Rear Seat Occupant Protection Investigation / Vehicle to Object
Dynamic Science, Inc. / Case Number: DS05006
1998 Ford Escort
Washington
April 2005

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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.

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16. Abstract

This on-site investigation focused on the performance of the lap seat belt that was installed in the middle rear seat position of a 1998 Ford Escort. The occupant seated in this position was fatally injured. The Ford Escort was occupied by a total of five occupants. All the outboard occupants were using the available lap and shoulder belts. The second row middle occupant was using the available lap belt. The Ford Escort was traveling on a two-lane roadway approaching a sharp, left hand curve. The Escort departed the roadway and struck a tree with its front end. The impact resulted in sufficient longitudinal deceleration of the Escort to command the deployment of the frontal air bag system. The Escort rebounded slightly and came to rest near the tree. The driver, front right occupant and second row left occupant sustained moderate injuries and were transported by ground ambulance to an area hospital for treatment. The second row right occupant sustained serious abdominal injuries and was transported by air to an area trauma center for treatment. The second row middle occupant was transected at the waist area by the lap belt and died moments after the crash.

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Dynamic Science, Inc.
Accident Investigation
Case Number: DS05006

TABLE OF CONTENTS

Background

Figure 1. Front right, 1998 Ford Escort

This on-site investigation focused on the performance of the lap seat belt that was installed in the middle rear seat position of a 1998 Ford Escort. The occupant seated in this position was fatally injured. The Ford Escort was occupied by a total of five occupants. The front left seat was occupied by a 17-year-old female. The front right seat was occupied by a 17-year-old female. The second row left seat was occupied by a 16-year-old male. The second row middle seat was occupied by a 22-year-old male. The second row right seat was occupied by a 23-year-old male. All the outboard occupants were using the available lap and shoulder belts. The second row middle occupant was using the available lap belt. This occupant was 157 cm (62 in) tall and weighed 68 kg (150 lbs). The pathologist measured his waist size as 71 cm (28 in). The Ford Escort was traveling on a two-lane roadway approaching a sharp, left hand curve. The Escort departed the roadway and struck a tree with its front end. The impact resulted in sufficient longitudinal deceleration of the Escort to command the deployment of the frontal air bag system. The Escort rebounded slightly and came to rest near the tree. The driver, front right occupant and second row left occupant sustained moderate injuries and were transported by ground ambulance to an area hospital for treatment. The second row right occupant sustained serious abdominal injuries and was transported by air to an area trauma center for treatment. The second row middle occupant was transected at the waist area by the lap belt and died moments after the crash.

This Rear Seat Occupant Protection case was identified by a local state patrol officer. Information regarding the crash was emailed to NHTSA. DSI was assigned the case on May 6, 2005. The vehicle was placed on a police hold and the case is being investigated as a crime. DSI located the vehicle and obtained permission to conduct the inspection. Field work was concluded on May 18, 2005.

SUMMARY

Crash Site

This single vehicle crash occurred during the early afternoon hours in April, 2005. The crash occurred off-road near a left hand curved roadway. The roadway is of asphalt construction. The approach to impact begins with a 5 degree positive grade that begins 32.5 m (107 ft) south of the impact and ends with a nearly level grade at the area of impact. Essentially, the road forms a hill crest. There are two travel lanes that are separated by double solid yellow lane lines. The roadway is bordered on both sides by numerous trees. The tree that was eventually struck by the Escort is 5.4 m (17.7 ft) north of the road edge and has a diameter of 50.0 cm (18.5 in).

Figure 2. Approach to point of impact-North

Pre Crash

The 1998 Ford Escort was traveling north at a police estimated speed of 113 km/h (70 mph). The occupants of the vehicle had just left a high school that was approximately 0.8 km (0.5 mile) south of the crash scene.

Crash

As the vehicle entered a left hand curve, the driver lost control. The Escort departed the roadway and struck a tree with its front end (12FCEW4). The impact resulted in sufficient longitudinal deceleration of the Escort to command the deployment of the frontal air bag system. The barrier routine of the WinSmash program computed a longitudinal delta V of -69.0 km/h (42.9 mph)[1]. The Escort rebounded slightly and came to rest near the tree.

Figure 3. Point of impact with tree

Post Crash

The driver was able to exit the vehicle through the driver's window under her own power. She sustained chest abrasions, a right knee abrasion and lacerations to the right hand. She was transported by ambulance to a local hospital. She arrived with a Total Trauma Score (TTS) of 12 and a Glasgow Coma Scale (GCS) score of

[1]Calculated using stiffness values derived from NCAP test 2731. Tree diameter used for Crash L.

between 13-15. She was treated and released.

