On-scene Investigation / Vehicle to Vehicle
Vehicle defect / Fire
Dynamic Science, Inc. / Case Number: DS02025
2000 Crown Victoria Police Interceptor
California
November, 2002

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

Technical Report Documentation Page

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16. Abstract

This crash occurred in November, 2002 at 0130 hours. The crash occurred in the southbound lanes of a divided municipal roadway approaching a four leg intersection. The weather was clear and dry and the asphalt roadway was level. The intersection is controlled by tri-color traffic signals. The speed limit for southbound traffic is 64 km/h (40 mph). The case vehicle, a 2000 Ford Crown Victoria Police Interceptor four-door sedan driven by a restrained 32-year-old male police officer, was initially traveling south and had stopped for a red light. The front right seat was occupied by a restrained 33-year-old male police officer. The other vehicle, a 2002 Hyundai Sonata four-door sedan driven by a 39-year-old male, was traveling behind the case vehicle at a police estimated speed of 56-64 km/h (35-40 mph). As the case vehicle stopped, it was rear-ended (06BDEW4) by the front of the other vehicle (12FDEW1). There was no pre-impact braking. The case vehicle was pushed forward into the intersection. The gas tank was penetrated by a crowbar in the trunk of the case vehicle and gasoline began leaking from the vehicle. Both occupants of the case vehicle were rendered unconscious. After some brief unknown period of time, the front right occupant regained consciousness. He found the driver slumped over and unconscious. This occupant saw that the case vehicle had caught on fire. He exited the vehicle from the right side and went to the left side and pulled the driver from the vehicle. The fire intensified and the vehicle was engulfed.

17. Key Words	18. Distribution Statement
Crown Victoria, fuel, fire, defect, injury,	

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Dynamic Science, Inc.
Accident Investigation
Case Number: DS02025

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BACKGROUND:

Description: This Office of Defects (ODI) fire case was identified through a newspaper article dated November 13, 2002. DSI was assigned the case on November 13, 2002. This case was conducted as an on-scene investigation. The vehicle inspections took place on November 20, 2002. In attendance at the inspection were members of the investigating police agency, representatives of the municipal maintenance facility, a representative from Ford, and various service technicians. The case vehicle make/model has been the subject of an ODI investigation (SQ01-014) regarding "Post Rear End Collision Fires"[1]. It should be noted that the second vehicle in this case was equipped with Advanced Occupant Protection System (AOPS) features.

Investigation Type:	On-scene
Crash Location:	California
Crash Date:	November, 2002
Notification Date:	November 13, 2002
Field Work Completed:	November 20, 2002

SUMMARY:

This crash occurred in November, 2002 at 0130 hours. The crash occurred in the southbound lanes of a divided municipal roadway approaching a four leg intersection. For the northern leg of the intersection there are three southbound through lanes, one left turn lane, a raised concrete median, and three northbound through lanes. The roadway is bordered on the east and west by raised concrete curbs. The weather was clear and dry and the asphalt roadway was level. The intersection is controlled by tri-color traffic signals. The speed limit for southbound traffic is 64 km/h (40 mph).

Figure 1. Approach to area of impact

[1]See Attachment 1

The case vehicle, a 2000 Ford Crown Victoria Police Interceptor four-door sedan driven by a restrained 32-year-old male police officer, was initially traveling south and had stopped for a red light. The front right seat was occupied by a restrained 33-year-old male police officer. Restraint use is based on information provided in the police report. This vehicle was equipped with a driver's air bag and a front right passenger air bag.

