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CALSPAN ON-SITE REAR IMPACT CRASH AND FIRE INVESTIGATION
OFFICE OF DEFECTS INVESTIGATION
SCI CASE NO: CA10023

VEHICLE: 2006 FORD CROWN VICTORIA POLICE INTERCEPTOR

LOCATION: FLORIDA

CRASH DATE: MAY 2010

Contract No. DTNH22-07-C-00043

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 are coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

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

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16. Abstract

This investigation focused on the rear-impact crash of a 2006 Ford Crown Victoria Police Interceptor (CVPI) and the cause/origin of its subsequent major fire. The force of the impact incapacitated the on-duty 35-year-old male law enforcement officer, who perished in the post-crash fire. At the time of the crash, the Ford was parked on the right shoulder of a northbound interstate when it was struck in the rear by a 1995 Lexus SC 300, driven by a 19-year-old male. The Ford was equipped with an original equipment manufacturer (OEM) installed Fire Suppression System (FSS) which deployed during the crash sequence. This system was designed to discharge chemicals intended to suppress the spread of fire or potentially extinguish a fire at the vehicle's rear undercarriage aspect. There was also an OEM storage and organization "Trunk Pack" in use within the cargo space of the Ford.

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BACKGROUND

This investigation focused on the rear-impact crash of a 2006 Ford Crown Victoria Police Interceptor (CVPI) and the cause/origin of its subsequent major fire. The force of the impact incapacitated the on-duty 35-year-old male law enforcement officer, who perished in the post-crash fire. **Figure 1** is an on-scene police image of the Ford at its final rest position. At the time of the crash, the Ford was parked on the right shoulder of a northbound interstate when it was struck in the rear by a 1995 Lexus SC 300, driven by a 19-year-old male. The Ford was equipped with an Original Equipment Manufacturer (OEM) installed Fire Suppression System (FSS) which deployed during the crash sequence. This system was designed to discharge chemicals intended to suppress the spread of fire or potentially extinguish a fire at the vehicle's rear undercarriage aspect. There was also an OEM storage and organization "Trunk Pack" in use within the cargo space of the Ford.

Figure 1: North-facing view of the Ford at final rest. Image supplied by the police investigator.

Notification of this crash was provided to the National Highway Traffic Safety Administration (NHTSA) Crash Investigation Division (CID) and Office of Defects Investigation (ODI) by the legal office of the Florida Department of Highway Safety and Motor Vehicles. NHTSA CID forwarded the notification and contact information to the Calspan Special Crash Investigations (SCI) team on June 22, 2010 and assigned an on-site investigative effort. Calspan SCI established cooperation with the legal office on the same day. The Ford and Lexus had been removed from the scene and impounded immediately following the crash. On July 15, 2010, a thorough inspection of the vehicles was completed by the SCI team in a joint venture with the investigating law enforcement agency, technical representatives of Ford Motor Company, and representatives of the deceased officer. The crash site was documented, and pertinent parties were interviewed.

SUMMARY

Vehicle Data

2006 Ford Crown Victoria Police Interceptor

Figure 2: Right rear oblique view of the 2006 Ford CVPI.

The 2006 Ford CVPI (**Figure 2**) was manufactured in Canada and was identified by the Vehicle Identification Number (VIN): 2FAHP71W26X (production sequence deleted). The exact odometer reading at the time of SCI inspection could not be obtained due to vehicle damage. This body-on-frame, four-door sedan had a 291 cm (114.7 in) wheelbase with rear-wheel drive. Power was derived from a 4.6-liter single overhead camshaft (SOHC) V8 gasoline engine linked to an electronically controlled 4-speed automatic transmission. The vehicle was equipped with four-wheel, power-assisted disc brakes with anti-lock. The manufacturer's recommended tire size was P235/55R17 front and rear, with a corresponding cold tire pressure of 241 kPa (35 PSI). The vehicle was equipped with OEM steel wheels at all four axle positions. Specific tire data at the time of SCI inspection was as follows:

POSITION	MAKE / MODEL	PRESSURE	TREAD DEPTH	DAMAGE
LF	Goodyear Eagle	Flat	6 mm (7/32 in)	Sidewall burned full-thickness
RF	Goodyear Eagle	Flat	7 mm (9/32 in)	Sidewall burned full-thickness
LR	Unknown	Flat	Unknown	Consumed by fire
RR	Unknown	Flat	Unknown	Consumed by fire

The interior of the Ford was configured for the seating of five occupants. In the front row were two bucket seats with manual track, seatback, and head-restraint adjustment features. A fixed rear bench seat provided seating for three occupants. All five seating positions were equipped with 3-point lap and shoulder safety belts for manual restraint. For the two front seats, the safety belt systems were equipped with retractor pretensioners and D-rings that were manually adjustable at the B-pillar. The Ford was also equipped with Certified Advanced-208 Compliant (CAC) driver and front right passenger air bags, front seat-mounted side impact air bags and side impact Inflatable Curtain (IC) air bags.

Aft of the front row was a steel and plexi-glass safety cage partition mounted to the floor and B-pillars. Intended for law enforcement utilization, the purpose of this passenger compartment divider was to separate the front row from the rear row to protect the driver. Other law enforcement equipment consisted of a broad center console between the two front seats, which incorporated communications equipment, emergency lighting switches and warning device controls.

The Ford was also equipped with an OEM “Trunk Pack” within the trunk area that served for the organization and lateral storage of equipment and supplies within the rear cargo area. Exemplar Ford CVPIs utilized by the same law enforcement agency employed the trunk packs to organize and store a fire extinguisher, lug wrench, tri-pod, shotgun, and numerous investigative equipment utilized during their daily duties. The communications equipment and spare tire were located on the shelf at the trunk’s forward aspect.

1995 Lexus SC 300

The 1995 Lexus SC 300 (**Figure 3**) was manufactured in Japan and identified by the VIN: JT8JZ31C6S0 (production sequence deleted). The odometer reading could not be obtained at the time of SCI inspection due to legal reasons. This two-door coupe had a 269 cm (106 in) wheelbase with rear-wheel drive. Power was provided by a 3.0-liter inline 6-cylinder gasoline engine linked to an automatic transmission. The service brakes were four-wheel discs with anti-lock. The manufacturer’s recommended tire size was P225/55R16 front and rear. However, this vehicle was equipped with aftermarket HP Design 10-spoke alloy wheels. The front-mounted tires were Nexen N3000 93Y of size P235/40R18, with matching Tire Identification Numbers (TIN) 8ELL RF8R 0108. The rear tires were Nexen N3000 97Y, size P245/40R18, with matching TIN 8EJK BHM7 1708. Specific tire data at the time of SCI inspection was as follows:

Figure 3: Right front oblique view of the Lexus SC 300.

POSITION	PRESSURE	TREAD DEPTH	DAMAGE
LF	200 kPa (29 PSI)	6 mm (7/32 in)	None
RF	Flat	6 mm (8/32 in)	Two punctures in sidewall with corresponding cut
LR	200 kPa (29 PSI)	6 mm (7/32 in)	None
RR	193 kPa (28 PSI)	4 mm (5/32 in)	None

The interior of the Lexus was configured for the seating of five occupants. The vehicle was equipped with leather-upholstered front folding bucket seats and a rear three-passenger bench seat. All five seating positions were equipped with 3-point lap and shoulder safety belts. The Lexus was also equipped with a dual frontal air bag system.

Crash Site

Figure 4: Northbound trajectory view of the Lexus.

