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CRASH DATA RESEARCH CENTER

Veridian Engineering
Buffalo, New York 14225

ADVANCED OCCUPANT PROTECTION SYSTEM INVESTIGATION

VERIDIAN CASE NO. CA01-034

VEHICLE: 2000 MERCURY SABLE

LOCATION - MICHIGAN

CRASH DATE - APRIL 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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17. *Abstract*

This on-site investigation focused on the performance of the Advanced Occupant Protection System (AOPS) in the 2000 Mercury Sable LS Premium. The AOPS consisted of the integrated use of 3-point lap and shoulder belts, buckle pretensioners, driver 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 driver seat position. The vehicle was also equipped with side impact air bags for the front occupants. The subject 2000 Mercury Sable impacted the highway's outboard concrete retaining wall subsequent to being sideswiped by a tractor trailer. The force of the frontal impact deployed the vehicle's frontal air bags and seat belt pretensioner. The restrained 51 year old female driver was not injured in the crash.

This crash was identified through the weekly sampling of Police Accident Reports conducted by the General Estimates System (GES). NASS Zone Center 1 relayed the crash notification to the Crash Investigations Division of the National Highway Traffic Safety Administration (NHTSA). NHTSA subsequently assigned an on-site investigation of the crash to the Special Crash Investigations team at Veridian Engineering as part of the Advanced Occupant Protection System Study. The vehicle was located at storage facility local to the crash site and was available for inspection. The crash data stored in the vehicle's Restraint Control Module was downloaded and forwarded to the Safety Office of the Ford Motor Company for analysis.

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ADVANCED OCCUPANT PROTECTION SYSTEM INVESTIGATION
VERIDIAN CASE NO: CA01-034
VEHICLE: 2000 MERCURY SABLE
LOCATION: MICHIGAN
CRASH DATE: APRIL, 2001

BACKGROUND

This on-site investigation focused on the performance of the Advanced Occupant Protection System (AOPS) in the 2000 Mercury Sable LS Premium. The AOPS consisted of the integrated use of 3-point lap and shoulder belts, buckle pretensioners, driver 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 driver seat position. The vehicle was also equipped with side impact air bags for the front occupants. The frontal area of the subject 2000 Mercury Sable impacted the highway's outboard concrete retaining wall subsequent to being sideswiped by a tractor trailer. The force of the frontal impact deployed the vehicle's frontal air bags and seat belt pretensioner. The restrained 51 year old female driver was not injured in the crash.

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SUMMARY

Crash Site

This two-vehicle crash occurred during the morning hours of April, 2001. At the time of the crash, it was daylight and the weather was not a factor. The road surfaces were dry. The crash occurred on a channelized three-lane divided interstate route in a suburban setting. The roadway was approximately 9 m (30 feet) below the surrounding ground level. The respective travel directions were separated by a concrete median barrier. A breakdown lane and a concrete retaining wall bordered the outboard lane, in both directions, at the site of the crash. The speed limit in the area of the crash was 105 km/h (65 mph). **Figure 1** is an overhead view of the area of the crash.

Figure 1: Southeastward view of the crash scene.

Crash Sequence

Pre-crash

The 2000 Mercury Sable LS Premium was eastbound in the outboard (right) lane driven by a 51 year old restrained female. The driver was the vehicle's sole occupant. The 1998 International tractor/semi trailer was eastbound in the center lane (lane #2) of the interstate, driven by a restrained 55 year old male. The tractor/semi trailer and Mercury were traveling side-by-side. The tractor driver initiated a lane change to the right, into the Mercury's travel lane, precipitating the crash.

Crash

In the process of the lane change maneuver, the right drive wheels of the tractor sideswiped the left side of the Mercury in the area of the left rear door. The driver of the Mercury steered to the right in an avoidance maneuver and lost control of the vehicle. The Mercury continued to the right, traveled through the breakdown lane and impacted the concrete retaining wall on the south side of the roadway. The front plane of the Mercury struck the wall resulting in a direction of force in the 11 o'clock sector. The impact induced deceleration was above the required air bag deployment threshold and the vehicle's frontal air bags deployed. The Mercury's momentum caused the vehicle to rotate clockwise along the concrete wall and it came to rest facing northeastward. The tractor trailer came to a controlled stop on the roadside, east of the Mercury. The final rest locations of the vehicles were not documented by the police investigation. **Figure 2** is a schematic of the crash.