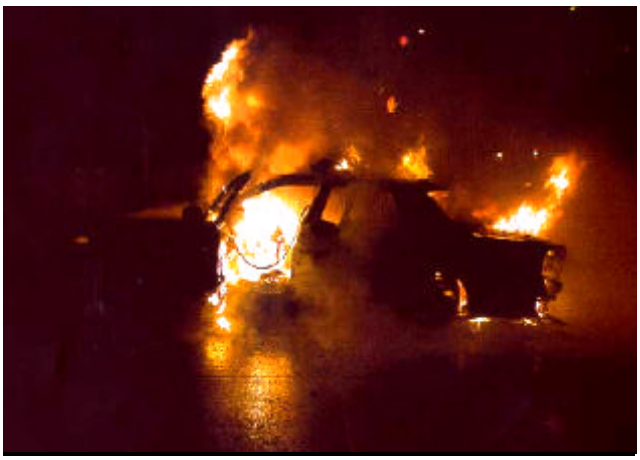

Figure 2. Case vehicle, on scene

The other vehicle, a 2002 Hyundai Sonata four-door sedan driven by a 39-year-old male, was traveling behind the case vehicle at a police estimated speed of 56-64 km/h (35-40 mph). This contractor estimates the pre-crash travel speed to be 66 km/h (41 mph)[2]. The Sonata is an AOPS equipped vehicle. The vehicle was equipped with a driver's air bag, front right passenger air bag, a seat mounted driver's side air bag, and a seat mounted passenger side air bag. The front seats were equipped with seat belt pretensioners. The right seat was equipped with Hyundai's "Passenger Presence Detection System" that will disable the passenger air bag if there is insufficient weight on the seat bottom.

Figure 3. Left side, case vehicle

As the case vehicle stopped, it was rear-ended (06BDEW4) by the front of the other vehicle (12FDEW1). There was no pre-impact braking. The case vehicle was pushed forward into the intersection. The total velocity change for the case vehicle calculated by the damage algorithm of the WinSmash collision model was 28 km/h (17 mph). The longitudinal and lateral delta v components were 28 km/h (17 mph) and 0 km/h (0 mph), respectively. The total velocity change for the other vehicle was 41 km/h (26 mph). The longitudinal and lateral delta v components were -41 km/h (-26 mph) and 0 km/h (0 mph), respectively. The results appear high.

[2]See Attachment 2. Calculations

Both occupants of the case vehicle were rendered unconscious. After some brief unknown period of time, the front right occupant regained consciousness. He found the driver slumped over and unconscious. This occupant saw that the case vehicle had caught on fire. He exited the vehicle from the right side and went to the left side and pulled the driver from the vehicle. The fire intensified and the vehicle was engulfed.

Figure 4. Right rear, case vehicle

The driver of the case vehicle sustained a concussion (with a loss of consciousness), a contusion to the back of his head, and a cervical strain. He complained of lower back pain. As he was pulled from the vehicle he sustained a right knee contusion, a laceration to his upper lip, and abrasions/contusions to his left hand. He was transported by ground ambulance to a local hospital for treatment. He was hospitalized overnight.

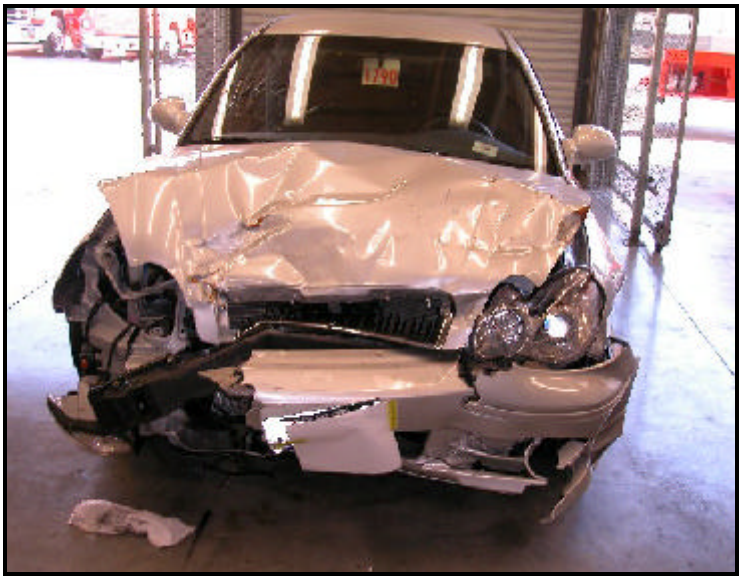

Figure 5. Front, other vehicle (Sonata)

The front right occupant sustained a concussion (with loss of consciousness), an abrasion to the back of his head, and a cervical strain. He complained of lower back pain. He was transported by ground ambulance to a local hospital where he was treated and released.

It appears likely that both occupants struck the head restraintswith the backs of their head–causing the unconsciousness.

The driver of the other vehicle complained of pain to his chest. He was transported to a local hospital. It is unknown if he received any treatment.