The crash occurred on a four-lane physically divided interstate highway with a posted speed limit of 113 km/h (70 mph). Physical division consisted of a grassy median with a dual W-beam center guardrail. The northbound portion was a straight and level bituminous roadway, supported by narrow inboard and broad outboard shoulders. All four lanes were 3.5 m (11.5 ft) wide and delineated by broken white lines. The narrow inboard shoulder contained a continuous rumble strip, and was separated from the inboard travel lane by a solid yellow edge line. The broad 3.6 m (12 ft) wide outboard shoulder was separated from the outboard travel lane by a solid white fog line and continuous rumble strip. To the east of the roadway, outboard of the shoulder was a narrow level grass swale area bordered by a cable guardrail. Outboard of the cable guardrail was a negative-sloped area covered with assorted vegetation. An entrance ramp onto the interstate was located approximately 0.4 km (0.25 mile) south of the crash site.

According to local weather reports, the conditions during the night of the crash were clear with a temperature of 30 Celsius (86 Fahrenheit) degrees, 37-percent relative humidity, and west-southwest breeze of 10 km/h (6 mph). **Figure 4** depicts the northbound trajectory view of the Lexus as it approached the shoulder where the Ford was parked. The Crash Schematic is attached as **Figure 20**.

Crash Sequence

Pre-Crash

On the night of the crash, the law enforcement officer was involved in traffic enforcement on the interstate. Refueling records retained by the law enforcement agency indicated that he had filled the Ford with 52.2 liters (13.8 US gallons) of gasoline approximately one hour prior to the crash, after which he began his patrol responsibilities on the interstate. He parked the Ford on the outboard shoulder of the interstate, with a heading angle parallel to the northbound travel lanes. Witnesses reported that the officer had an interior overhead dome light activated within the vehicle, but none of the exterior lights were illuminated. It was theorized that the officer may have been completing the documentation of a recent citation at the time of the crash.

Coincident to the officer and his activities, the 19-year-old male operated the Lexus northbound in the left center travel lane of the interstate. Witnesses reported that the Lexus was travelling at highway speed, similar to that of adjacent traffic. As it approached the location of the stationary Ford, the Lexus drifted to the right from its travel lane, crossed through the two adjacent travel lanes and over the fog line onto the east shoulder. It maintained its forward trajectory within the shoulder as it approached the rear aspect of the stationary Ford. There was no physical evidence at the scene to support avoidance braking; however the driver of the Lexus apparently steered left in an attempt to correct the vehicle's errant trajectory. This steering maneuver reoriented the Lexus parallel to the northbound travel lanes, nearly in-line with the parked Ford.

Crash

The impact occurred when the front plane of the Lexus impacted the back plane of the Ford (Event 1). The reconstructed impact speed of the Lexus based on a Conservation of Momentum analysis was approximately 113 to 121 km/h (70 to 75 mph). The point of impact and post-impact trajectories of the Ford and Lexus were evidenced by gouge marks, tire marks, and damage patterns on the asphalt shoulder surface and within the roadside grass swale area. Based on vehicle damage patterns, the centerline of the Lexus was offset 13 cm (5 in) to the left of the centerline of the Ford at initial engagement. An imprint of the Lexus emblem was identified on the trunk lid of the Ford (**Figure 5**) during the SCI inspection. The relative position of the emblems defined the vehicles' position at impact. The back of the stationary Ford was crushed and displaced forward by the 6 o'clock direction of force. The front plane of the Lexus, including the bumper, fascia, fenders, hood, and under-hood components, were crushed and displaced rearward by the 12 o'clock direction of force. This longitudinal crush also displaced both front axle positions of the Lexus, which immediately deflated the right front tire and shortened both wheelbases.

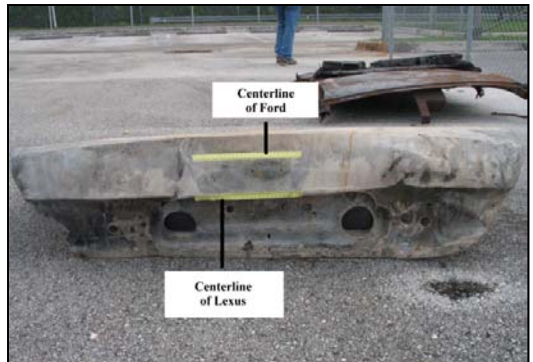


Figure 5: View of the Ford's trunk lid and the contact evidence from the Lexus.

The Damage Algorithm of the WinSMASH model was used to calculate the severity (delta-V) of the crash. The total calculated delta-V of the Ford was 53 km/h (32.9 mph). The longitudinal component of the delta-V was 53 km/h (32.9 mph). Given the near in-line orientation of the impact configuration, the lateral component of the Ford's delta-V was 0 km/h. The total calculated delta-V of the Lexus was 75 km/h (46.6 mph), with longitudinal and lateral components of -75 km/h (-46.6 mph) and 0 km/h, respectively. Based on SCI experience and vehicle damage, the WinSMASH calculations of the Lexus appear to be overestimated. The overestimation was attributed primarily to the use of the default stiffness values in the WinSMASH analysis, as vehicle-specific stiffness values for the Lexus were not available.

Impact forces associated with the pre-crash momentum of the Lexus, and in conjunction with the vehicles' configuration at impact, rapidly transitioned the Ford from its original stationary state and initiated forward movement with respect to the heading angle of its parked position.

Subsequently, the vehicles experienced prolonged engagement as they translated northward approximately 13.1 m (43 ft). During this engagement, the rear crash sensors and Electronic Control Module (ECM) of the Ford's FSS identified the severe rear-impact and deployed the fire suppression system. The deployment was evidenced by suppressant residue on the exterior body surfaces of the Lexus and the deployed state of the FSS upon inspection.

Severe longitudinal crush to the rear aspect of the Ford sustained during the initial impact event resulted in a complete collapse of the trunk and its enclosed constituents with significant forward displacement of the rear undercarriage components. The gasoline fuel tank mounted to the forward wall of the trunk was displaced forward and engaged the rear axle differential. Engagement of these vehicular components compromised the integrity of the fuel tank and instigated a gasoline leak. High-temperature exhaust components in the vicinity of the aforementioned fuel tank and/or impact-related sparks ignited the gasoline vapors, which initiated the subsequent major fire (Event 2).

The left offset of the impact forces resulted in the clockwise (CW) rotation of the Ford as it separated from the Lexus. It rotated 100 degrees CW as it slid to rest, facing east, approximately 34.2 m (112 ft) north of the initial impact point. At rest, the Ford was straddling the pavement edge; the front tires of the vehicle were in the grass. This final rest position was documented by the on-scene law enforcement as depicted in **Figure 6.** As the gasoline continued to leak from the compromised fuel tank, the fuel pooled underneath the forward aspect of the vehicle due to the negative cross slope of the road shoulder. As the gasoline burned, the fire completely consumed the vehicle.

Figure 6: North view of the Ford's final rest position. Image supplied by the police investigator.

The Lexus separated with a northeast trajectory after the prolonged engagement, departed the outboard shoulder and entered the roadside grass swale area. It impacted the outboard cable guardrail in a sideswipe configuration (Event 3) and came to rest. At final rest, the Lexus remained in contact with the cable guardrail and was located approximately 22.5 m (74 ft) from the point of initial impact. The final rest position of the Lexus as documented by on-scene law enforcement is depicted in **Figure 7** *(note the burn pattern in the roadside grass swale area)*.

Figure 7: East view of the Lexus's final rest position. Image supplied by the police investigator.

Post-Crash

The local emergency response system was notified of the crash and dispatched law enforcement, the local fire department, and emergency medical services (EMS) to the scene. First arriving personnel found the Ford with all of its doors closed, fully involved in fire. Firefighters extinguished the fire that had engulfed the Ford, finding the body of the officer in the driver's seat. On-scene law enforcement personnel secured the scene and performed their on-scene investigation. The vehicle was then transported to the Medical Examiner's office, where the Medical Examiner removed the officer's body and performed an autopsy. Both vehicles were impounded by the investigating law enforcement agency and held for this SCI investigation. The driver of the Lexus was treated by EMS at the scene and transported via helicopter to a regional trauma center for the treatment of unknown injuries.