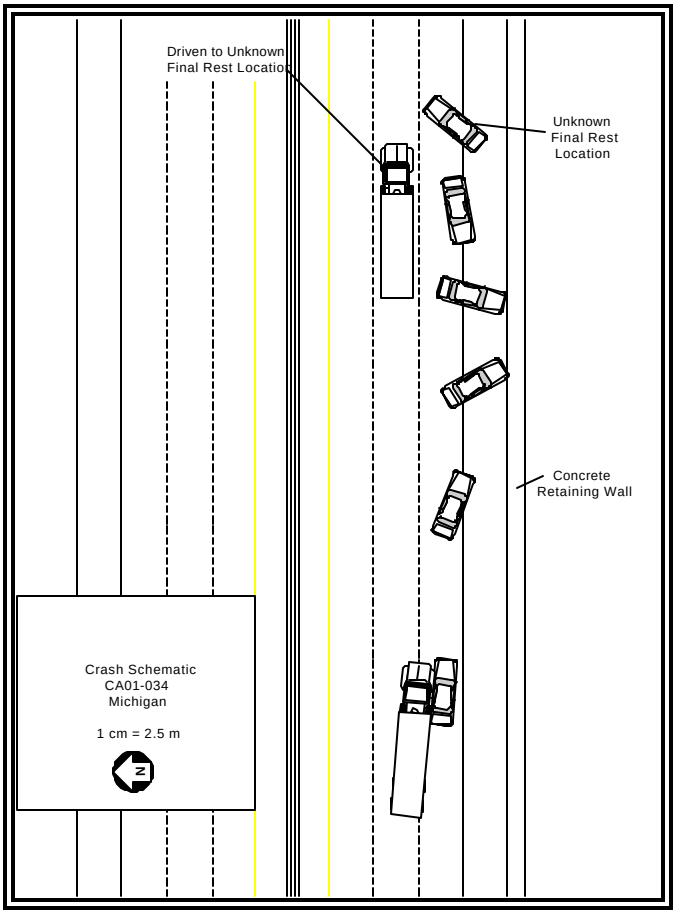


Figure 2: Crash schematic.

Post-Crash

The police and EMS services responded to the scene. The Mercury sustained disabling damage and was towed. The driver of the Mercury sustained a police reported non-incapacitating injury. Although she was transported to a local hospital, the driver was not injured in the crash. The tractor driver was not injured and the tractor trailer was driven from the scene at the conclusion of the police investigation. The tractor driver was cited for an unsafe lane change.

2000 MERCURY SABLE

The 2000 Mercury Sable LS Premium was identified by the Vehicle Identification Number (VIN): 1MEFM55S2YA (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 leather 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 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 and seat mounted side impact air bags for the driver and front right passenger. The 4-door sedan was manufactured in April 2000. The odometer read 11,582 km (7,197 miles) at the time of the inspection.

Exterior Damage

The exterior of the Mercury sustained direct contact damage to its left side resultant to its sideswiping contact with the tractor and frontal damage as a result of its impact with the concrete retaining wall. **Figure 3** is a view of the left side damage. The left side direct contact damage began on the mid aspect of the left door, 166.4 cm (65.5 in) forward of the left rear axle. The direct contact damage extended rearward 214.8 cm (84.5 in) and ended 48 cm (19 in) rear of the left rear axle. The maximum lateral deformation was located on the mid-aspect of the left rear door and measured 6.4 cm (2.5 in). Minor snagging of the left side body panel was noted immediately forward of the rear wheel opening. This damage pattern related to contact with the right side tires of the tractor. The left rear tire was cut and had debeaded. The left front door remained operational. The left rear door was jammed shut. The left side window glazings were intact. The Collision Deformation Classification (CDC) was 06-LZES-1.

Figure 3: View of the left side damage.