Scene Diagram

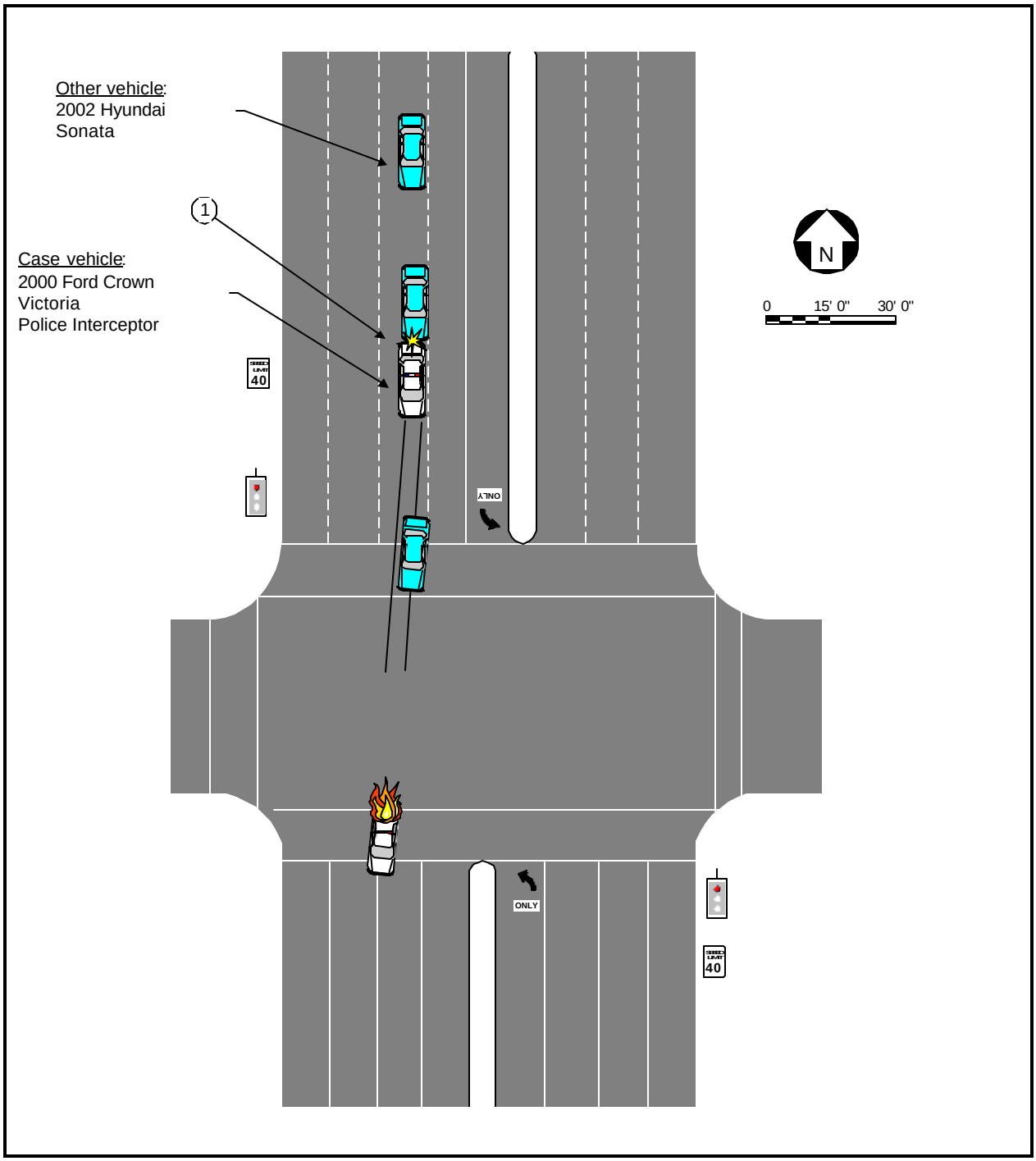

Figure 6. Scene diagram

DETAILED INFORMATION

Vehicles

Case vehicle

Description:	2000 Crown Victoria Police Interceptor	
VIN:	2FAFP71W3YXxxxxxx	
Odometer:	Unknown	
Engine:	4.6 L V8	
Reported Defects:	See Attachment 1 for discussion of fuel tank issues.	
Cargo:	Computer CPU, radios, weapons, search and rescue kit.	
Damage Description:	Major crush to rear bumper reinforcement bar, trunk, and right rear fender. Fire damage over rear 2/3 of vehicle.	
CDC:	06BDEW4	
Delta V:	Total	28 km/h (17 mph)[3]
	Longitudinal	28 km/h (17 mph)
	Latitudinal	0 km/h (0 mph)
	Energy	125,928 joules (95,415 ft-lbs)