2006 Ford Crown Victoria Police Interceptor

Exterior Damage

The back plane of the Ford sustained severe direct and induced damage as a result of the impact. **Figure 8** depicts the rear-impact damage as documented by the impounding law enforcement agency. The combined width of the direct and induced damage extended across the full 152 cm (62 in) end-width of the vehicle. The direct contact damage began at the left corner and extended 140 cm (55 in) to the right (consistent with the bumper width of the Lexus and the offset impact configuration). The dynamics and force of the impact completely compressed the volume of the trunk space and its contents forward, below the level of the rear parcel shelf.

Figure 8: Left lateral view of the damage to the Ford. Impound image provided by police investigator.

Figure 9: Overhead view of the damage profile to the back plane of the Ford.

The rear residual deformation profile of the Ford was documented along the rear bumper reinforcement bar, as depicted in **Figure 9**. The crush profile resultant to those measurements was as follows: C1 = 99 cm (39.0 in), C2 = 102 cm (40.2 in), C3 = 105 cm (41.3 in), C4 = 104 cm (40.9 in), C5 = 88 cm (34.6 in), C6 = 75 cm (29.5 in). The maximum crush measured 105 cm (41.3 in) and was located at C3. The rear axle was displaced forward during the impact. The left and right wheelbase dimensions were reduced 26 cm (10.2 in) and 8 cm (3.1 in), respectively. The Collision Deformation Classification (CDC) associated with this damage pattern was 06BDEW6.

The Ford sustained severe damage that was attributable to the post-crash fire event. Exterior paint was burned full-thickness on all exterior body surfaces, with the exception of the rear aspect of the left front fender and left front door. The majority of all exterior combustible materials, including the head and tail lamp assemblies, side mirrors, roof-mounted emergency light bar, and other polymer components, were consumed by the fire. The tires at the four wheel positions were damaged by the fire as previously stated, and the spare tire remained in its stowed position where it sustained full-thickness burn damage from the post-crash fire. Melted and deformed materials from the windshield were the lone remnants of the vehicle's glazing. Accordingly, it was presumed that any glazing that remained intact post-crash had been subsequently consumed during the post-crash fire.

The roof, doors, and trunk were cut using hydraulic rescue tools and separated from the vehicle during the extrication of the driver's body. The investigating law enforcement agency reported that this had been done by fire department personnel in a controlled environment to remove the body and examine vehicular components. However, all separated components were with the vehicle at the time of SCI inspection.

Interior Damage

The interior of the Ford sustained severe damage attributed to the intrusion of rear vehicle components into the passenger compartment and the post-crash fire. Virtually all combustible components were burned full-thickness or fully consumed, as depicted in **Figure 10**. The longitudinal intrusion of the second row measured 25 cm (10 in) at the left position, 21 cm (8.2 in) at the center position and 17 cm (6.8 in) at the right position. The longitudinal intrusion of the left and right C-pillar measured 14 cm (5.5 in) and 9 cm (3.5 in), respectively.

Figure 10: Interior fire damage to the Ford.

Manual Safety Restraint Systems

The front row of the Ford was equipped with manual 3-point, continuous loop lap and shoulder safety belt systems. The driver's safety belt system was equipped with a sliding latch plate, an Emergency Locking Retractor (ELR), and a retractor pretensioner. The front right belt system was equipped with a sliding latch plate, an ELR/Automatic Locking Retractor (ALR), and a retractor pretensioner. Both front belt systems utilized adjustable B-pillar-mounted D-rings. The second row seat positions were equipped with 3-point, continuous loop lap and shoulder safety belt systems, incorporating sliding latch plates, fixed D-rings and switchable ELR/ALR retractors. The shoulder belt and retractor of the second row center position was integrated into the seatback.

All the combustible components of the vehicle's safety belts were fully consumed by the fire. An inspection of the driver's safety belt system determined that the latch plate was still engaged within the buckle. Based on the buckled condition of the safety belt, it was determined that the officer-driver was restrained at the time of the crash.

Air Bag Systems

The Ford was equipped with CAC frontal air bags, front seat-mounted side impact air bags and side impact IC air bags. The manufacture of the Ford certified that the frontal air bags were compliant to the advanced air bag requirements of Federal Motor Vehicle Safety Standard (FMVSS) 208. The driver air bag was steering wheel hub-mounted, and the front right passenger air bag was mounted within the right aspect of the instrument panel. Side impact air bags were located in the outboard aspects of the front seats and side impact IC air bags were mounted in the respective roof side rails. All the air bag modules and associated components were completely consumed by the fire.

Event Data Recorder

The Ford was equipped with a Restraint Control Module (RCM) which performed the diagnostic, sensing and control functions associated with the deployment of the vehicle air bag systems. The RCM was mounted under the center instrument column immediately right of the accelerator pedal and was designed to measure and record longitudinal deceleration data, for the purpose of identifying critical events and determining whether or not the deployment of the air bag systems was required. The RCM had Event Data Recording (EDR) capabilities.

The RCM was removed by the investigating law enforcement agency and was available for SCI inspection. The EDR was imaged utilizing the Bosch Crash Data Retrieval tool via a direct cable connection and applying 12-volt external power supply. The data was imaged by software version 3.4 and was reanalyzed with version 3.5.1. The imaged EDR had two stored events, termed "Frontal Trigger" and "Side Trigger". However, neither of these recorded events was related to the subject crash. Historically, the "Side Trigger" event occurred on Ignition Cycle 620 and the "Frontal Trigger" occurred on Ignition Cycle 3383. The delta-V of the "Frontal Trigger" was -2.3 km/h (-1.44 mph). This delta-V was associated with an impact from the front of the vehicle (10 to 2 o'clock direction of force) and therefore was not associated with the rear impact crash. The Ignition Cycle of the rear crash was not known; however, this impact imparted a positive acceleration to the Ford. That positive acceleration and subsequent positive delta-V was not measured or recorded by the RCM. The imaged RCM data is included at the end of this technical report as **Attachment A**.

Undercarriage Damage and Fuel Tank Examination

After the exterior inspection of the Ford by all of the involved parties, a procedure to inspect the undercarriage of the vehicle and to remove the fuel tank was discussed. To facilitate this process, the Ford was lifted vertically for visual inspection prior to being rolled onto its right side. By rolling and securing the Ford on its right side, the vehicle could be safely inspected and sequentially disassembled to gain access to the fuel tank and the left side-mounted fuel filler neck. The disassembly of the vehicle involved removing the exhaust pipes immediately rearward of the mufflers, removing the drive shaft, and cutting the rear suspensions components and sway bar to free and then remove the rear axle. With the rear axle removed, it was possible to access and the fuel tank and fire suppression system. **Figure 11** is an overall view of the Ford's undercarriage as the vehicle rested on its right side plane prior to disassembly. **Figure 12** is a close-up view of the aft section of the damaged Ford.

Figure 11: View of the undercarriage of the Ford.

Figure 12: Close-up view of the damaged rear undercarriage of the Ford prior to disassembly.

During the impact sequence, the back section of the Ford crushed and deformed forward. The impact force fully compressed the trunk's volume and produced significant forward displacement of the rear undercarriage components resulted. The fuel tank mounted on the trunk's forward wall was displaced forward into the differential and the rear axle tube. The rear axle was displaced forward and the drive shaft fractured and separated from the differential. The aft aspect of the vehicle's frame members deformed and crushed. The arch of the left frame at the left rear wheel opening was compressed and hindered the removal of the rear axle. There was no apparent frame deformation forward of the C-pillar area. Relief cuts into the left frame arch allowed the rear axle to then be removed.