Figures 3 and 4 are the front and left lateral side views of the vehicle's frontal damage. The direct contact frontal damage extended across the vehicles's entire 137 cm (54 in) end width. The hood, right front fender and the vehicle's structures forward of the radiator support panel had been removed by the body shop during its repair estimate. The removal of these components exposed the forward uni-body sub-frame. The vehicle's deformation was estimated by measuring to the end of the sub-frame. The residual crush at the left and right sub-frame measured 8.6 cm (3.4 in) and 9.7 cm (3.8 in), respectively. There was no measurable change in the wheelbase dimensions. The windshield was not fractured. The delta V calculated by the Barrier Algorithm of the WINSMASH was 17.9 km/h (11.1 mph). The longitudinal and lateral delta V components were -17.3 km/h (-10.8 mph) and 4.6 km/h (2.9 mph), respectively. This

calculation under estimated the crash severity as compared to the RCM. The RCM recorded longitudinal delta V was 28.5 km/h (17.7 mph). The discrepancy between the WINSMASH calculation and the RCM was a result of the estimated crush profile of the vehicle. The estimated CDC of this impact was 11-FDEW-1.

Figure 4: Front view of the Mercury.

Figure 5: Left lateral view.

Interior Damage

Figure 6 is a view of the Mercury's front interior. The vehicle's interior damage was only related to the deployment of the frontal air bags. There was no intrusion and no occupant contacts were noted. The use of the manual belt system and the deployment of the vehicle's safety systems mitigated significant occupant interior contact.

The driver seat was adjusted in a rear track position at the time of the inspection. The track position measured 2.5 cm (1.0 in) forward of full rear and had reportedly been moved by the body shop personnel. The RCM recorded the driver seat was in a forward position at the time of the crash. The 4-spoke adjustable steering wheel was adjusted to a center position. There was no rim deformation. Inspection of the steering column determined there was no displacement of the shear capsules. The bend bracket supporting the mid-aspect of the steering column and the shear coupling on the lower aspect of the column were intact and undamaged. The location of the adjustable pedals measured 1.3 cm (0.5 in) rear of the most forward position (with respect to the vehicle). The total pedal adjustment was 7.6 cm (3.0 in).

Figure 6: Interior view.

Manual Restraint System

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. Dual mode/load limiting retractors were located in the base of the B-pillars. The front restraints were also equipped with buckle mounted pretensioners. 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 stowed within the retractor and the retractor was operational. The left D-ring was adjusted to the full up position. Inspection of the webbing identified an area of abrasion and a crease in the webbing at the latch plate turning loop with the belt in the buckled condition. This evidence was consistent with restraint use during the crash. The latch plate exhibited signs of historical use consistent with the vehicle's age. The driver's buckle pretensioner had fired. The post-crash measurement of the pretensioner's piston barrel was 55.9 mm (2.2 in). The pre-crash specification of the barrel length measured 110.0 mm (4.3 in), therefore the fired pretensioner removed 53.3 mm (2.1 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.

Supplemental Restraint System

The Supplemental Restraint System in the 2000 Mercury Sable LS Premium consisted of frontal air bags and seat mounted side impact for the driver and front right passenger. The frontal air bags deployed as a result of the above-threshold crash. The force of the left sideswiping impact to the Mercury did not warrant deployment of the side impact air bags, therefore the side impact air bags did not deploy.

The driver air bag module was designed in the typical manner and located 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, **Figure 7**, 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. The following nomenclature identified the air bag: P5206000-00D TXM000842132

Figure 7: Deployed driver air bag.

A 7.0 cm x 7.0 cm (2.8 in x 2.8 in) area of make-up transfer was located on the face of the air bag in the 2 o'clock sector, **Figure 8**. The location of the transfer measured 8 cm (3 in) right and 10 cm (4 in) above the center of the bag, respectively. The make-up consisted of a pair of lipstick imprints 3.8 cm (1.5 in) in

length and a 5 cm x 7 cm (2 in x 3 in) area of beige rouge. The orientation of the lipstick imprint indicated the steering wheel was rotated approximately 180 degrees clockwise at the time of air bag deployment and driver contact.

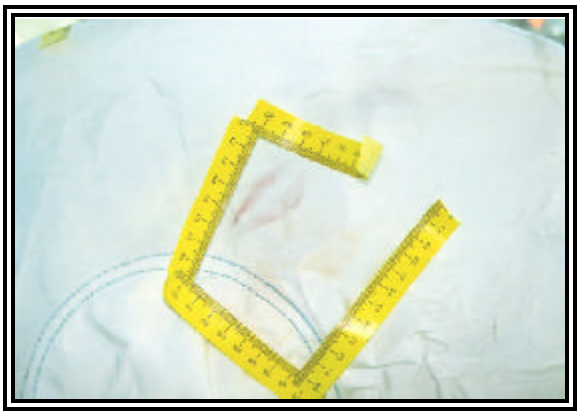


Figure 8: Close-up view of the make-up transfer.