The case vehicle was equipped for use by police agencies. It is designed with Ford's full-size "Panther" platform–a body on frame design undergirds the Ford Crown Victoria, Mercury Grand Marquis, and Lincoln Town Car. The Panther fuel tank is steel construction and has a usable capacity of 71 L (19 gallons). The system is equipped with a fill limiting feature to provide an air space of 12-14 percent at full capacity. The tank is positioned aft and slightly above the vertical centerline of the rear axle. In essence, the fuel tank is sandwiched between the rear axle and the forward trunk wall. It is estimated that approximately 17 gallons of fuel was in the fuel tank at the time of the crash (see Attachment 3). The rear seats are comprised of a plastic composite and are separated from the front seats by a clear plastic partition. The rear trunk area contains a computer CPU, the service radio, and a shotgun mounted horizontally near the rear trunk edge. In addition, the trunk for the case vehicle contained a less-lethal shotgun, ammunition, handgun ammunition, manuals, flares, forms, and an SOS

[3]Results appear high

Emergency Search and Rescue Kit containing urban rescue equipment. The following items were in the black polyester bag[4]: 2 hard hats, 4 pair of leather gloves, goggles, dust masks, 2 utility knives, 2 flashlights with batteries, 2 orange safety vest, light sticks, duct tape, rope, barricade tape, triage tags, 2 whistles, and a 61 cm (24 in) long wrecking bar (see Figure 13). The bag had been positioned in the trunk to the right. The wrecking bar was placed in the bag so that the curved end faced the rear of the vehicle and the pointed end faced the front of the vehicle.

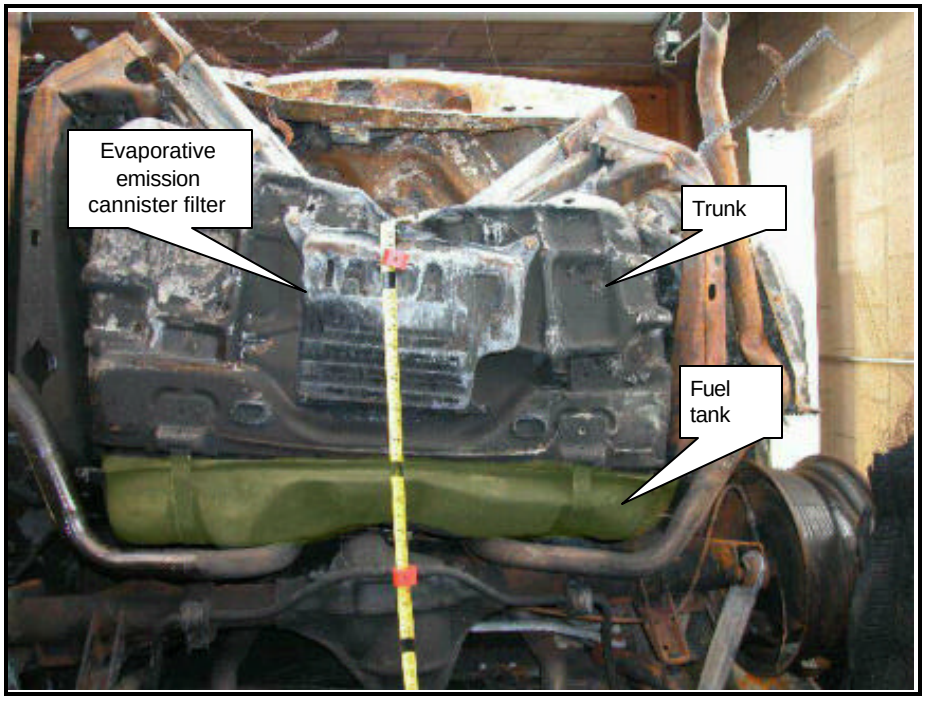

Figure 7. Under side of case vehicle

The rear 2/3 of the case vehicle was damaged by the fire. The interior was completely gutted. The trunk compartment was badly burned, however, the flares and ammunition were not damaged. This vehicle sustained approximately 118 cm (47 in) of direct contact damage that extended across the middle and right of the vehicle's rear bumper. The rear bumper reinforcement bar was rotated upwards. The residual crush measured along the bar was as follows: C1=16 cm (6 in), C2=41 cm (16 in), C3=69 cm (27 in), C4=69 cm (27 in), C5=54 cm (21 in), C6=50 cm (20 in). The maximum crush was located 6 cm (2 in) right of C3 and measured 75 cm (30 in). The principle direction of force was within the 6 o'clock sector and was an estimated 180 degrees. The damaged components (from the crash) included the bumper fascia and reinforcement bar, trunk lid, and rear fenders. There was a 10 cm (4 in) reduction of the right wheelbase. Both front doors remained closed and operational. The rear doors were locked and could not be opened. The controls to unlock the rear doors are in the front of the vehicle and were not operating at the time of the inspection. It does appear, however, that the right rear door would have been jammed shut due to the impact.

