TRANSPORTATION SCIENCES
CRASH RESEARCH SECTION

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ADVANCED OCCUPANT PROTECTION SYSTEM STUDY
2000 FORD TAURUS INVESTIGATION

VERIDIAN CASE NO. CA00-023

LOCATION - TENNESSEE

CRASH DATE - JUNE 2000

Contract No. DTNH22-94-07058

Prepared for:

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

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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.

TECHNICAL REPORT STANDARD TITLE PAGE

1. *Report No.* CA00-023	2. *Government Accession No.*	3. *Recipient's Catalog No.*	
		4. Weights	
5. *Title and Subtitle* Advanced Restraint Crash Study Vehicle -2000 Ford Taurus Location - Tennessee		6. *Report Date*: September 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 0291-(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 Ford Taurus was northbound driven by an unrestrained 18 year old female. The vehicle entered a right curve at a speed too fast to maintain its travel lane and traveled left of center into the path of a southbound 1996 Ford Explorer. The left front aspect of the Taurus struck the left front aspect of the Explorer resulting in the deployment of the Supplemental Restraint Systems in both vehicles. The driver of the Taurus sustained only an ankle sprain and unspecified upper extremity contusions. The 36 year old restrained female driver of the Explorer was not injured.

This crash was identified through the weekly poll of the police agencies conducted by PSU 45 of the National Automotive Sampling System (NASS). This crash was reported to the Special Crash Investigations team at Veridian Engineering in July, 2000. The Crash Investigations Division of the National Highway Traffic Safety Administration (NHTSA) was informed of the crash by the Veridian SCI team and was subsequently assigned the task of inspecting the subject vehicle, as part of the Advanced Occupant Protection System Study. The vehicle was inspected and the on-board crash data in the Restraint Control Module (RCM) was downloaded for analysis.

18. *Key Words* Personal Protection System, Supplemental Restraint System Air bag, 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* 9	23. *Price*

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ADVANCED OCCUPANT PROTECTION SYSTEM STUDY
2000 FORD TAURUS

VERIDIAN CASE NO: CA00-023
LOCATION: TENNESSEE
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 Ford Taurus was northbound driven by an unrestrained 18 year old female. The vehicle entered a right curve at a speed too fast to maintain its travel lane and traveled left of center into the path of a southbound 1996 Ford Explorer. The left front aspect of the Taurus struck the left front aspect of the Explorer resulting in the deployment of the Supplemental Restraint Systems in both vehicles. The driver of the Taurus sustained only an ankle sprain and unspecified upper extremity contusions. The 36 year old restrained female driver of the Explorer was not injured.

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SUMMARY

Crash Site

This two-vehicle crash occurred during the afternoon hours in June, 2000. It was daylight at the time of the crash and the weather was not a factor. The road surface was dry. The crash occurred on a two-lane north/south county roadway. At the scene, there was a right curve for northbound traffic with a positive eight percent grade. Refer to **Figure 1**. The radius of the curve measured 67 m (220 ft). The curve's super-elevation measured seven percent. Two skid marks in the northbound direction defined the pre-crash trajectory of the Ford Taurus. The skid marks measured 25 m (82 ft) in length. The point of impact was defined by a westward deflection of the skid marks and an area of pavement gouges. The speed limit in the area of the crash was 48 km/h (30 mph).

Figure 1: Trajectory view of the Ford Taurus.

Pre-Crash

The 1996 Ford Explorer was southbound driven by a 36 year old restrained female. The 2000 Ford Taurus was northbound driven by an unrestrained 18 year old female. The Taurus was in the process of entering a right curve when the driver observed the southbound Ford Explorer and realized her speed was too great for the road's curvature. The driver applied and locked the Taurus's brakes and skidded left of center into the southbound lane, directly into the path of the Ford Explorer.