Figure 13 is a view of the damaged steel fuel tank and the deployed fire suppression system after the removal of the rear axle. As the lower aspect of the fuel tank crushed, hydraulic pressure in the nearly-full tank increased. Contact between the central aspect of the fuel tank and the differential's ring gear protrusion resulted in a 23 cm (9 in) long by 2 cm (1 in) wide split/tear in the forward wall of the fuel tank. The tear was not located at, or in close proximity to, any seam. There were no other noted perforations in the fuel tank. The fuel filler neck, routed through the left quarter panel, was entangled in the deformation but remained engaged with the tank and was intact. There were no indications of leakage at the filler neck. The sending unit located on the forward side of the fuel tank remained engaged. The grommets inserted in the various ports located on the top of the fuel tank were in place and melted from exposure to the fire.

Figure 13: View of the damaged fuel tank and deployed FSS (circled).

The fuel tank was removed by cutting the two mounting straps and removing the filler neck from the quarter panel. With the tank removed, the forward wall of the trunk was inspected. The trunk wall was observed to be intact and had not been penetrated by any interior trunk objects. **Figure 14** is a view of the forward trunk wall after removal of the fuel tank. The deployed fire suppression system can also be seen in the image.


Figure 14: View of the forward trunk wall after removal of the fuel tank.

The fuel tank damage resulted in a pressurized fuel leak, the vapors of which were ignited by the high-temperature exhaust components and/or impact-related sparks. This was determined to be the probable cause of the post-crash major fire event which consumed the vehicle. **Figure 15** provides an overall view of the removed fuel tank and large split/tear. The fuel tank was a seam welded clam-shell design and was constructed of steel. The tank had a capacity of approximately 72 liters (19 gallons).

Figure 15: View of the forward wall of the removed fuel tank and the large split/tear.

Fire Suppression System

The Ford was equipped with the OEM Fire Suppression System (FSS) mounted within the rear undercarriage area of the vehicle. This system was designed to reduce the risk of fire-related injury in high-energy rear impact crashes by deploying chemicals designed to suppress the spread of, or potentially extinguish, a fire.[1] **Figure 16** is an image depicting the undamaged undercarriage of an exemplar Ford and the location of the FSS. The system was designed and tested to withstand a 121 km/h (75 mph) 50 percent offset rear impact by a 1587 kg (3500 lb) vehicle under controlled conditions that involved the artificial deployment and ignition of 5.7 liter (200 oz) of gasoline.[2]

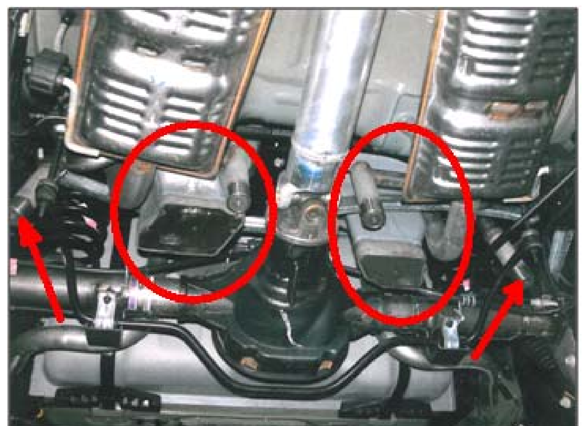


Figure 16: View of the undamaged undercarriage of an exemplar Ford and the location of the FSS.

The FSS consisted of two alloy containers storing the suppressant and surfactant material, a stainless steel distribution system, an ECM and the associated wiring harness. The distribution manifold consisted of a two horizontal spray bars and four vertically-oriented deployable nozzles. Mounted under the second row seat cushion, the ECM contained advanced electronics including rear crash sensors, a processing computer, and a large electrical capacitor. The ECM was removed from the vehicle during the SCI inspection and forwarded to the manufacturer for potential imaging of the stored data. The results of that imaging were not available at the time of this final report. An interior-mounted manual activation switch was also integrated into the FSS. This switch was mounted to the center aspect of the windshield header.

The FSS was designed to deploy automatically through ECM detection of a high-energy impact via rear-impact sensors, in conjunction with the ABS wheel sensor data that detected vehicle movement. After crash recognition, the ECM delayed deployment until wheel movement slowed to optimize the deployment time. Alternatively, if ABS sensor data was not available, the FSS deployed by an internal timer up to six seconds after initial event recognition.[1] The two alloy containers operated as hybrid fire extinguishers which contained solid propellant pyrotechnic gas generators to pressurize, vaporize, and expel an Aqueous Film Forming Foam (AFFF) suppressant through strategically located spray bars and nozzles.[2] Four of the nozzles deployed downward to assist in the dispersion of the suppressant throughout the undercarriage area surrounding the fuel tank and rear wheel positions. The remaining fixed spray bars served for the dispersion of the suppressant within the vehicle body above the rear axle. To ensure deployment reliability and prevent malfunction in the event that the system itself sustained damage due to severe vehicle deformation resulting from a rear-impact event, the system was wired with two separate fully redundant circuits.[2]

The FSS of the Ford deployed as a result of the rear-impact event. This was confirmed during SCI team inspection, wherein the four vertically oriented nozzles were located in their extended (deployed) position. **Figure 17** is an image of the FSS after its removal from the vehicle. The four deployed nozzles are highlighted in the image. In addition to the deployed condition of the nozzles, residue from the AFFF suppressant/surfactant was observed on the exterior body surfaces of the Lexus dispersed in an aerodynamic fashion, **Figure 18**. This evidence suggested that the FSS deployed after the impact and the Lexus passed through, and/or was contacted by, the plume of dispersed suppressant/surfactant as it traveled to final rest.

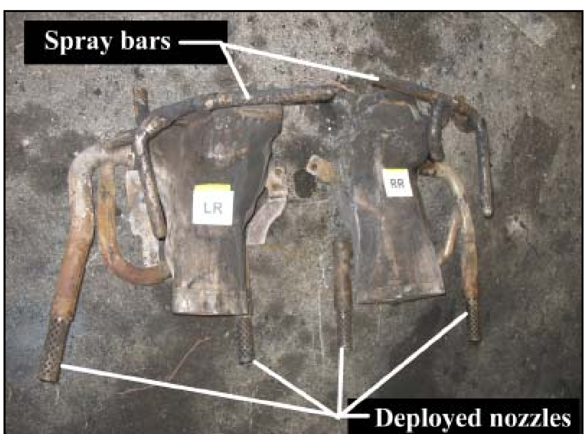


Figure 17: View of the deployed FSS after its removal from the Ford.

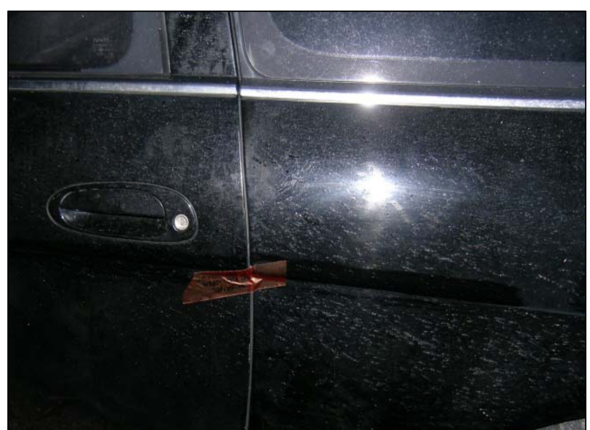


Figure 18: AFFF suppressant/surfactant residue on the exterior surfaces of the Lexus.

Although the FSS deployed during the crash, the major crash-induced fire developed. It was theorized that the volume of the gasoline dispersed from the nearly full and compromised fuel tank overwhelmed the capabilities of the suppression system thus leading the fuel-fed fire.

