TRANSPORTATION SCIENCES
CRASH DATA RESEARCH CENTER

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REMOTE ADVANCED OCCUPANT PROTECTION SYSTEM INVESTIGATION SCI TECHNICAL SUMMARY REPORT

NASS/SCI COMBO CASE NO. 02-47-111C

SUBJECT VEHICLE – 2003 FORD CROWN VICTORIA

LOCATION - STATE OF ALABAMA

CRASH DATE – SEPTEMBER 2002

Contract No. DTNH22-01-C-17002

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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.

TECHNICAL REPORT STANDARD TITLE PAGE

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16. Abstract This remote investigation focused on the performance of the Advanced Occupant Protection System (AOPS) in a 2003 Ford Crown Victoria police vehicle. The AOPS consisted of dual-stage frontal air bags, a front left seat track sensor, a front right passenger seat sensor for front right passenger air bag suppression, retractor pretensioners, and an Event Data Recorder (EDR). The Crown Victoria was involved in an intersection crash with a 2000 Dodge Intrepid. The crash resulted in moderate frontal damage to the Crown Victoria and was sufficient to deploy the first stage of the driver's air bag and driver's seat belt pretensioner. The Crown Victoria was occupied by a 63-year-old male driver who was restrained by the vehicle's manual 3-point lap and shoulder belt. He initiated a forward and lateral trajectory to the left and loaded the safety belt and driver's air bag. He sustained interview-reported burns on the left aspect of his head and on his left hand (although these injuries were reported as burns, they were probably abrasions associated with air bag expansion). He was transported by ambulance to a local hospital where he was treated and released.			
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BACKGROUND

This remote investigation focused on the performance of the Advanced Occupant Protection System (AOPS) in a 2003 Ford Crown Victoria police vehicle. The AOPS consisted of dual-stage frontal air bags, a front left seat track sensor, a front right passenger seat sensor for front right passenger air bag suppression, retractor pretensioners, and an Event Data Recorder (EDR). The Crown Victoria **(Figure 1)** was involved in an intersection crash with a 2000 Dodge Intrepid. The crash resulted in moderate frontal damage to the Crown Victoria and was sufficient to deploy the first stage of the driver's air bag and driver's seat belt pretensioner. The Crown Victoria was occupied by a 63-year-old male driver who was restrained by the vehicle's manual 3-point lap and shoulder belt. He initiated a forward and lateral trajectory to the left and loaded the safety belt and driver's air bag. He sustained interview-reported burns on the left aspect of his head and on his left hand (although these injuries were reported as burns, they were probably abrasions associated with air bag expansion). He was transported by ambulance to a local hospital where he was treated and released.

Figure 1. Damaged 2003 Ford Crown Victoria

This crash was identified by the National Automotive Sampling System (NASS) PSU 47 during the weekly sampling of Police Accident Reports (PARs). This crash was selected as CDS Case No. 02-47-111C. The NASS PSU performed the vehicle inspection, EDR download, and scene inspection. Due to the presence of the AOPS in the 2003 Ford Crown Victoria, the National Highway Traffic Safety Administration (NHTSA) assigned the tasks of case review and report preparation to the Veridian SCI team.

SUMMARY

Crash Site

This two-vehicle crash occurred during the daylight hours of September 2002. At the time of the crash, there were no adverse weather conditions and the asphalt roadway surface was dry. The crash occurred at a four-leg intersection of two local roadways. The east/west roadway was configured with one travel lane in each direction, separated by a double-yellow centerline. The north/south roadway was also configured with one travel lane in each direction, however, there was no marked centerline. A concrete curb was present on the northwest corner of the intersection. The remaining corners and roadsides were bordered by grass. Traffic flow through the intersection was controlled by stop signs for north/south traffic. The roadside environment

consisted of residential properties and the posted speed limit for both roadways was 32 km/h (20 mph).

Pre-Crash

The 63-year-old male driver of the Ford Crown Victoria was operating the vehicle westbound on approach to the four-leg intersection **(Figure 2)** at a police-reported speed of approximately 32 km/h (20 mph). A 22-year-old male driver of the 2000 Dodge Intrepid was operating the vehicle northbound at a high rate of speed on approach to the four-leg intersection. Police estimated the speed of the Intrepid to be 97 km/h (60 mph). The driver of the Intrepid disregarded the stop sign and proceeded into the intersection across the path of the Crown Victoria. The driver of the Crown Victoria did not attempt any avoidance maneuvers prior to the crash.