Crash

The left frontal area of the Taurus struck the left frontal of the Explorer in an offset frontal configuration. Both vehicles came to rest in the southbound lane, near the point of impact. The Explorer was also braking prior to the crash. The crash force was of moderate severity. The impact caused the deployment of the Supplemental Restraint Systems (frontal air bags) in both vehicles. **Figure 2** is a schematic of the crash scene. At the time of the SCI inspection, both vehicle's were disassembled and in a state of partial repair. An analysis of the crash through the use of the WINSMASH model could not be performed.

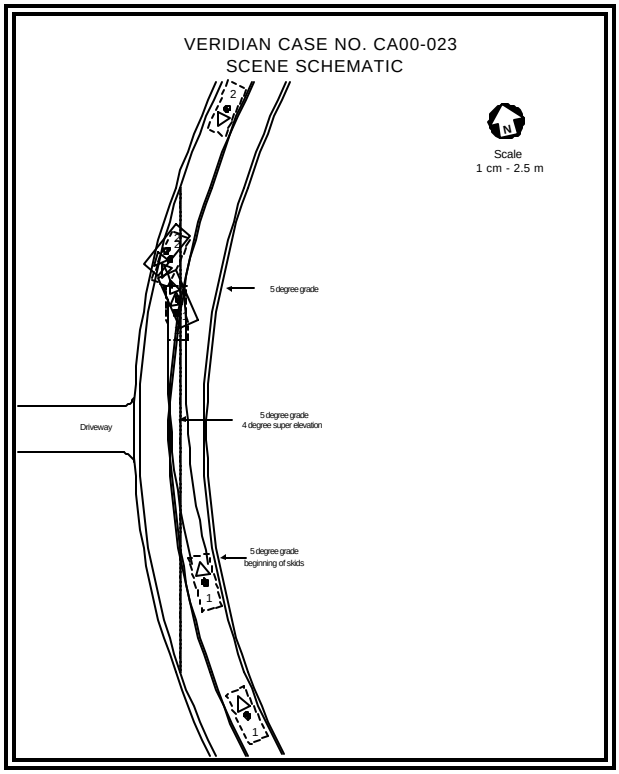


Figure 2: Crash scene schematic

Post-crash

The police and ambulance services responded to the scene. The driver of the Ford Taurus was seated in the right rear of the vehicle upon their arrival. She did not lose consciousness. She was alert and ambulatory with a Glasgow Coma Scale of 15. Presumably, she exited the vehicle under her own power and walked around to vehicle's passenger side to wait for the emergency responders. Her chief complaint was right ankle pain. She was transported to the emergency room of a local hospital for treatment. Diagnostic X-rays were negative for an ankle fracture. Examination revealed she suffered a severe ankle sprain and minor upper extremity contusions. She was released several hours post-crash. The driver of the Ford Explorer was not injured.

1996 FORD EXPLORER

The 1996 Ford Explorer was identified by the Vehicle Identification Number (VIN): 1FMDU34X7TU (production sequence deleted). The sport utility vehicle was manufactured in January 1996 and had an odometer reading of 113,818 km (70,725 miles). The Explorer, **Figure 3**, was being repaired at the time

of the inspection and had been disassembled preventing crush measurements. The direct contact damage to the vehicle began 30 cm (12 in) left of center and extended 46 cm (18 in) left to the front bumper corner. Due to the higher frontal profile of the Explorer (relative to the braking Taurus), there was minimal damage to the upper radiator support and no damage to the hood. The Explorer's damage was localized to the left aspect of the lower radiator support and left front suspension. The left front fender buckled both longitudinally and laterally from the angular impact. The left side damage extended rearward to the leading edge of the front door. The Collision Deformation Classification was 11-FLEW-1.

Figure 3: Left front view of the Ford Explorer.

2000 FORD TAURUS STATION WAGON

The 2000 Ford Taurus was identified by the Vehicle Identification Number (VIN): 1FAFP58S7YA (production sequence deleted). The vehicle was configured as a Station Wagon. The vehicle's power train consisted of a 3.0 liter/V-6 engine linked to a 4-speed automatic transmission. The brake system consisted of 4-wheel disc with an anti-lock braking system. The date of manufacture was March, 2000. The vehicle's odometer read 11,738 km (7,294 miles) at the time of the inspection.