Occupant Data - 2006 Ford Crown Victoria Police Interceptor

Driver Demographics

Age/Sex:	35-year-old / Male
Height:	178 cm (70 in) estimated by police investigator (145 cm (57 in) recorded in autopsy)
Weight:	100 kg (220 lb) estimated by police investigator (69 kg (153 lb) recorded in autopsy)
Seat Track Position:	Rear-third track position
Safety Belt Usage:	Restrained by the 3-point lap and shoulder safety belt
Usage Source:	SCI vehicle inspection
Egress from Vehicle:	Occupant deceased prior to removal from vehicle
Type of Medical Treatment:	None

Driver Injuries

Injury	Injury Severity (AIS 2005/08)	Injury Source	Confidence
Thermal burns of the head/face/neck, upper extremities, chest abdomen and back, lower extremities (partial) with absence of skin and significant charring exposing muscle and underlying tissue; Total Body Surface Area estimated at greater than 90 percent; heat related fractures of the calvarium and bilateral radii and ulnas	Maximum (912032.6,0)	Vehicle Fire	Certain

Source of injury data = Autopsy report

Driver Kinematics

The on-duty law enforcement officer of the Ford was seated in rear-third seat track position and restrained by the manual 3-point lap and shoulder safety belt system. The presence of the latch plate engaged within the buckle at the time of SCI inspection confirmed belt use. At the onset of the rear impact to the Ford, the driver initiated a rearward trajectory in response to the 6-o'clock direction of force. As the vehicle accelerated forward, the driver's seat back compressed and accelerated the driver's torso. The inertia of (initially stationary) head resulted in the flexion of his neck and the posterior aspect of his scalp contacted the head restraint; this sudden movement and contact probably rendered the officer unconscious. Although not possible to substantiate, it is theorized that the officer's posterior scalp could also have contacted the steel/plexiglass partition located between the seat rows resulting in unconsciousness. The officer then remained restrained in the driver's seat by the 3-point lap and shoulder safety belt as the Ford accelerated forward during impact engagement and decelerated to final rest. The unconscious officer was unable to remove himself from the vehicle as the gasoline-fed fire spread. Smoke and other toxic vapors filled the passenger compartment of the vehicle, depleting the available oxygen level within the vehicle and further preventing the officer from regaining consciousness.

The fire soon engulfed the entire vehicle, and the driver perished in the blaze. His body was later removed from the vehicle by the Medical Examiner in a controlled environment.

1995 Lexus SC 300

Exterior Damage

The front plane of the Lexus sustained moderate direct and induced damage as a result of the initial impact with the rear of the Ford. This included the disintegration of both headlight assemblies and the deformation of the bumper, fascia, grille, hood, and front fenders. These components were crushed rearward, with subsequent damage to the engine compartment and associated power train elements (**Figure 19**). Both the left and right front axle positions were displaced rearward, having shortened their corresponding wheelbase measurements by 2 cm (0.8 in) and 12 cm (4.7 in), respectively. The sidewall of the right front tire was punctured and lacerated by the longitudinally crushed body components.

Figure 19: Left front oblique view of the Lexus.

Direct damage extended the full 139 cm (54.5 in) bumper width from corner to corner, with induced damage extending across the full 160 cm (63 in) undeformed end width. The residual deformation profile of the Lexus was documented along the front plane at mid bumper level. The crush profile resultant to those measurements was as follows: C1 = 51 cm (20.1 in), C2 = 67 cm (26.5 in), C3 = 69 cm (27.2 in), C4 = 68 cm (26.8 in), C5 = 64 cm (25.2 in), C6 = 61 cm (24.0 in). The maximum crush measured 69 cm (27.2 in) and was located at C3. The CDC associated with this initial impact event was 12FDEW3.

The Lexus sustained sideswipe-type damage as a result of the secondary impact with the cable guardrail. Direct contact damage that consisted of scratches and abrasions to the exterior surfaces and paint began at the right corner of the front plane and extended down the right side plane. This was located in three distinct areas, including; (1) overlapping damage from the initial impact event located on the crushed components of the front plane above the right front axle position, (2) on the right front fender, beginning at the A-pillar and extending 38 cm (28 in) forward, and (3) beginning 10 cm (4 in) aft of the right rear axle and extending 80 cm (31.5 in) rearward on the right rear quarter panel. The associated Field L included the entire right side plane. There was no measurable crush associated with the damage pattern from the cable guardrail, and the corresponding CDC was 01FRES1.

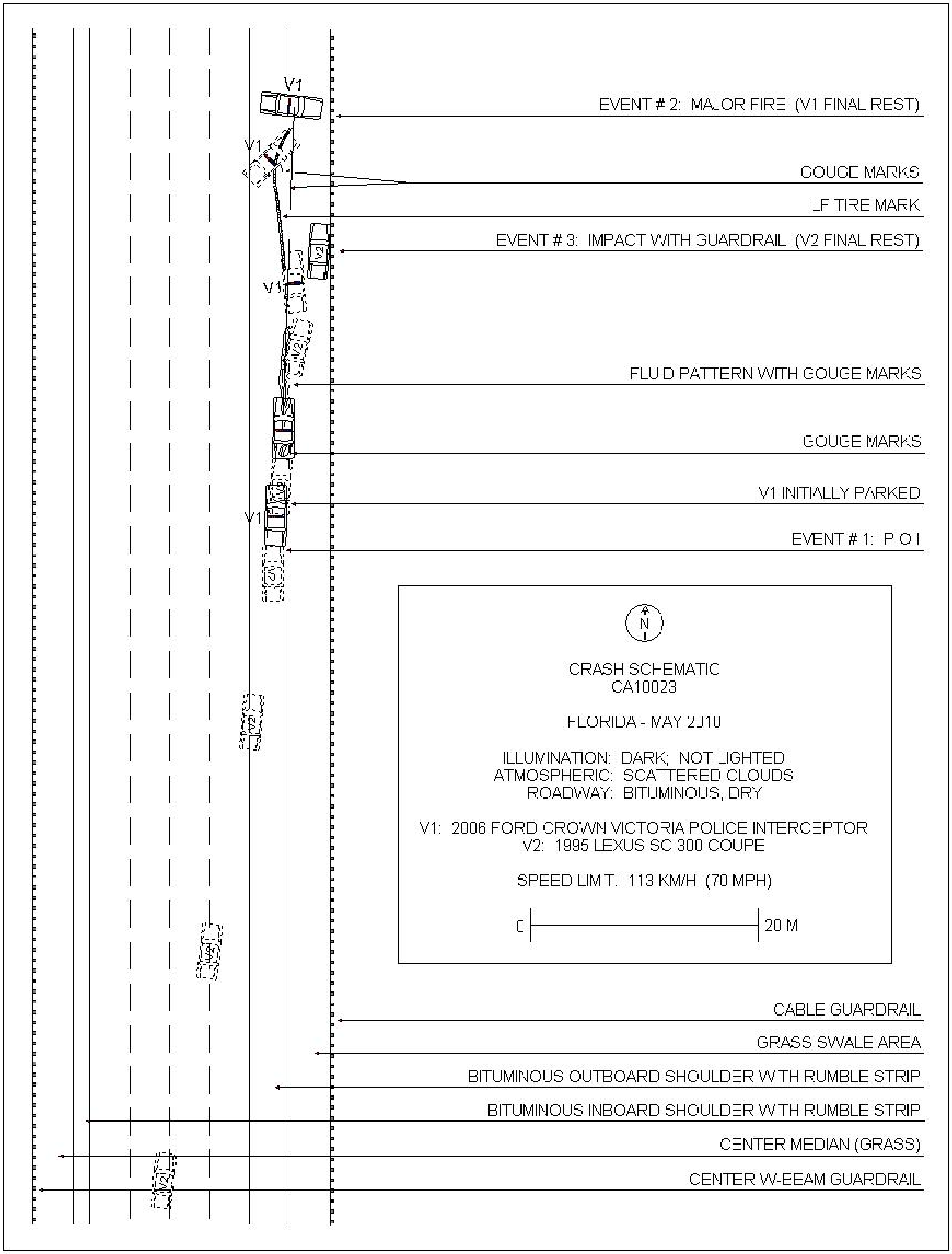


Figure 20: Crash Schematic.