Figure 2. Westbound approach for the Crown Victoria

Crash

The front aspect of the Crown Victoria impacted the right side aspect of the Dodge Intrepid. Impact resulted in moderate damage to both vehicles and was sufficient to deploy the redesigned frontal air bags in the Intrepid and the driver's air bag in the Crown Victoria. The damage algorithm of the WinSMASH program calculated a total delta-V of 21 km/h (13 mph) for the Crown Victoria and a total delta-V of 23 km/h (14 mph) for the Intrepid. The longitudinal and lateral components for the Crown Victoria were -7 km/h (-4 mph) and 20 km/h (12 mph), respectively. The longitudinal and lateral components for the Intrepid were -22 km/h (-14 mph) and -8 km/h (-5 mph), respectively. The EDR maximum-recorded longitudinal velocity change for the Crown Victoria was 3.74 km/h (2.33 mph). Based on the longitudinal crash pulse data represented by the graph from the EDR output, the Restraint Control Module (RCM) anticipated a significant increase in the delta-V based on the acceleration pulse, and commanded a first-stage driver's air bag deployment. However, according to the graph, the delta-V did not increase as expected. The EDR summary is included in **Appendix A** at the end of this report.

Figure 3. Northbound approach for the 2000 Dodge Intrepid

The Crown Victoria rotated approximately 90 degrees in a clockwise (CW) direction, and came to rest facing north in the northwest quadrant of the intersection. The Intrepid was deflected onto the southbound lane as it continued in a north direction through the intersection. The Intrepid departed the left roadside over a concrete curb and sideswiped a tree with the left side aspect. The tree impact redirected the Intrepid in a counterclockwise (CCW) rotation back onto the roadway. The Intrepid came to rest facing southwest on the northbound lane.

Post-Crash

The driver of the Crown Victoria exited the vehicle under his own power. He was transported by ambulance to a local hospital where he was treated and released. It was not known how the occupants of the Intrepid exited the vehicle. The occupants of the Intrepid did not sustain injury and were not transported to a medical facility.

VEHICLE DATA – 2003 Ford Crown Victoria

The 2003 Ford Crown Victoria was identified by the Vehicle Identification Number (VIN): 2FAFP71WX3X (production sequence omitted). At the time of the vehicle inspection the odometer read 8,967 km (5,572 miles). The vehicle was configured with the Police Interceptor package which included a 4.6L overhead cam SEFI V8 engine, an electronically controlled automatic transmission with overdrive and transmission oil cooler, heavy duty frame, steering gear, body mounts and suspension, power 4-wheel disc brakes with anti-lock braking system (ABS), power-assisted, speed sensitive steering, and a Personal Safety System™, which included dual stage front air bags, safety belt pretensioners, a front left seat track sensor, and a front right seat position weight sensor.

An aftermarket center console was installed between the front bucket seats that extended forward to the center instrument panel. The center console was anchored to the floor and housed two-way radio equipment, siren controls, and emergency warning light controls. A radar unit and display module was mounted on the top aspect of the center instrument panel. A video camera was mounted on the windshield header to the right of the rear view mirror and the controls were located on the center aspect of the front headliner. A full-width safety cage with center sliding plexiglass doors was installed between the front seat backs and the rear seating area. Vertical bars were present on the interior window frames of the both rear doors.

The Crown Victoria was equipped with Goodyear Eagle RS-A Plus P225/60R16 tires. The specific tire data is summarized as follows:

Tire	Measured Pressure	Tread Depth	Restricted	Damage
LF	221 kpa (32 psi)	8 mm (10/32”)	No	None
LR	228 kpa (33 psi)	8 mm (10/32”)	No	None
RF	221 kpa (32 psi)	6 mm (8/32”)	No	None
RR	228 kpa (33 psi)	7 mm (9/32”)	No	None

The front seating positions in the Crown Victoria were configured with bucket seats with adjustable head restraints. At the time of the vehicle inspection, both front seats were positioned at the mid-track position, both head restraints were in the full-down position, and both seat backs were upright. The rear seating positions were configured with a single bench seat. There were no head restraints on the rear seat back and tether anchors for child safety seats were present on the rear deck behind each seating position.