The front right occupant was able to exit the vehicle through the front right passenger's window under her own power. She sustained chest abrasions, a neck abrasion, a laceration to her left knee and a contusion to the right hand. She was transported by ambulance to a local hospital. She arrived with a TTS score of 12 and a GCS score of between 13-15. She was treated and released.

The second row left occupant was able to get out of the vehicle under his own power but apparently had to lie down immediately once he got outside. He sustained seat belt patterned abrasions and contusions to his chest, shoulder and abdomen. He also sustained cervical and left shoulder strains. He complained of serious abdominal pain. A CT scan ruled out any abdominal or pelvic injuries. He was transported to an area trauma center. He arrived with a TTS score of 12 and a GCS score of 15.

The second row middle occupant was transected at the waist area by the lap belt and died moments after the crash. His torso initially came to rest, face down, behind the front right seat and on the legs of the second row right occupant. It has been reported that he did not die immediately, but spoke to the second row right occupant asking first for help getting up and then asking if he was going to die. He passed away moments later. He sustained a complete transection of the abdomen (complete transection of L2 vertebra with complete spinal cord transection), complete transection of the descending aorta at the level of T12, complete transection of segments of the small and large intestines, and a displaced fracture of the left wrist.

The second row right occupant was able to exit the vehicle through the second row right passenger's window under his own power. The police indicated that he sustained moderate seat belt related injuries. He was transported by ground ambulance to an area hospital for treatment.

The Ford Escort was towed from the scene due to damage and placed on a police hold.

Vehicle Data - 1998 Ford Escort

The 1998 Ford Escort SE was identified by the Vehicle Identification Number (VIN): 1FAFP13P6WWxxxxxx. The vehicle had 174,377 km (108,356 miles) on the odometer. The Escort was a four-door sedan that was equipped with a 2.0 liter four-cylinder engine, an automatic four-speed transmission, front disc/rear drum power brakes, power steering, front wheel drive, and a tilt steering wheel. The Escort was configured with Falken P185/65R14 tires on the front and Uniroyal Tiger Paw P185/65R14 tires on the rear. The vehicle manufacturer's recommended tire pressure was unknown. The specific tire information is as follows:

Position	Measured Pressure	Measured Tread Depth	Restricted	Damage
LF	172 kPa (25 psi)	5 mm (6/32 in)	Yes	None
LR	193 kPa (28 psi)	2 mm (3/32 in)	No	None
RR	186 kPa (27 psi)	2 mm (3/32 in)	No	None
RF	Flat	5 mm (6/32 in)	Yes	None

The seating in the Escort was configured with fabric covered front bucket seats and a rear bench seat with folding backs. The driver's seat was adjusted to the full forward track position. The front right seat was adjusted to a position between mid and full forward track position. The front seats were equipped with adjustable head rests. Both front seat backs were deformed by occupant contact during the crash.

Vehicle Damage

Exterior Damage - 1998 Ford Escort

Figure 4. Front left, 1998 Ford Escort

The 1998 Ford Escort sustained major front end damage as a result of the impact with the tree. The direct damage began 39.9 cm (15.7 in) from the right front bumper corner and measured 32.0 cm (12.6 in) in width. There was damage to the hood, grille, and radiator. There was remote buckling to the right roof/B pillar area. All four doors were jammed shut. The left wheelbase was shortened by 25.9 cm (10.2 in); the right by 13.0 cm (5.1 in). Both front tires were restricted. The front right tire was deflated. The windshield was cracked due to impact forces and from contact with the passenger air bag module cover.

CDC:	12FCEN4	
Delta V:	Total	69.0 km/h (42.9 mph)
	Longitudinal	-69.0 km/h (-42.9 mph)
	Latitudinal	0 km/h (0 mph)
	Energy	259,908 joules (191,698 ft lbs)

Six crush measurements were documented at the bumper level as follows: C1=16.0 cm (6.3 in), C2=45.0 cm (17.7 in), C3=76.0 cm (29.9 in), C4=77.0 cm (30.3 in), C5=37.0 cm (14.5 in), C6=27.0 cm (10.6 in).