[4]Per SOS Survival Products web page: http://ww.sossurvicalproducts.com

Vehicle fire discussion

The case vehicle had been fueled two hours prior to the crash. The officers handled several service calls and traffic stops during this time period. The driver estimated that the engine was running for 1.5 hours–a combination of city speeds patrolling and parked idling. This contractor estimates[5] that the vehicle used 2 gallons of gasoline during this period, leaving 17 gallons on board.

Shortly after the vehicle came to rest it caught on fire. The fire was a result of fuel leakage from two punctures to the right side of the fuel tank. The puncture to the front of the tank was 2.4 cm (0.9 in) wide. It was located 9.0 cm (3.5 in) from the bottom of the tank and 2.4 cm (0.9 in) from the right side. The puncture to the rear of the tank was 3 cm (1.2 in) wide. It was located 7.7 cm (3.0 in) from the bottom of the tank and 2.0 cm (0.8 in) from the right side. The punctures occurred as the wrecking bar was forced forward. The blade end of the bar penetrated the front of the trunk, penetrated the back of the fuel tank, and then penetrated the front of the fuel tank. As restitution took place, the bar was drawn backward–leaving the front puncture open. Fuel flowed out of the two holes–primarily the front hole and began pooling on the ground. DSI estimates that the fuel would have flowed out of the tank at a rate of between 15 and 19 liters (4 and 5 gallons) per minute. At this point, the gasoline ignited. The ignition source is not known for sure, but it was likely related to sparks from dragging metal components. There were no indications of any crash related damage to the fuel lines or the tank filler pipe.

Figure 8. Puncture to back of fuel tank

Figure 9. Shows wrecking bar exiting trunk (left) and penetrating back of fuel tank (right).

Figure 10. Close up of puncture to back of fuel tank(entry)

[5]See Attachment 3

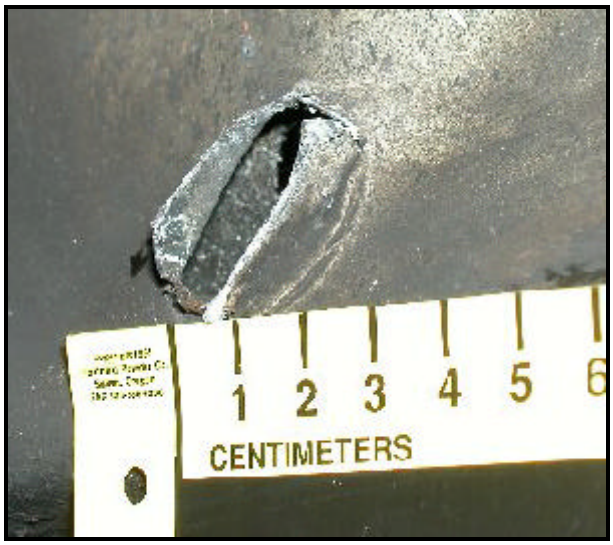

Figure 11. Puncture to front of fuel tank (exit)