APPENDIX A

References

1. Ford. "Fire Suppression." *Ford Fleet – Crown Victoria Police Interceptor*. Ford Motor Company, Mar. 2009. Web. May 2010. <https://www.fleet.ford.com/showroom/CVPI/FireSuppression.asp>.

2. Dierker, Joseph B., Robert H. Thompson, Paul H. Wierenga, and Matthew A. Schneider. "Development of Ford Fire Suppression System." Fire Suppression System Development for the Ford Crown Victoria Police Interceptor. Ford Motor Company. Aerojet. Society of Automotive Engineers International *SAE Technical Paper Series,* 1791st ser. 2005.01 (2005).

ATTACHMENT A:

2006 Ford Crown Victoria Police Interceptor
EDR Data

IMPORTANT NOTICE: Robert Bosch LLC and the manufacturers whose vehicles are accessible using the CDR System urge end users to use the latest production release of the Crash Data Retrieval system software when viewing, printing or exporting any retrieved data from within the CDR program. Using the latest version of the CDR software is the best way to ensure that retrieved data has been translated using the most current information provided by the manufacturers of the vehicles supported by this product.

CDR File Information

User Entered VIN	2FAHP71W26X******
User	
Case Number	
EDR Data Imaging Date	
Crash Date	
Filename	CA10023_CDR.CDR
Saved on	Thursday, July 15 2010 at 04:25:14 PM
Collected with CDR version	Crash Data Retrieval Tool 3.4
Reported with CDR version	Crash Data Retrieval Tool 3.5.1
EDR Device Type	airbag control module
Event(s) recovered	Frontal trigger event Side trigger event

Comments

No comments entered.

Data Limitations

The retrieval of this data has been authorized by the vehicle's owner, or other legal authority such as a subpoena or search warrant, as indicated by the CDR tool user on Thursday, July 15 2010 at 04:25:14 PM .

Limitations that are important for users of the Bosch Crash Data Retrieval (CDR) tool on this Ford product to know

Disclaimer: Ford Motor Company Restraint Control Modules (RCM's) were designed to record deceleration data for the purpose of understanding the approximate input data the Restraint Control Module used to determine whether or not to deploy restraint devices. Ford Motor Company RCM's were not designed for the purpose of assisting accident reconstructionists. Ford RCM modules do not record vehicle speed, throttle position, brake on-off, and other data desired by accident reconstructionists, which may be recorded in some 1999 model year and later General Motors modules. There is a second module in the vehicle, the Powertrain Control Module (PCM) which may record vehicle speed, brake, and throttle information. Proper precautions must be taken when reading the RCM not to spoliate the data in the PCM. Those precautions are discussed later in this document.

The time series deceleration data recorded by Ford's module during a crash is mathematically integrated into a partial Delta V by the Bosch tool. Delta_V is the change in velocity during the recording time and is NOT the speed the vehicle was traveling before the accident.

Accident reconstructionists must be aware of the limitations of the data recorded in Ford's control modules and should compare the recorded data with the physical evidence at the accident scene using professional accident reconstruction techniques (i.e. vehicle crush characteristics, momentum analysis. etc.) before making any assumptions about the import and validity of the data recorded in the module with respect to the crash event being analyzed. The following describes specific limitations that must be considered when analyzing recorded data.

1. There may be no deceleration data recorded in the module.
Loss of power (cut wires, damaged battery, crushed fuse box) to the module during or immediately after the crash may prevent the crash data from being written to NVM (non-volatile memory). A backup power supply within the module has sufficient power to continue to analyze the deceleration data and deploy restraint devices if needed, but there is limited backup power for recording.

2. If there are no deployment times recorded, but airbags or other restraint devices are observed to have deployed, the recorded data that you read after that event are most likely from a prior event. This module family does utilize backup power left over after any deployment to attempt to record information from the crash, and is much more likely to get a recording than prior modules, but it is still theoretically possible that there may not be any recording from a new event in which power is lost.

3. The recorded Longitudinal Delta V may understate or overstate the total Delta_V under certain circumstances.

3.1. This module has two different displays with Delta V information. The cumulative longitudinal Delta V shown in the system status section of the report reflects the change in forward velocity that the sensing system experienced from the point of algorithm entry to algorithm exit. The cumulative longitudinal Delta V may understate the Delta V slightly because the algorithm does not begin until the deceleration reaches a pre-specified level of approximately 2 G's, so the first one or two milliseconds of actual Delta V may not be included in the total.

3.2. If the acceleration levels measured exceed the sensor range of +/- 40G's, the data may be clipped and the area under the curve beyond +/-40G's will not be integrated in to the cumulative Delta V.

3.3. In addition to the cumulative Delta V, this module records and displays a time series up to 192 data points of longitudinal vehicle acceleration at 0.8 millisecond intervals from which a partial Delta V is calculated and displayed. The 192 data points consist of 64 data points post deployment, 1 at deployment, and 127 prior to deployment. Depending upon the time from algorithm wake up to deployment, the duration of the data in the graph may not be sufficient to reach the maximum or final Delta V of the collision.

3.4. The cumulative longitudinal Delta V is more likely than the graph to represent the Delta V of the complete crash because it will typically be over a longer duration. One purpose of looking at the graph is to determine if the G level exceeded the sensor range of +/- 40G's which would lead to under or over reporting Delta V.

3.5. The cumulative longitudinal Delta V is not the total resultant Delta V in anything other than a pure frontal collision. If the collision is angular, you must determine the Principal Direction of Force and divide by the cosine of the PDOF angle from frontal to get the total resultant Delta V.

3.6. The "Cumulative Delta V during the algorithm run time accurately reports observed delta-V for the period the RCM's decision making algorithm runs which may, in some cases, be longer than the actual crash pulse for a given event. For that reason, the reported Delta V may be different than a reconstruction based calculated Delta V for a given event. For example, during heavy slowing, such as braking or wheels locked from damage after the initial contact phase in a crash, the vehicle is capable of slowing as much as 2 mph per 100 milliseconds. If the algorithm runs for another 100 milliseconds beyond the end of the normally observed crash pulse, the data recorded may reflect an over reported event Delta V inasmuch as it includes the 2 mph from post contact braking observed while the system was still active. Similarly, after contact a vehicle may continue through the contact area to rest and may experience some level of positive X axis acceleration during that period. Even over a short period, some of that positive X axis acceleration may be observed by the RCM while the algorithm is still running and that may cause an under reporting of the delta-V relative to what may be calculated by a reconstructionist. Users should compare the reported algorithm run time to a normal crash duration of approximately 100-150 ms. If the algorithm run time is significantly longer than the reconstruction estimated crash duration, you may want to consider accounting for after contact acceleration - whether X positive or negative - where appropriate. End users using the crash pulse graph to estimate the event Delta V, should not include any speed loss accumulated as a function of braking prior to algorithm wake up in the event Delta V."

4. Event Recording Complete will indicate if data from the recorded event has been fully written to the RCM memory or if it has been interrupted and not fully written. Even if the event Recording Complete is "no", the data may still be valid. In general, fields with nonzero data written in them have been written successfully. The exception is passenger airbag occupant classification, which when unwritten displays "empty".

5. The module is not intended to record longitudinal acceleration/deceleration in a side-impact event. If the side impact generates a longitudinal deceleration component sufficient to wake up the frontal deployment algorithm, there may be a recording of longitudinal deceleration.