VEHICLE DAMAGE

Exterior Damage – *2003 Ford Crown Victoria*

The 2003 Ford Crown Victoria sustained moderate frontal damage as a result of the impact with the Dodge Intrepid. The direct contact damage involved the entire frontal width of the vehicle **(Figures 4 and 5)**. The combined direct and induced damage measured 79 cm (31") across the bumper beam and the maximum crush measured 57 cm (22") and was located at C2. The left fender and left frame rail were pulled inward as a result of the Intrepid's momentum across the front of the Crown Victoria. The lateral displacement measured approximately 51 cm (20") at the forward edge of the left front fender. The hood was displaced to the right and buckled rearward and upward on the right side. Direct contact abrasions were present on the leading edge of the left corner of the hood. The grille, bumper fascia, and head lamps were separated from the vehicle. Six crush measurements were documented along the front bumper beam of the Crown Victoria and were as follows: C1 = 45 cm (18"), C2 = 57 cm (22"), C3 = 56 cm (22"), C4 = 36 cm (14"), C5 = 22 cm (9"), C6 = 8 cm (3"). The Collision Deformation Classification (CDC) for the frontal impact with the Dodge Intrepid was 10-FDEW-2.

Figure 4. Front left view of damaged Crown Victoria

Figure 5. Front right view of damaged Crown Victoria

Interior Damage – *2003 Ford Crown Victoria*

Interior damage to the Ford Crown Victoria was minor **(Figure 6)**. There was no integrity loss and no damage to the laminated windshield or vehicle glazing. There was no passenger compartment intrusion. Occupant contact was identified on the left front door armrest from probable interaction with the driver's left arm.

Figure 6. Interior view of the Crown Victoria

Exterior Damage – *2000 Dodge Intrepid*

The 2000 Dodge Intrepid sustained moderate damage **(Figures 7 and 8)** as a result of the right side impact with the Crown Victoria and minor damage from the post-crash curb impact and tree impact. The direct damage from the impact with the Crown Victoria began 157 cm (62”) forward of the axle on the right side plane and extended forward 225 cm (89”) to the right front corner. The front bumper fascia was fractured outboard of the right side of the bumper beam. The right front fender was crushed and displaced rearward. The right front wheel was displaced rearward, outward, and was partially separated. The right front tire sustained a tear in the sidewall and partial sidewall separation from the impact. The right front wheel rim was deformed from the impact and the front right tire was flat. At the time of the vehicle inspection, the right front wheel was positioned outboard of the right front fender and the rear aspect of the wheel was adjacent to the right A-pillar. The rearward displacement of the right front wheel against the lower right A-pillar resulted in induced longitudinal crush and deformation to the leading edge of the right front door. Contact abrasions were present on the right front fender and right front door panel from contact with the front aspect of the Crown Victoria. Six crush measurements were taken along the right side plane of the Intrepid at the lower door level and were as follows: C1 = 5 cm (2”), C2 = 14 cm (6”), C3 = 6 cm (2”), C4 = 8 cm (3”), C5 = 4 cm (2”), C6 = 0 cm. The CDC for the impact with the Crown Victoria was 01-RYEW-2.

Figure 7. Front right view of damaged Dodge Intrepid

Figure 8. Close-up of right front damage

The secondary impact with the concrete curb resulted in a small fracture and abrasion on the left front wheel cover and scuffing on the sidewall of the left front tire. from contact with the curb. The CDC for the curb impact was 12-FLWN-3.

The left side impact with the tree resulted in minor damage to the left side aspect. The direct damage began 129 cm (51”) forward of the left rear axle and extended 216 cm (85”) rearward along the left side plane. Pieces of tree bark were present in the left rear wheel rim and the left rear wheel cover was deformed from direct contact. The left lower corner of the rear bumper fascia was fractured and abraded. Longitudinal abrasions were present on the left rear door and left rear quarter panel from direct contact with the tree. The CDC for the tree impact was 12-LZES-1.

MANUAL RESTRAINT SYSTEMS – 2003 Ford Crown Victoria

The 2003 Ford Crown Victoria was equipped with manual 3-point, continuous loop, lap and shoulder belts with sliding latch plates. The driver's safety belt **(Figure 9)** was configured with a belt-sensitive, emergency locking retractor (ELR). The remaining safety belts were configured with belt-sensitive, switchable ELR/automatic locking retractors (ALR). The front seat manual restraints utilized adjustable D-rings that were both in the full-down positions. The rear outboard restraints retracted into the inboard aspects of the C-pillars, and the center safety belt retracted into the retractor housing located on the center aspect of the rear deck above the seat back.