Figure 12. Wrecking bar

Figure 13. Close up of wrecking bar

Figure 14. Side view of fuel tank showing entry and exit points

Figure 15. Interior views of undamaged police equipped Crown Victoria

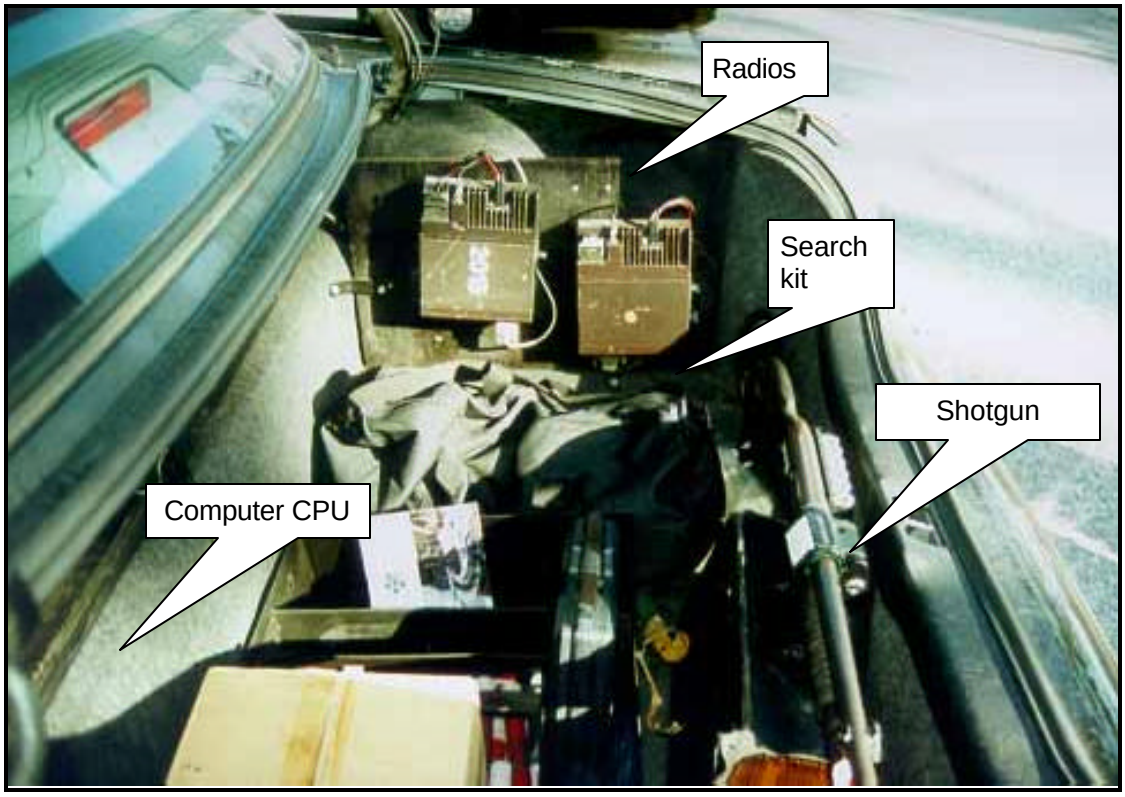

Figure 16. View shows typical trunk contents

Other vehicle

Description:	2002 Hyundai Sonata four-door	
VIN:	KMHWF25S92Axxxxxx	
Odometer:	13,112 km (8,148 miles)	
Engine:	2.4 L, 4 cylinder	
Reported Defects:	None noted[6]	
Cargo:	None	
Damage Description:	Moderate frontal crush to bumper, grille, radiator supports, and hood. Vehicle towed from the scene due to damage.	
CDC:	12FDEW1	
Delta V:	Total	41 km/h (26 mph)[7]
	Longitudinal	-41 km/h (-26 mph)
	Latitudinal	0 km/h (0 mph)
	Energy	35.694 joules (26,327 ft-lbs)

The other vehicle sustained 117 cm (46 in) of direct contact damage beginning at the right front bumper corner. The residual crush measured along the exposed areas of the reinforcement bar was as follows: C1=10 cm (4 in), C2=13 cm (5 in), C3=24 cm (9 in), C4=23 cm (9 in), C5=9 cm (3 in), C6=0 cm (0 in). The maximum crush was located at C3. The principle direction of force was within the 12 o'clock sector and was an estimated 0 degrees.

Figure 17. Front, other vehicle (Sonata)

[6]Hyundai Motor America recalled Sonatas manufactured between June 2001 – February 2002 for possible inadvertent side air bag deployments. This vehicle had a manufacture date of March, 2002.

[7]Results appear high

The damaged components included the bumper facia and reinforcement bar, hood, grille, and radiator. There was no glazing damage and all doors remained closed and operational.

Safety Systems discussion

The Hyundai Sonata was equipped with a steering wheel mounted driver's air bag, front right passenger air bag, a seat back mounted driver's side impact air bag, and a seat back mounted passenger side impact air bag. The front seats were equipped with seat belt pretensioners. The right seat was equipped with Hyundai's "Passenger Presence Detection System" that will disable the passenger air bag if there is insufficient weight on the seat bottom. At impact, the driver's seat belt pretensioner did fire, the right side pretensioner did not. No air bags deployed.