Interior Damage - 1998 Ford Escort

The 1998 Ford Escort sustained moderate interior damage as a result of passenger compartment intrusion and occupant contacts. There was toe pan intrusion on both the right and left sides. Both front seat backs were deformed forward due to rear occupant loading. The seat bight area for the entire rear seat was slightly forward of its normal position. The glove box had opened and was broken away. The lower right instrument panel was scuffed from a right knee contact.

There was blood in a variety of locations, including: second seat middle, lower right B pillar, right rear floorboard, back of front right seat, right door panel, and on the second row middle lap belt.

The specific passenger compartment intrusions were documented as follows:

Position	Intruded Component	Magnitude of Intrusion	Direction
LF	Toe pan	8.0 cm (3.1 in)	Longitudinal
RF	Toe pan	8.0 cm (3.1 in)	Longitudinal
LF	Seat back	9.0 cm (3.5 in)	Longitudinal
RF	Seat back	10.0 cm (3.9 in)	Longitudinal
LR	Seat bottom	6.0 cm (2.5 in)	Longitudinal
MR	Seat bottom	6.0 cm (2.5 in)	Longitudinal
RR	Seat bottom	6.0 cm (2.5 in)	Longitudinal

Figure 5. Damage to glove box

Manual restraints - 1998 Ford Escort

The 1998 Ford Escort was configured with manual 3-point lap and shoulder belts for each of the four outboard seating position. The front safety belts were equipped with adjustable shoulder belt anchorages. The left was adjusted to the full down position; the right to the full up position. All four lap and shoulder belts were equipped with emergency locking retractors and sliding latch plates. The driver's seat belt showed heavy evidence of loading to the webbing that started 114.0 cm (44.9 in) from the bottom anchorage. The front right seat belt was found in the used position with the webbing trapped in the latch plate. The second row left seat belt was found locked in the used position.

Figure 6. Loading to driver's seat belt–viewed through left rear window

Figure 7. Front right passenger seat belt, webbing trapped in latch plate

Figure 8. Second row right seat belt

The middle rear seat was configured with a manual Type 1 lap seat belt assembly intended for pelvic restraint. The police measured the circumference of the latched lap belt as 83.8 cm (33 in). During the vehicle inspection, the seat belt length on the right side was measured as 68.0 cm (26.7 in) from the seat bight to the latch locking bar and on the left side was measured as 15.5 cm (6.1 in) from the seat bight to the end of the latch. The belt was measured while latched; the maximum excursion was 40.0 cm (15.7 in) with a base of 36.0 cm (14.2 in). The pathologist measured the waist size of the middle rear occupant as 71.1 cm (28.0 in). Several calculations were made to determine the extent of slack in the belt relative to the occupants's waist size.

Figure 9. Second row middle seat position and lap belt

	Area	% difference
Occupant waist circumference = 28 in	62.3 sq in	NA
Police measured lap belt circumference = 33 in	86.7 sq in	+21.2
Maximum belt excursion of 15.7 in with a base of 14.2 in	106.4 sq in	+32.3

At the time of the police investigation, the lap belt was found still latched with the webbing toward the forward aspect folded in half – with the bottom of the fold toward the occupant.

Supplemental Restraint System - 1998 Ford Escort

The 1998 Ford Escort was equipped with dual stage frontal air bags. Both front air bags deployed as a result of the longitudinal deceleration of the Escort during the tree impact.

Figure 10. Driver's air bag–top of bag is to the right

The driver's air bag deployed from the center of the steering wheel hub through symmetrical H-configuration module cover flaps. The top flap measured 20.0 cm (7.9 in) wide and 8.5 cm (3.3 in) high. The bottom flap measured 20.0 cm (7.9 in) wide and 10.5 cm (4.1 in) high. The deployed driver's bag measured 51.0 cm (20.0 in) in its deflated state. The air bag was tethered by a single internal strap attached to the circular stitching in the center of the air bag. Two circular vent ports were located at the 11 and 1 o'clock aspects on the rear of the air bag. There was no air bag or module cover damage. There were blood drops found on the left aspect of the air bag face.

Figure 11. Front right passenger's air bag

The front right passenger's air bag deployed from a top mount module with a curved rectangular cover flap that was hinged at the forward aspect. The module cover flap measured 31.0 cm (12.2 in) wide by 15.0 cm (5.9 in) high. The deployed front right passenger's air bag measured 41.0 cm (16.1 in) wide seam-to-seam, 90.0 cm (35.4 in) high, and with a maximum excursion of 84.0 cm (33.0 in). There were no tethers. Two circular vent ports were located at the 3 and 9 o'clock aspects of each side panel. The air bag was undamaged. There was scuffing damage to the bottom right cover of the air bag module that likely came from contact with the windshield during deployment.