Exterior Damage

The Ford Taurus was inspected at a Ford dealership and the vehicle was in a state of partial repair. Reportedly, some of the crash damage had been repaired by the dealership prior to the inspection. The frame had been pulled. A crush profile could not be measured.

Figure 4: View of the damaged hood.

Figure 4 is a view of the damaged hood. Inspection revealed the direct contact began approximately on the vehicle's centerline and extended to the left front corner. **Figures 5 and 6** are front and left side views of the vehicle, respectively. The major damaged exterior components consisted of the hood, bumper fascia, reinforcement bar, radiator support and left front fender. Referring to Figure 5, the forward aspect of the left inner fender and left bumper reinforcement mounting structure were damaged as well. The left toe pan and the floorpan at the driver's seat were buckled approximately 2 cm (1 in).

The Collision Deformation Classification (CDC) of the damage was 11-FYEW-01. The severity of the crash was estimated to be moderate based on the vehicular damage analysis and SCI experience. The Restraint Control Module (RCM) measured and stored a longitudinal delta V of 12.4 mph at 78 milliseconds. The slope of the delta V curve was still rising. It should be noted that the RCM is not capable of recording and storing the entire crash pulse and the recorded delta V may not be the maximum delta V experienced in the crash. A stage 1 air bag deployment was commanded at 31 milliseconds. The data sheets from the RCM download are included at the end of this report as **Attachment A**.

Figure 5: Front view of the Ford Taurus.

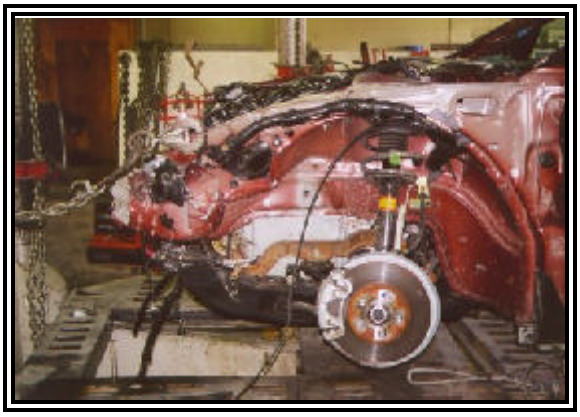


Figure 6: View of the left front suspension area.

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, adjustable foot controls 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 center console 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. These data were downloaded by the SCI investigator during the vehicle inspection.

At the time of inspection, the entire interior of the Taurus had been disassembled and removed. **Figure 7** is an overall view of the instrument panel. The driver's knee bolster exhibited evidence of contact from the driver's right lower extremity. The contacts measured approximately 1 cm x 1 cm (0.5 in x 0.5 in) and were located symmetrically about the steering column centerline. It was probable only one of these contacts

Figure 7: View of the instrument panel.

was crash related. A second area of contact was identified on the left aspect of the mid panel, outboard of the bolster. This contact measured approximately 10 cm (4 in) in width and was consistent with contact from the left lower extremity. The mid-panel was crushed in approximately 5 cm (2 in). The steering column was still attached to the instrument panel at the shear capsules and lower bracket. Examination of the column revealed no damage to the column's components nor shear capsule movement.

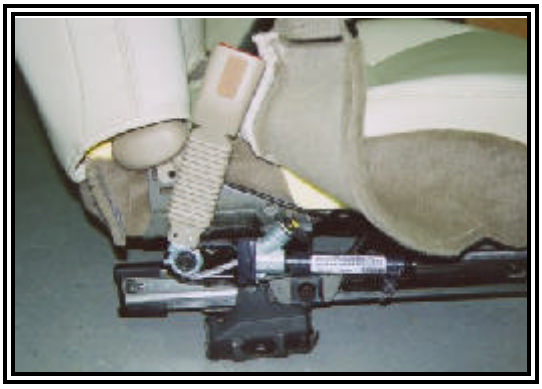


Figure 8: View of the buckle pretensioner.