The front right passenger air bag module was a top mount design located in the right aspect of the instrument panel. The air bag had deployed as designed from the module. 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) from the aft edge of the module. A series of vertical vinyl transfers was located on the lower central aspect of the face of the bag. These transfer marks resulted from contact between the air bag and the module cover flap during the deployment sequence. This transfer pattern had been identified on several other Ford/Mercury AOPS investigations and was typical of this system's deployment. Further inspection of the passenger air bag was unremarkable. No evidence of occupant contact was identified.

Advanced Occupant Protection System

The Advanced Occupant Protection System in the 2000 Mercury Sable LS Premium was designated by the manufacturer as the Personal Safety System (PSS). The AOPS consisted of the integrated use of manual 3-point lap and shoulder belts with load limiting retractors, buckle pretensioners, 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 was buckled at the time of the crash and the buckle pretensioner fired 18 milliseconds after algorithm initiation. The driver seat was adjusted to a forward position. A Stage 1 deployment command for the driver and front right passenger air bags was also sent 18 milliseconds after

algorithm initiation. The forward position of the driver seat lowered the deployment threshold for the driver to the unrestrained condition. The second stage of the dual stage system was disposed of approximately 100 milliseconds after the stage 1 deployment.

The RCM recorded the crash acceleration pulse for a duration of 78 milliseconds and calculated a delta V for that time frame. The 78 millisecond longitudinal delta V recorded by the RCM was approximately -28.5 km/h (-17.7 mph). The 78 millisecond lateral delta V was approximately 4.0 km/h (2.5 mph). Analysis of the acceleration pulse and velocity curves indicated that the majority of this crash event was recorded. The magnitude of the acceleration appeared to have maximized and the velocity curves had begun to plateau.

DRIVER DEMOGRAPHICS

Age/Sex:	51 year old/Female
Height:	Unknown
Weight:	Unknown
Restraint Use:	3-point lap and shoulder
Usage Source:	SCI inspection/PAR/RCM
Medical Outcome:	Examined and released