6. If there is any question that the restraint system did not perform as it was designed to perform, please read the system only through the diagnostic link connector. The Bosch CDR kit provides a connector to plug directly into the restraint control module. The Bosch CDR RCM Interface Cable connects only power, ground, and memory readout pins to the relevant vehicle restraint control module. The other pins normally connected to inputs, like sensors, and outputs, such as airbags, are not connected to anything when you use the RCM Interface Cable connector to plug directly into the module. Since the vehicle restraint control module is constantly monitoring airbag system readiness, it will detect that the connection to the input sensors and output airbags has been lost. The restraint control module will write a new diagnostic trouble code into memory for each device that is not connected. These new diagnostic trouble codes could potentially overwrite previously written diagnostic trouble codes present prior to the accident and spoil evidence necessary to determine if the restraint system performed in the accident as it was designed to perform. Not only could this prevent Ford from being able to determine if the system performed as it was designed to perform, but, regardless of innocent inadvertence, you could be charged with evidence spoliation in any litigation that may arise out of the accident. If you cannot read the module out through the diagnostic link connector, and if you suspect improper system performance, contact Ford Motor Company and request their assistance to read the module out with a proper vehicle simulator attached. If you choose to read out through the module small connector, Ford recommends that you do so in the vehicle and that you leave the second large connector plugged into the vehicle wiring harness to minimize the number of new diagnostic trouble codes created.

POWERTRAIN CONTROL MODULE DATA SPOLIATION CAUTIONS:

When reading the RCM users must use caution to not spoil data in the PCM. This Restraint Control Module does not record vehicle speed, braking, or throttle inputs prior to or during a collision event. There is a Powertrain Control Module (PCM) in this vehicle which records vehicle speed, brake, throttle angle and other parameters in a Data Recording Device (DRD), an EEPROM chip, whenever the key is in the run position. The PCM is intended to lock the recording if an airbag or safety belt pretensioner has deployed, and the vehicle data bus stays up long enough for the deploy signal from the RCM to reach the PCM. If the deploy signal has not reached the PCM and the PCM is powered, the DRD data can be overwritten by new data. If there is any doubt as to the PCM deployment lock status, the user must proceed with the understanding that the data may not be locked and could be overwritten if key power is turned on. It is recommended that the PCM not be key powered until it the EEPROM memory can be properly read out by a special procedure that prevents data from being overwritten. To read PCM data, follow the instructions in the CDR help file to determine which cable and adapter to use and how to connect to Ford PCMs for the purpose of downloading DRD data. The Bosch PCM readout cables and adapter are not included in the CDR kit and can be purchased directly from Bosch or through an authorized CDR tool distributor.

The PCM also has a diagnostic trouble code history kept in Keep Alive Memory (KAM). KAM is a form of RAM memory powered directly from the battery and is preserved as long as there is battery power to the PCM (the ignition key does not have to be on). If all power is removed from the PCM or the PCM exits flash mode after reading the Data Recording Device, KAM is cleared. The reader must make a judgment as to which data, DRD or KAM, is more likely to provide useful data for the situation at hand.

It has been Ford’s experience that the DRD data is more useful than the KAM data when:
1. The airbag has deployed and it is likely that the DRD is locked and has data
2. Power was lost in the crash and KAM is already cleared due to power loss
3. Power has been depleted subsequent to the crash and KAM is already lost.
4. Crash damage makes it likely there are multiple codes in KAM due to accident damage which were not likely to be present before the crash, where it is difficult to isolate codes present before the crash that may have contributed to the cause of the crash.

The KAM data may be more valuable when there has been no airbag deployment and it is likely the key has been left on after the event such that no useful data is likely to remain in the DRD.

If there is insufficient information to make a judgment per the above, Ford’s experience is that the DRD data is more likely to have significance, and that it is better to prioritize reading the DRD data first. To preserve the DRD data, unplug the PCM connectors while the RCM is being read.

AIRBAG MODULE DATA SOURCES:

All RCM recorded data is measured, calculated, and stored internally, sensors external to the RCM include the following:
1. The Driver and Passenger Belt Switch Circuits are wired directly to the RCM.
2. The Driver's Seat Track Position Switch Circuit is wired directly to the RCM.
3. The Side Impact Sensors (if equipped) are located at the base of the B-pillars and are wired directly to the RCM.
4. The Occupant Classification Sensor is located in the front passenger seat and transmits data directly to the RCM on a dedicated high-speed CAN bus.
5. Front Impact Sensors (right and left) are located on top of radiator support bracket.

02004_RCM-Takata2_r001

System Status at Time of Data Retrieval

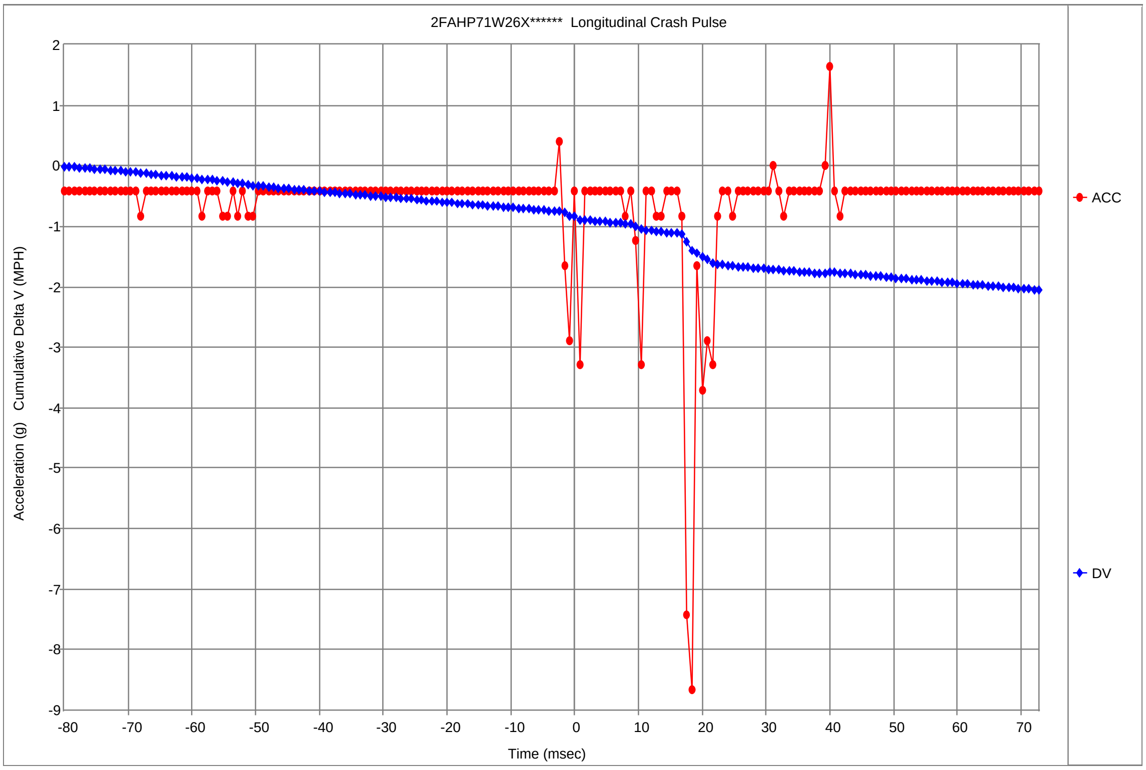
Vehicle Identification Number	2FAHP71W26X******
Module Serial Number	052461VU
Restraints Control Module Part Number	6W73-14B321-DA
Restraints Control Module Software Version Number	0
Restraints Control Module Software Date	January 5, 2005
Longitudinal velocity change during algorithm run time (MPH)	-1.44
Algorithm run time (msec)	100
Deployment Counter	0
Restraints System Faults Present at time of read out.	Yes

System Status At Frontal Trigger Event

Ignition Cycle Key On Timer at Start of Frontal Event (sec)	3383
Driver's Belt Switch Circuit Status	Buckled
Passenger's Belt Switch Circuit Status	Unbuckled
Driver seat forward of switch point	Rearward
Passenger occupant classification status	Empty
Frontal Event Record Locked	No
Frontal Event Recording Complete	No