Occupants Demographics

Case vehicle	Driver	Occupant 2
Age/Sex:	17/Female	17/Female
Seated Position:	Front left	Front right
Seat Type:	Fabric covered front bucket seat, seat adjusted to forward most track position	Fabric covered front bucket seat, seat adjusted to between forward most and middle track position
Height:	Unknown	Unknown
Weight:	Unknown	Unknown
Occupation:	None	None
Pre-existing Medical Condition:	None	None
Alcohol/Drug Involvement:	None	NA
Driving Experience:	Unknown	NA
Body Posture:	Upright	Upright
Hand Position:	Unknown	Unknown
Foot Position:	Right foot on brake, left on floor board	Unknown
Restraint Usage:	Lap and shoulder belt available, used	Lap and shoulder belt available, used
Air bag:	Driver's air bag available, deployed	Front right passenger air bag available, deployed

	Occupant 3	Occupant 4	Occupant 5
Age/Sex:	16/Male	22/Male	23/Male
Seated Position:	Second row left	Second row middle	Second row right
Seat Type:	Fabric covered bench	Fabric covered bench	Fabric covered bench
Height:	Unknown	157 cm (62 in)	Unknown
Weight:	Unknown	68 kg (150 lbs)	Unknown
Occupation:	NA	Unknown	Unknown
Pre-existing Medical Condition:	None noted	None noted	None noted
Alcohol/Drug Involvement:	NA	NA	NA
Driving Experience:	NA	NA	NA
Body Posture:	Presumed upright	Presumed upright	Presumed upright
Hand Position:	Unknown	Unknown	Unknown
Foot Position:	Unknown	Unknown	Unknown
Restraint Usage:	Lap and shoulder belt available, used	Lap belt available, used incorrectly	Lap and shoulder belt available, used

OCCUPANT INJURIES - 1998 Ford Escort

Driver: Injuries obtained from medical records (emergency department). A CT scan for possible head injury was negative.

Injury	OIC Code	Injury Mechanism	Confidence Level
Chest, contusion	490402.1,0	Seat belt webbing	Certain
Right hand, cuts (laceration)	790600.1,1	Flying glass	Probable
Right knee abrasion	8902021,1	Knee bolster	Probable

Front right occupant: Injuries obtained from hospital (Emergency Department and Radiology). A CT scan for a possible abdominal injury was negative.

Injury	OIC Code	Injury Mechanism	Confidence Level
Abrasion, right side of neck	390202.1,1	Seat belt webbing	Certain
Chest abrasion	490202.1,0	Seat belt webbing	Certain
Small skin tear (laceration), left knee	890602.1,2	Lower instrument panel	Probable
Small bruise (contusion), right hand	790402.1,1	Unknown	Unknown

Second row left occupant: Injuries obtained from Medical Records (emergency department). A CT scan ruled out any abdominal or pelvic injuries.

Injury	OIC Code	Injury Mechanism	Confidence Level
Left shoulder abrasion (seat belt pattern)	790202.1,2	Seat belt	Certain
Left chest edema (contusion)	790402.1,2	Seat belt	Certain
Lower abdominal abrasion (seat belt pattern)	590202.1,8	Seat belt	Certain
Acute left shoulder strain	740402.1,2	Seat belt	Certain
Acute cervical strain	640278.1,6	Impact forces	Probable
Right upper arm scratch (laceration)	790600.1,1	Unknown	Unknown
Abdominal pain	Not codeable		

Second row right occupant: Injuries obtained from police. The police indicate that he sustained moderate seat belt related bruises.

Injury	OIC Code	Injury Mechanism	Confidence Level
Shoulder contusion	790402.1,1	Seat belt	Certain
Chest contusion	490402.1,4	Seat belt	Certain
Abdominal contusion	590402.1,0	Seat belt	Certain

Second row, middle occupant: Injuries obtained from autopsy report.