DRIVER INJURY

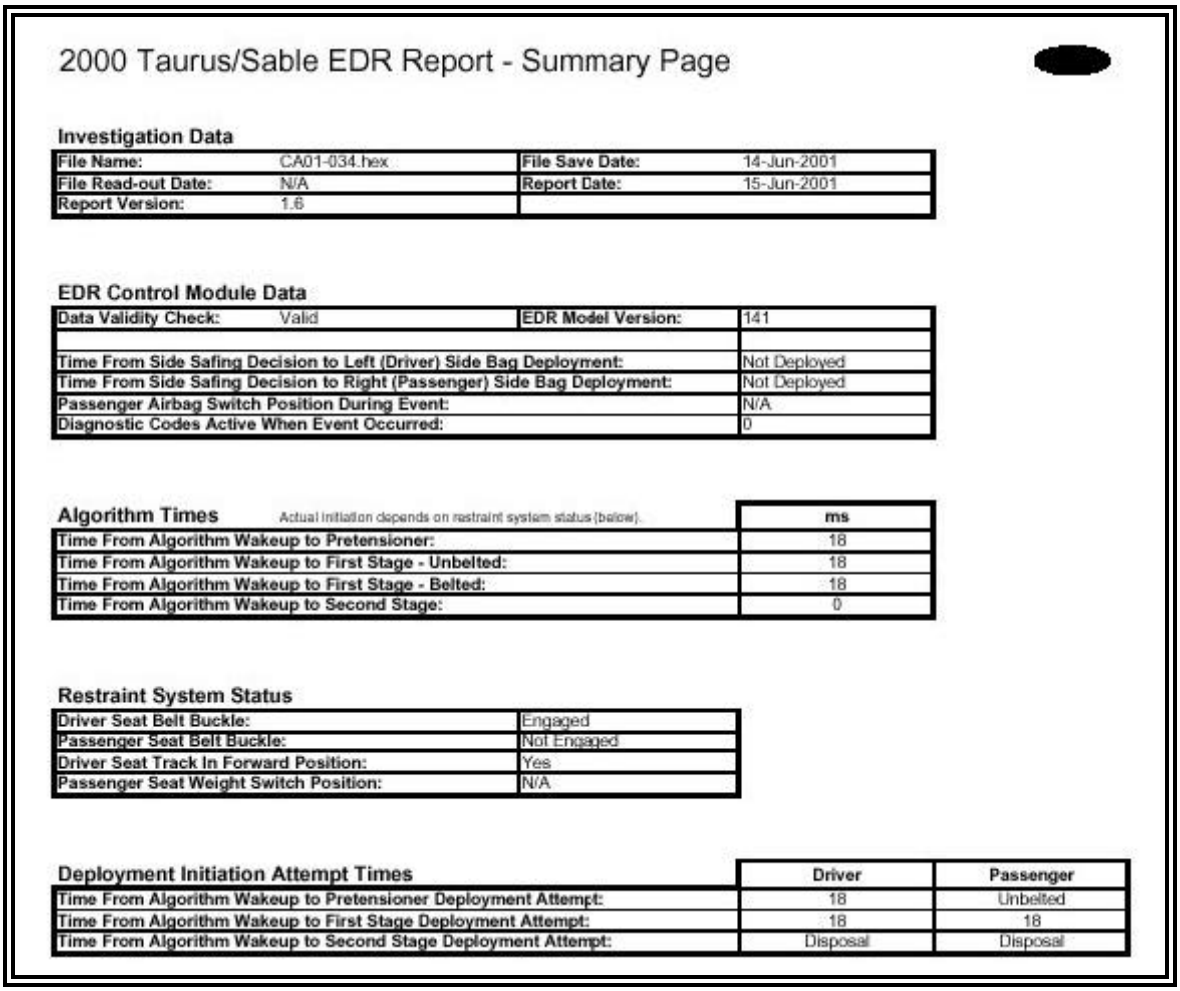
The driver was not injured in the crash.

DRIVER KINEMATICS

The restrained driver of the Mercury Sable was seated in a forward track position in a normal posture. She was operating her vehicle in the outboard lane and traveling adjacent to the tractor-trailer. As the tractor-trailer attempted a lane change to the right, the right drive tires of the tractor contacted the left side of the Mercury. The Mercury's driver responded to the contact by steering clockwise (right) in an avoidance maneuver and impacted the concrete retaining wall with the front of the vehicle.

Upon impact, the seat belt buckle pretensioner and frontal air bags deployed. The fired pretensioner removed slack from the seat belt, tightened the webbing about the driver, and helped to maintain her upright position. The driver responded to the 11 o'clock direction of the impact by initiating a forward and slight lateral left trajectory. The driver's face contacted the expanded driver air bag evidenced by the make-up transfer to the face of the bag. This contact to the bag did not result in any injury. The proper use of the manual restraint and the supplemental protection provided by the air bag allowed the driver ride down the forces of the crash without significant interior contact and no resultant injuries.

ATTACHMENT A



2000 Taurus/Sable EDR Report - Summary Page

Investigation Data

File Name:	CA01-034.hex	File Save Date:	14-Jun-2001
File Read-out Date:	N/A	Report Date:	15-Jun-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:	18
Time From Algorithm Wakeup to First Stage - Unbelted:	18
Time From Algorithm Wakeup to First Stage - Belted:	18
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:	Yes
Passenger Seat Weight Switch Position:	N/A

Deployment Initiation Attempt Times	Driver	Passenger
Time From Algorithm Wakeup to Pretensioner Deployment Attempt:	18	Unbelted
Time From Algorithm Wakeup to First Stage Deployment Attempt:	18	18
Time From Algorithm Wakeup to Second Stage Deployment Attempt:	Disposal	Disposal