Figure 9. View of driver's safety belt in the Crown Victoria

The front safety belts were equipped with retractor pretensioners that were designed to fire in conjunction with the frontal air bag system. "The System Status At Deployment" section of the EDR summary displayed the status of both pretenioners as "Fire," but the pretensioner timing information was not displayed. Both safety belts were operational at the time of the vehicle inspection, and due to the position of the retractor pretensioners, the post-crash pretensioner status could not be confirmed.

The driver of the Crown Victoria was utilizing the manual restraint at the time of the crash, based on the EDR output and interview. Loading evidence to the restraint system could not be determined from the available photographs.

FRONTAL AIR BAG SYSTEM – 2003 Ford Crown Victoria

The 2003 Ford Crown Victoria was equipped with dual-stage frontal air bags for the driver and front right passenger positions. The air bag system was equipped with a front left seat track position sensor. The front right seat was equipped with a sensor in the front right passenger seat cushion that was designed to suppress the front right passenger's air bag based on the weight of the front right occupant. The EDR "System Status At Deployment" section showed an air bag "Fire" command for Unbelted Stage 1 and Belted Stage 1, which suggested that the first stage of the driver's air bag would have deployed whether or not the driver was utilizing the safety belt. Given the restraint usage by the driver and the unoccupied front right seat, the EDR summary supports the vehicle inspection findings of the deployed driver's air bag only. The EDR summary is included in **Appendix A** at the end of this report.

Figure 10. View of the deployed driver's air bag

The driver's air bag **(Figure 10)** was housed in the center of the steering wheel. The module was configured with a single cover flap that measured 10 cm (4") in width at the top aspect, 18 cm (7") in width at the bottom aspect, and 12 cm (5") in height. The driver's air bag measured 56 cm

(22”) in diameter in its deflated state. There was no contact evidence present on the air bag. The air bag was tethered by four internal straps and was vented by two circular ports located at the 11 and 1 o’clock positions on the rear aspect of the air bag.

The front right passenger’s air bag did not deploy in this crash. Since the front right passenger’s seat was equipped with a weight sensor, it is likely that the unoccupied status of the front right passenger’s seat suppressed the deployment of the front right passenger’s air bag.

OCCUPANT DEMOGRAPHICS – 2003 Ford Crown Victoria

Driver

Age/Sex:	63-year-old male
Height:	173 cm (68”)
Weight:	91 kg (201 lb)
Seat Track Position:	Mid-track
Manual Restraint Use:	3-point lap and shoulder belt
Usage Source:	EDR output, driver interview
Eyewear:	Sunglasses
Type of Medical Treatment:	Transported by ambulance to a local hospital and treated and released

Driver Injuries

Injury	Injury Severity (AIS 90/Update 98)	NASS Injury Mechanism
Burn on left side of head	Minor (192002.1,2)	Air bag exhaust gases*
Burn on left hand	Minor (792002.1,2)	Air bag exhaust gases*

Injury source: Driver interview

*See Driver Kinematics section

Driver Kinematics

The 63-year-old male driver of the Crown Victoria was seated in an upright posture with the seat adjusted to the mid-track position. He was restrained by the manual 3-point lap and shoulder belt. At impact with the Intrepid, the driver’s air bag deployed (first stage deployment) and the retractor pretensioner fired. The driver initiated a forward and lateral trajectory in response to the 1 o’clock impact force and loaded the safety belt. His face probably contacted the deployed driver’s air bag, which offered additional protection from the frontal crash forces. During the NASS interview, the driver reported sustaining burns to the left aspect of his head and left hand. Official medical records for the driver were not available. The driver’s NASS-coded injuries included a first-degree burn on the left aspect of his head and a first-degree degree burn on his left hand from air bag exhaust gases. The air bag was vented through ports located on the upper rear aspect of the air bag, and given the restraint usage by the driver, thermal burns from air bag gases venting through the ports were unlikely. Based on SCI experience, the driver’s injuries were probably abrasions that resulted from interaction of the expanding air bag against his left hand, and the left aspect of his head contacting the membrane as he loaded the air bag. There were no official medical records available, and based on NASS Coding Protocols, burns were coded based on interview data. He was redirected to the left as the vehicle rotated to final rest

and exited the vehicle under his own power. He was transported by ambulance to a local hospital where he was treated and released.