The front seats had been unbolted from the floor pan and were found in a storage room adjacent to the repair bay. They were not damaged. **Figure 8** is a close-up view of the right aspect of the driver's seat and the buckle pretensioner. The pretensioner did not fire in the crash. The pretensioner's barrel length measured 110 mm (4.3 in).

The manual 3-point lap and shoulder belts were stowed in the retractors at inspection. The left front latch plate displayed some historical usage marks consistent with the vehicle's age. However, there was no evidence on the webbing or hardware surfaces indicative of use during the subject crash. The driver was not restrained by the vehicle's manual lap and shoulder belt in this crash.

The Taurus was equipped with adjustable foot controls. The foot controls, **Figure 9,** were a complete assembly which bolted to the driver's toe pan. The mounting structure of the assembly was deformed by the force of the crash and toe pan intrusion. The assembly had been removed from the vehicle during its repair. The fore/aft adjustment of accelerator and brake pedals was controlled electronically. Switch actuation controlled an electric motor on the pedal assembly, which in-turn drove jack screws within the cylinders on which the pedals were mounted. The pedals had a 7.6 cm (3 in) range of motion and measured 4 cm (1.6 in) rear of most forward position (measured with respect to the vehicle). The foot pad of the brake pedal was noted to be rotated clockwise relative to the vertical mounting arm. This rotation occurred due to the off-center loading of the foot pad imparted by the driver's foot at impact. This evidence was linked to the driver's right ankle sprain and indicated the driver was braking with her right foot at the time of the impact.

Figure 9: View of the adjustable pedal assembly.

The steering wheel had been removed from the steering column during the repair process. There was no rim deformation. The driver air bag module was still attached to the center hub of the wheel. The driver air bag had deployed from the H-configuration module cover flaps. 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, **Figure 10**, measured 53 cm (21 in) in diameter. It was tethered by4 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. The following nomenclature was found on a manufacturer's label fixed to the 12 o'clock sector of the module:

P206000-00D
TXM000670189

A tan make-up and red lip stick transfer was identified in the 10 o'clock sector of the face of the bag. The nature of the transfer indicated that the air bag was fully inflated at the time the driver contact. The contact area measured approximately 8 cm x 5 cm (3 in x 2 in), width by height, and was located 8.9 cm (3.5 in) left and 11.1 cm (4.3 in) above the center of the air bag. The red lipstick was oriented vertically, in the 12/6 o'clock direction and was concave to the right. The orientation of the lipstick indicated the steering wheel was rotated 90 degrees counterclockwise when contact occurred.

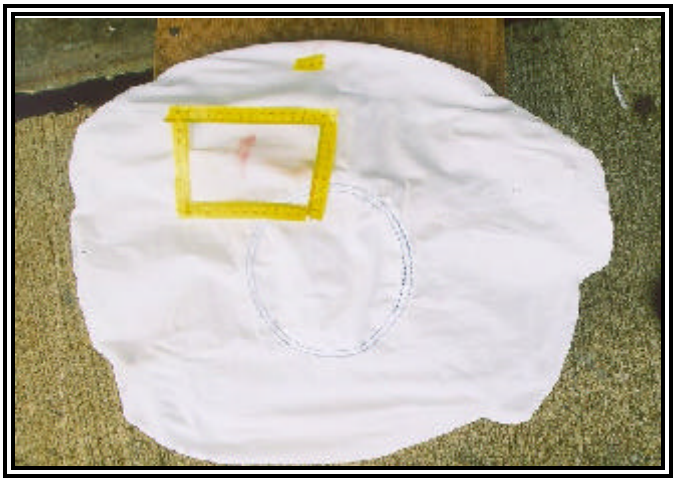


Figure 10: View of the driver air bag. Note, the 12 o'clock sector is at the top of the photograph.