Figure 9: RCM Summary

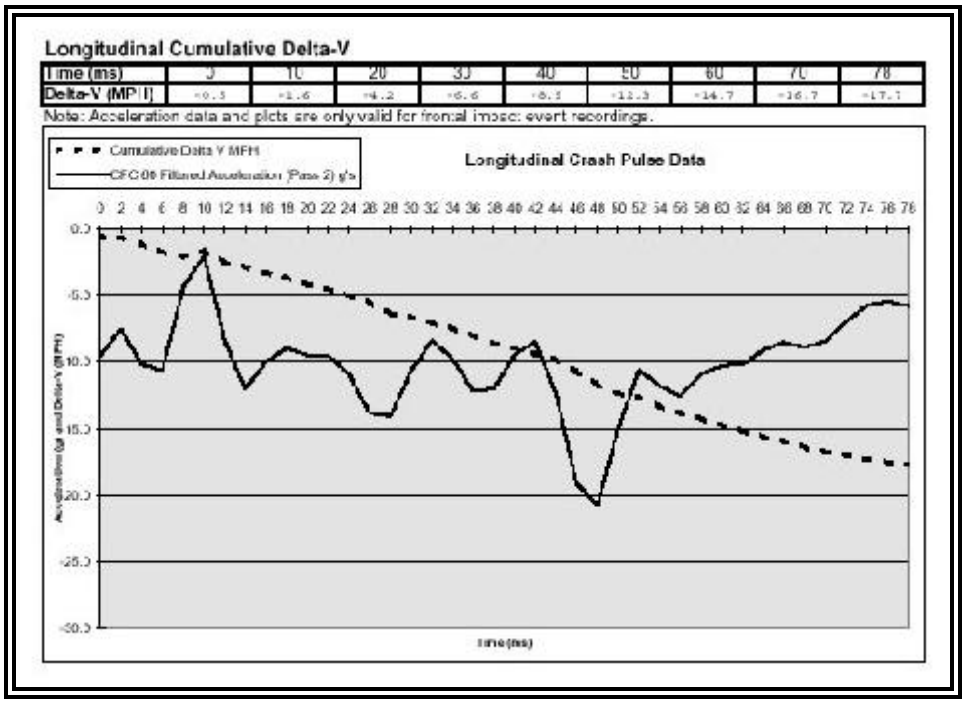


Figure 10: Longitudinal Delta V.

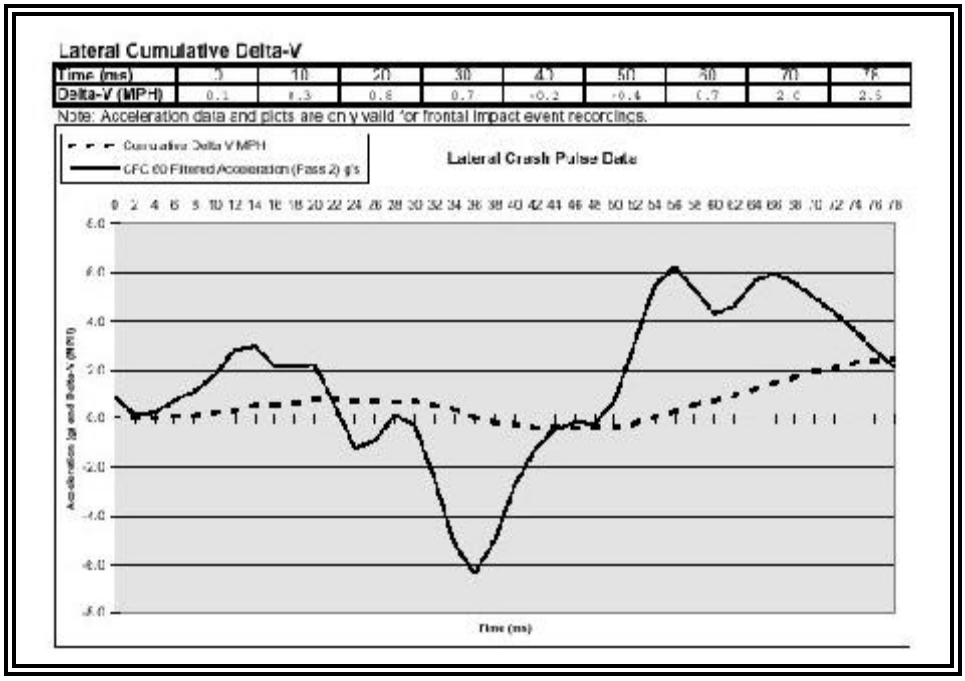


Figure 11: Lateral Delta V.