control Module/driver interview
Medical outcome:	Seat belt related contusions - left shoulder & right hip (AIS 1)

1999 Ford Expedition

Age/Sex:	36 year old/female driver	4 y/o male right rear passenger
Height:	157 cm (62 in)	127 cm (50 in)
Weight:	53 kg (118 lb)	23 kg (50 lb)
Restraint Use:	3-point lap and shoulder	3-point lap and shoulder belt under the arm
Usage Source:	Driver interview	Driver interview
Medical outcome:	No injury	No injury

ATTACHMENT A

2000 Taurus/Sable EDR Report - Summary Page

Investigation Data

File Name:	2000-12-093C.hex	**File Save Date:**	27-Jun-2000
File Read-out Date:	N/A	**Report Date:**	27-Jun-2000
Report Version:	1.2		

EDR Control Module Data

Data Validity Check:	Valid	**EDR Model Version:**	141
Left (Driver) Side Bag Deployment Time (ms):			Not Deployed
Right (Passenger) Side Bag Deployment Time (ms):			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:	8
Time From Algorithm Wakeup to First Stage - Unbelted:	10
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:	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:	8	Unbelted
Time From Algorithm Wakeup to First Stage Deployment Attempt:	21	21
Time From Algorithm Wakeup to Second Stage Deployment Attempt:	Disposal	Disposal

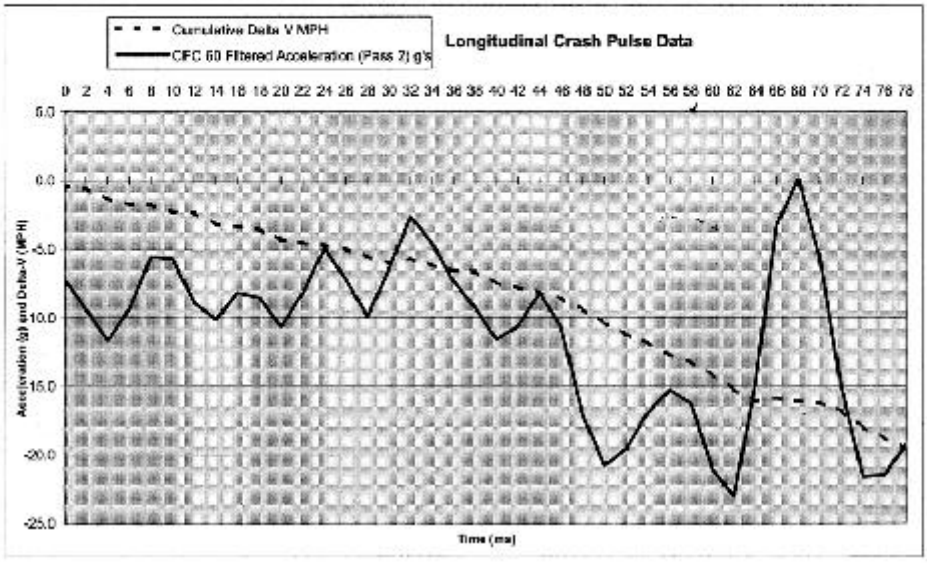
Notes

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)	-0.4	-2.3	-4.3	-5.9	-7.6	-10.3	-14.1	-16.2	-18.5



Lateral Cumulative Delta-V

Time (ms)	0	10	20	30	40	50	60	70	78
Delta-V (MPH)	-0.2	0.0	0.1	0.7	1.4	1.5	1.7	1.1	1.6