The front right passenger air bag module was a top mount design located in the right aspect of the instrument panel. The module had been removed from the IP during the repair process. The face of the deployed passenger bag measured 58.4 cm x 39.4 cm (23.0 in x 15.5 in), width by height, and extended 46 cm (18 in) form the aft edge of the module. Five vertical vinyl striations were identified on the face of the air bag. The striations were approximately 8 cm (3 in) long and were spaced 5 cm (2 in) apart. These transfer resulted from frictional contact between the face of the air bag and edge of the vinyl module during the deployment sequence. There was no evidence of occupant contact the passenger air bag. The following manufacturer's nomenclature identified the air bag:
FAD900750439

DRIVER DEMOGRAPHICS

Age/Sex:	18 year old/ Female
Height:	178 cm (70 in)
Weight:	82 kg (180 lb)
Restraint Use:	Unrestrained
Usage Source:	SCI inspection, Occupant Kinematics, RCM
Medical treatment:	Treated and released

DRIVER INJURY

Injury	*Severity (AIS 90)*	*Injury Mechanism*
Right ankle sprain	Minor (850206.1,1)	Foot Controls
Upper extremity contusions, NFS	Minor (790402.1,9)	Rebound contact to seat (possible)

Note: the following injuries were identified in records obtained from the Emergency Department.

DRIVER KINEMATICS

Immediately prior to the crash, the driver was seated in a presumed mid-to-rear seat track position consistent with her stature. She was steering right in an effort to negotiate the curve and was braking hard evidenced by the skid marks at the crash scene. The police report and medical records indicated the driver was restrained in the crash. Contrary to those records, the SCI investigation has determined the driver was not restrained. There was no physical evidence within the vehicle to support belt use. Additionally, the driver's kinematic pattern and Restraint Control Module both indicated she was unrestrained.

Upon impact, the frontal air bags deployed. The driver responded to the 1 o'clock direction of the impact force by initiating a forward trajectory. The driver probably began to submarine with her lower torso sliding forward on the seat cushion. Her lower extremities contacted the mid-panel and knee bolster evidenced by the aforementioned contacts. Her right foot was still depressing the brake. The foot controls deformed rearward due to the toe pan resulting in the severe right ankle sprain.

The driver then translated further forward and flexed about the waist . Her face contacted the inflated driver air bag evidenced by the make-up transfers identified on the bag. The force of the impact caused the front wheels (and steering wheel) to turn to the left. This resulted in the steering wheel exhibiting the counterclockwise (left) steer at the time of the facial contact with the driver air bag. The reduced force of the stage 1 air bag deployment may have mitigated injury to the unrestrained driver.

The driver then rebounded into the seat. The location and aspect of upper extremity contusions were not specified. It was possible these resulted from contact to the seat back or other interior component.

ATTACHMENT A

2000 Taurus/Sable EDR Report - Summary Page

Investigation Data

File Name:	ca00-023.hrx	File Save Date:	22-Aug-2000
File Read-out Date:	N/A	Report Date:	22-Aug-2000
Report Version:	1.3		

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:	31
Time From Algorithm Wakeup to First Stage - Unbelted:	31
Time From Algorithm Wakeup to First Stage - Belted:	0
Time From Algorithm Wakeup to Second Stage:	0

Restraint System Status

Driver Seat Belt Buckle:	Not 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:	Unbelted	Unbelted
Time From Algorithm Wakeup to First Stage Deployment Attempt:	31	31
Time From Algorithm Wakeup to Second Stage Deployment Attempt:	Disposal	Disposal