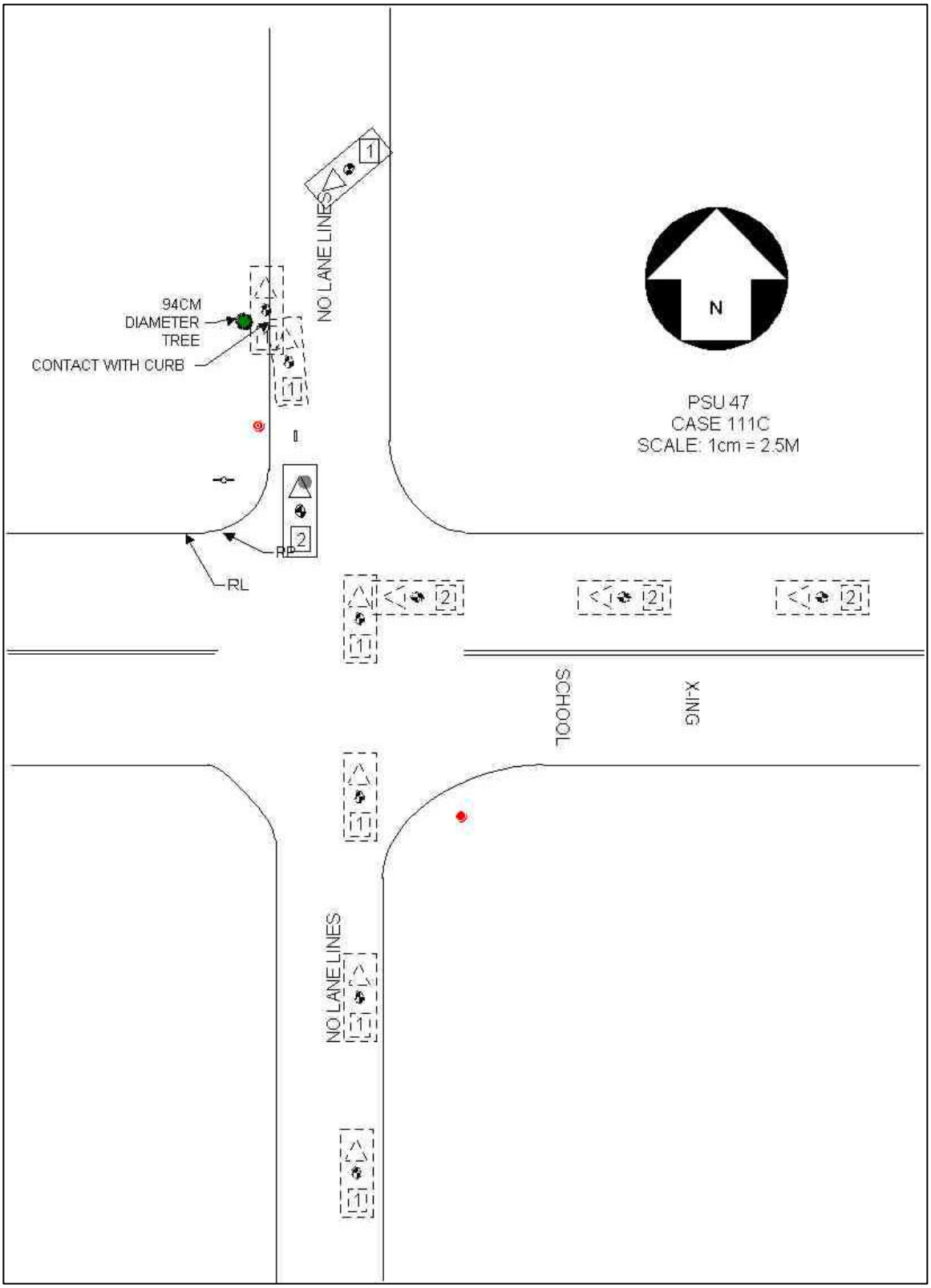

Figure 11. NASS scene schematic

APPENDIX A – EDR OUTPUT

2FAFP71WX3X	System Status At Deployment
Ford Part Number Prefix	3W7A
Number Of Active Faults	0
Driver Seat Belt Buckle	Buckled
Passenger Seat Belt Buckle	Unbuckled
Driver Seat Track In Forward Position	No
Occupant Classification Status Value	Empty
Unbelted Stage 1	Fire
Unbelted Stage 2	No Fire
Belted Stage 1	Fire
Belted Stage 2	No Fire
Driver Pretensioner	Fire
Passenger Pretensioner	Fire

Parameter	Driver	Passenger
Pretensioner Time (milliseconds)	40.8	NONE
First Stage Time (milliseconds)	40.8	NONE
Second Stage Time (milliseconds)	140.8	NONE