System Status At Side Trigger Event

Ignition Cycle Key On Timer at Start of Side Event (sec)	620
Driver's Belt Switch Circuit Status	Buckled
Passenger's Belt Switch Circuit Status	Unbuckled
Driver seat forward of switch point	Rearward
Passenger occupant classification status	Empty
Side Event Record Locked	No
Side Event Recording Complete	Yes


2FAHP71W26X****** Longitudinal Crash Pulse
Acceleration (g) Cumulative Delta V (MPH)
Time (msec)
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-80
-70
-60
-50
-40
-30
-20
-10
0
10
20
30
40
50
60
70
ACC
DV

Crash Pulse Data

Milliseconds	Long. Acceleration (Gs)	Long. Cumulative Delta V (MPH)
-80.0	-0.41	-0.01
-79.2	-0.41	-0.01
-78.4	-0.41	-0.02
-77.6	-0.41	-0.03
-76.8	-0.41	-0.04
-76.0	-0.41	-0.04
-75.2	-0.41	-0.05
-74.4	-0.41	-0.06
-73.6	-0.41	-0.07
-72.8	-0.41	-0.07
-72.0	-0.41	-0.08
-71.2	-0.41	-0.09
-70.4	-0.41	-0.09
-69.6	-0.41	-0.10
-68.8	-0.41	-0.11
-68.0	-0.82	-0.12
-67.2	-0.41	-0.13
-66.4	-0.41	-0.14
-65.6	-0.41	-0.14
-64.8	-0.41	-0.15
-64.0	-0.41	-0.16
-63.2	-0.41	-0.17
-62.4	-0.41	-0.17
-61.6	-0.41	-0.18
-60.8	-0.41	-0.19
-60.0	-0.41	-0.20
-59.2	-0.41	-0.20
-58.4	-0.82	-0.22
-57.6	-0.41	-0.22
-56.8	-0.41	-0.23
-56.0	-0.41	-0.24
-55.2	-0.82	-0.25
-54.4	-0.82	-0.27
-53.6	-0.41	-0.27
-52.8	-0.82	-0.29
-52.0	-0.41	-0.30
-51.2	-0.82	-0.31
-50.4	-0.82	-0.33
-49.6	-0.41	-0.33
-48.8	-0.41	-0.34
-48.0	-0.41	-0.35
-47.2	-0.41	-0.35
-46.4	-0.41	-0.36
-45.6	-0.41	-0.37
-44.8	-0.41	-0.38
-44.0	-0.41	-0.38
-43.2	-0.41	-0.39
-42.4	-0.41	-0.40
-41.6	-0.41	-0.41
-40.8	-0.41	-0.41

Milliseconds	Long. Acceleration (Gs)	Long. Cumulative Delta V (MPH)
-40.0	-0.41	-0.42
-39.2	-0.41	-0.43
-38.4	-0.41	-0.43
-37.6	-0.41	-0.44
-36.8	-0.41	-0.45
-36.0	-0.41	-0.46
-35.2	-0.41	-0.46
-34.4	-0.41	-0.47
-33.6	-0.41	-0.48
-32.8	-0.41	-0.48
-32.0	-0.41	-0.49
-31.2	-0.41	-0.50
-30.4	-0.41	-0.51
-29.6	-0.41	-0.51
-28.8	-0.41	-0.52
-28.0	-0.41	-0.53
-27.2	-0.41	-0.54
-26.4	-0.41	-0.54
-25.6	-0.41	-0.55
-24.8	-0.41	-0.56
-24.0	-0.41	-0.56
-23.2	-0.41	-0.57
-22.4	-0.41	-0.58
-21.6	-0.41	-0.59
-20.8	-0.41	-0.59
-20.0	-0.41	-0.60
-19.2	-0.41	-0.61
-18.4	-0.41	-0.62
-17.6	-0.41	-0.62
-16.8	-0.41	-0.63
-16.0	-0.41	-0.64
-15.2	-0.41	-0.64
-14.4	-0.41	-0.65
-13.6	-0.41	-0.66
-12.8	-0.41	-0.67
-12.0	-0.41	-0.67
-11.2	-0.41	-0.68
-10.4	-0.41	-0.69
-9.6	-0.41	-0.69
-8.8	-0.41	-0.70
-8.0	-0.41	-0.71
-7.2	-0.41	-0.72
-6.4	-0.41	-0.72
-5.6	-0.41	-0.73
-4.8	-0.41	-0.74
-4.0	-0.41	-0.75
-3.2	-0.41	-0.75
-2.4	0.41	-0.75
-1.6	-1.65	-0.77
-0.8	-2.89	-0.82
0.0	-0.41	-0.83
0.8	-3.30	-0.89
1.6	-0.41	-0.90

Milliseconds	Long. Acceleration (Gs)	Long. Cumulative Delta V (MPH)
2.4	-0.41	-0.90
3.2	-0.41	-0.91
4.0	-0.41	-0.92
4.8	-0.41	-0.93
5.6	-0.41	-0.93
6.4	-0.41	-0.94
7.2	-0.41	-0.95
8.0	-0.82	-0.96
8.8	-0.41	-0.97
9.6	-1.24	-0.99
10.4	-3.30	-1.05
11.2	-0.41	-1.06
12.0	-0.41	-1.06
12.8	-0.82	-1.08
13.6	-0.82	-1.09
14.4	-0.41	-1.10
15.2	-0.41	-1.11
16.0	-0.41	-1.11
16.8	-0.82	-1.13
17.6	-7.42	-1.26
18.4	-8.66	-1.41
19.2	-1.65	-1.44
20.0	-3.71	-1.51
20.8	-2.89	-1.56
21.6	-3.30	-1.61
22.4	-0.82	-1.63
23.2	-0.41	-1.64
24.0	-0.41	-1.64
24.8	-0.82	-1.66
25.6	-0.41	-1.66
26.4	-0.41	-1.67
27.2	-0.41	-1.68
28.0	-0.41	-1.69
28.8	-0.41	-1.69
29.6	-0.41	-1.70
30.4	-0.41	-1.71
31.2	0.00	-1.71
32.0	-0.41	-1.72
32.8	-0.82	-1.73
33.6	-0.41	-1.74
34.4	-0.41	-1.74
35.2	-0.41	-1.75
36.0	-0.41	-1.76
36.8	-0.41	-1.77
37.6	-0.41	-1.77
38.4	-0.41	-1.78
39.2	0.00	-1.78
40.0	1.65	-1.75
40.8	-0.41	-1.76
41.6	-0.82	-1.77
42.4	-0.41	-1.78
43.2	-0.41	-1.79
44.0	-0.41	-1.79

Milliseconds	Long. Acceleration (Gs)	Long. Cumulative Delta V (MPH)
44.8	-0.41	-1.80
45.6	-0.41	-1.81
46.4	-0.41	-1.82
47.2	-0.41	-1.82
48.0	-0.41	-1.83
48.8	-0.41	-1.84
49.6	-0.41	-1.85
50.4	-0.41	-1.85
51.2	-0.41	-1.86
52.0	-0.41	-1.87
52.8	-0.41	-1.87
53.6	-0.41	-1.88
54.4	-0.41	-1.89
55.2	-0.41	-1.90
56.0	-0.41	-1.90
56.8	-0.41	-1.91
57.6	-0.41	-1.92
58.4	-0.41	-1.92
59.2	-0.41	-1.93
60.0	-0.41	-1.94
60.8	-0.41	-1.95
61.6	-0.41	-1.95
62.4	-0.41	-1.96
63.2	-0.41	-1.97
64.0	-0.41	-1.98
64.8	-0.41	-1.98
65.6	-0.41	-1.99
66.4	-0.41	-2.00
67.2	-0.41	-2.00
68.0	-0.41	-2.01
68.8	-0.41	-2.02
69.6	-0.41	-2.03
70.4	-0.41	-2.03
71.2	-0.41	-2.04
72.0	-0.41	-2.05
72.8	-0.41	-2.06