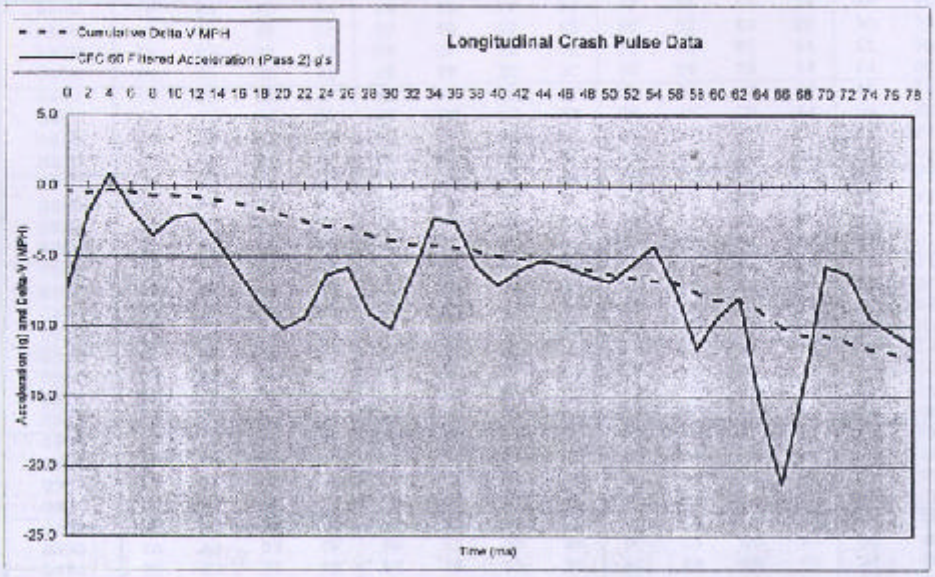
Notes

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

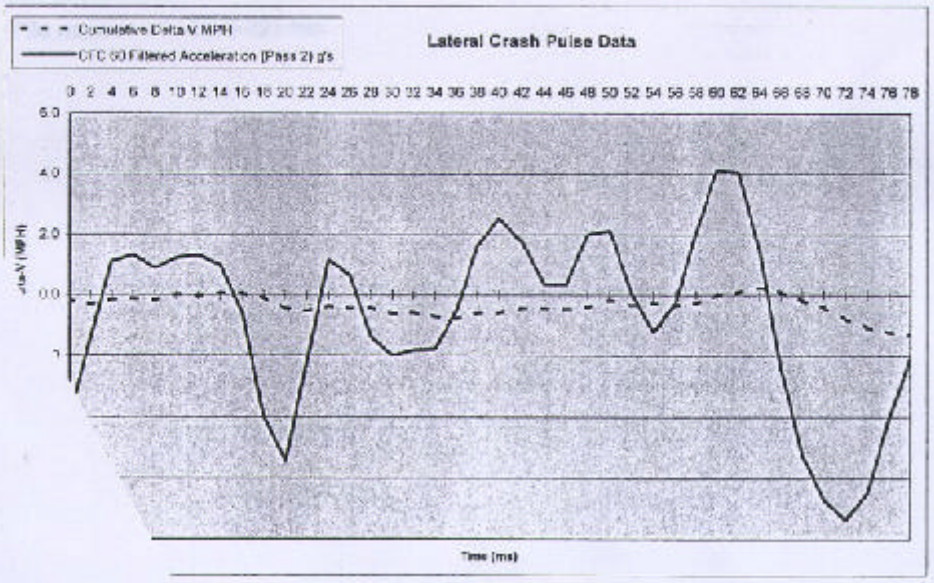
Longitudinal Cumulative Delta-V

Time (ms)	0	10	20	30	40	50	60	70	78
Delta-V (MPH)	-0.1	-0.7	-4.1	-8.9	-9.0	-8.3	-8.1	-10.5	-12.4



Lateral Cumulative Delta-V

Time (ms)	0	10	20	30	40	50	60	70	78
Delta-V (MPH)	-0.3	0.0	-0.4	-0.6	-0.6	-0.2	0.0	-0.4	-1.3



Y23 hex