Figure 18. Driver's seated position

Occupants

Case vehicle	Occupant 1	Occupant 2
Age/Sex:	32/Male	33/Male
Seated Position:	Front left	Front right
Seat Type:	Bucket, unknown track position	Bucket, unknown track position
Height:	180 cm (71 in)	178 cm (70 in)
Weight:	86 kg (190 lbs)	73 kg (160 lbs)
Occupation:	Police officer	Police officer
Pre-existing Medical Condition:	None noted	None noted
Alcohol/Drug Involvement:	None	None
Driving Experience:	> 10 years	NA
Body Posture:	Normal, upright	Normal, upright
Hand Position:	Both hands on steering wheel	Unknown
Foot Position:	Right foot on brake, left on floorboard	Both feet on floorboard
Restraint Usage:	Continuous loop 3-point lap and shoulder belt available, used	Continuous loop 3-point lap and shoulder belt available, used
Air bag:	Steering wheel mounted air bag available, did not deploy	Top instrument panel mounted air bag available, did not deploy

Other vehicle

Age/Sex:	39/Male
Seated Position:	Front left
Seat Type:	Bucket,
Height:	170 cm (67 in)
Weight:	68 kg (150 lbs)
Occupation:	Unknown
Pre-existing Medical Condition:	None noted
Alcohol/Drug Involvement:	Alcohol test given, results not known.
Driving Experience:	Unknown
Body Posture:	Unknown
Hand Position:	Unknown
Foot Position:	Right presumed to be on accelerator, left on floor board. Witness did not report any pre-impact braking.
Restraint Usage:	Continuous loop 3-point lap and shoulder belt available, used. Pretensioner fired.

Injuries and Injury Mechanisms

Case vehicle

	INJURY	OIC CODE	SOURCE
Driver:	Concussion, unconsciousness < 1 hour[8]	160202.2,0	Head restraint
	Contusion, back of head	190402.1, 0	Head restraint
	Neck strain	640278.1,6	Head restraint
	Injuries from post-crash fall from vehicle: right knee contusion, lip laceration, and abrasion/contusion to left hand.		
Front right ocucpant:	Concussion, unconsciousness < 1 hour	160202.2,0	Head restraint
	Neck strain	640278.1,6	Head restraint

Other vehicle

	INJURY
Driver:	Complained of pain to chest

[8]Based on doctor statement to officer as reported to his superior officer

Occupant Kinematics

The 32-year-old male driver of the case vehicle was seated in normal, upright fashion. His right foot was on the brake, the left on the floorboard. The bucket seat was slightly reclined; its track position is not known. He was wearing the available 3-point lap and shoulder belt. At impact, he responded to the 180 degree direction of force by moving rearward and engaged the head restraint with the back of his head–causing the concussive injury, head contusion, and neck strain. The head restraint likely struck the rear seat partition given its proximity to the partition. This would have made the head rest stiffer and the impact more severe. The front right passenger indicated that the driver came to rest against the steering wheel due to rebound.

The 33-year-old male front right passenger of the case vehicle was seated in a normal, upright fashion. The bucket seat was slightly reclined; its track position is not known. He was wearing the available 3-point lap and shoulder belt. At impact, he responded to the 180- degree direction of force by moving rearward and engaged the head restraint with the back of his head–causing the concussive injury and neck strain.

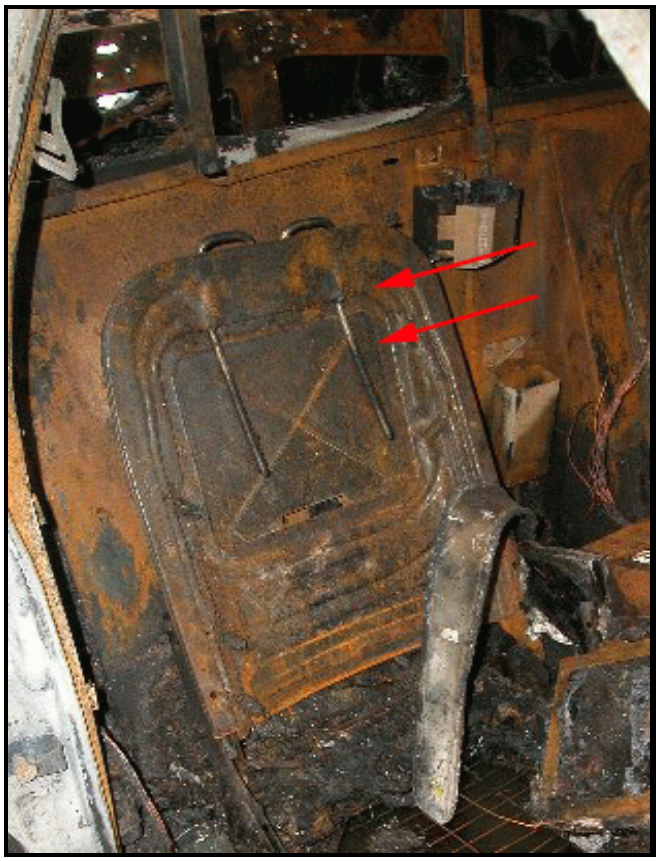

Figure 19. Front right seat–head restraint was in up position during the fire

Attachment 1. Rear end collision fires

Post Rear End Collision Fires

ODI opened an investigation (SQ01-014) regarding "Post Rear End Collision Fires" on November 27, 2001. The investigation focused on the Ford Crown Victoria, Mercury Grand Marquis, and Lincoln Town Car for model years 1992-2001. The investigation was prompted by Ford Technical Service Bulletin (TSB) No. 01-21-14 consumer complaints. The problem description was as follows: "The fuel tank can rupture following a high-energy rear collision resulting in severe fires. A vehicle occupant surviving the impact trauma could be killed as a result of fire intrusion into the passenger compartment." The investigation was closed on October 3, 2002.

The case vehicle had undergone the modifications indicated in the Ford TSB.

FMVSS 301 (for rear impact)

FMVSS 301 requires that a stationary vehicle withstand an impact with a flat 1,814 kg (4,000 lbs) barrier moving at 48 km/h (30 mph) and leak fuel in excess of 28 g (1 oz) from impact until motion of the vehicle has ceased. Additionally, the vehicle shall not leak fuel in excess of 142 g (5 oz) in the 5-minute period following cessation of motion.

Attachment 2. Speed Calculations

Conservation of linear momentum calculation.

CASE NUMBER: DS02025

Comments: Front to rear - V2 = Crown Victoria, V1 = Sonata

*** * LINEAR MOMENTUM * ***

W1 × V1 + W2 × V2 = W1 × V3 + W2 × V4
3216.00 × V1 + 3796.00 × 0.00 = 3216.00 × 5.84 + 3796.00 × 29.83
3216.00 × V1 + 0.00 = 18781.44 + 113234.68
3216.00 × V1 + 0.00 = 132016.12
3216.00 × V1 = 132016.12 - 0.00
3216.00 × V1 = 132016.12

$$V1 = \frac{132016.12}{3216.00}$$

V1 = 41.04

W1 = The Wt of Veh 1 in Pounds.
W2 = The Wt of Veh 2 in Pounds.
V1 = The Speed of Veh 1 in MPH.
V2 = The Speed of Veh 2 in MPH.
V3 = The Spd After Impact, Veh 1.
V4 = The Spd After Impact, Veh 2.

INPUTS:	
The Wt of Veh 1 in Pounds is:	3216.00
The Min. Spd After Impact, Veh 1 is:	5.84
The Wt of Veh 2 in Pounds is:	3796.00
The Impact Spd of Veh 2 is:	0.00
The Min. Spd After Impact, Veh 2 is:	29.83

RESULTS:	
The Spd of Veh 1 in MPH is:	41.04
The Vel of Veh 1 in FPS is:	60.16

AIS V2	Speed
20.00	29.44
25.00	35.34
30.00	41.25
35.00	47.15
40.00	53.05

INCREMENTATION CALC's:

AIS V2	Speed

AR Pro, Ver. 6.14: © Since 1994, Maine Computer Group.

Crown Victoria	
59 ft skid, f=0.7, 70% braking	29.4 mph
43 ft travel to final rest, engine braking=0.02	5.07 mph
Combined speed, post crash speed	29.8 mph
Hyundai	
57 ft travel from impact to final rest, engine braking=0.02	5.84 mph

Attachment 3. Gas consumption calculation

Estimated average speed (patrolling/idling)		hours	Miles traveled	MPG (per DOE)	Fuel used
35	17.5	1.5	26.25	15	1.75