Injury	OIC Code	Injury Mechanism	Confidence Level
Complete transection of the descending aorta at the level of T-12	420210.5,4	Lap belt	Certain
Complete transection of L2 vertebra with spinal cord transection	640646.5,8	Lap belt	Certain
Complete transection of the abdomen	544426.4,7	Lap belt	Certain
Complete transection of segments of small and large intestines (jejunum-ileum / small bowel and colon / large bowel)	541426.4,8 540826.4,8	Lap belt	Certain
Mild focal thin subarachnoid hemorrhage over the right parietal region (probably secondary to the spinal injury)	140684.3,1	Unknown	Unknown
Displaced fracture of the left wrist	751800.2,2	Seat back	Probable
Laceration across the abdomen (the upper margin is approx. 69.9 cm / 27 ½ in. below the top of head and the lower margin is approx. 16.5 cm / 6 ½ in. above the base of the penis)	590604.2,8	Lap belt	Certain
Superficial bruise lateral to the right orbit	290402.1,1	Seat back	Probable
Abrasion over the right cheek area 2.5 cm x1.3 cm / 1.0 x 0.5 in.	290202.1,1	Seat back	Probable
Wide areas of abrasions on lateral surface associated with stretch marks iliofemoral region	590202.1,8	Lap belt	Certain
Superficial abrasion over the medial surface of the distal left ankle	890202.1,2	Unknown	Unknown

OCCUPANT KINEMATICS - 1998 Ford Escort

Driver Kinematics

The 17-year-old female driver was seated in an upright posture and was restrained by the 3-point lap and shoulder belt. The shoulder belt anchorage was in the full down position. The fabric covered bucket seat was adjusted to the forward most track position. The seat back was slightly reclined. She was braking just prior to impact. Her right foot was on the brake, her left on the floor. At impact, the frontal air bags deployed. The female driver initiated a forward trajectory in response to the 12 o'clock direction of force. She loaded the safety belt with her chest, causing a chest contusion. She also likely engaged the air bag with her face and torso. Both knees contacted the lower instrument panel/knee bolster area. She sustained a contusion to the right knee. She exited the vehicle on her own through the left front window. She was transported by ground ambulance to an area hospital for treatment.

Figure 12. Left lower instrument panel and toe pan

Front Right Occupant Kinematics

The 17-year-old front right seat female occupant was seated in an upright posture and was restrained by the 3-point lap and shoulder belt. The shoulder belt anchorage was in the full up position. The fabric covered bucket seat was adjusted to between the middle and forward most track position. The seat back was slightly reclined. The driver was braking just prior to impact. At impact, the frontal air bags deployed. This female occupant initiated a forward trajectory in response to the 12 o'clock direction of force. She loaded the safety belt, causing abrasions to the right side of her neck and her chest. She also likely engaged the air bag with her face and torso. Both knees contacted the lower instrument panel/knee bolster area, as well as the glove box. She sustained a small laceration to the left knee. She exited the vehicle on her own through the right front window. She was transported by ground ambulance to an area hospital for treatment.

Figure 13. Contact to front right instrument panel, next to glovebox

Second Row Left Occupant Kinematics

The 16-year-old second row left seat male occupant was seated in an upright posture and was restrained by the 3-point lap and shoulder belt. The driver was braking just prior to impact. At impact, this male occupant initiated a forward trajectory in response to the 12 o'clock direction of force. He loaded the safety belt–causing abrasions to the left shoulder and abdomen, and a left chest contusion. He sustained strains to the shoulder and cervical spine from the impact forces. Both lower legs likely contacted the back of the driver's seat. His hands also may have contacted the seat back given the compact passenger compartment area.

Figure 14. Second row left seat position

Second Row Right Occupant Kinematics

The 23-year-old second row right seat male occupant was seated in an upright posture and was restrained by the 3-point lap and shoulder belt. The driver was braking just prior to impact. At impact, this male occupant initiated a forward trajectory in response to the 12 o'clock direction of force. He loaded the safety belt. Both lower legs likely contacted the back of the front right passenger's seat. The police indicated that he sustained moderate seat belt related injuries. He exited the vehicle on his own through the right rear window. He was transported by ground ambulance to an area hospital for treatment.

Figure 15. Second row right seat position, deformation to front right seat back

Second Row Middle Occupant Kinematics

The 22-year-old second row middle male occupant (157 cm/62 in, 68 kg/150 lbs) was seated in an upright posture and was loosely restrained by the manual lap belt. As indicated earlier, there was considerable slack in the belt. He was wearing a cloth belt with a spring type metal buckle. This belt can be released by pressing on one end. He appears to have been wearing the manual lap belt at the abdomen level–above the iliac crests. At impact, he pitched forward sharply, jack knifing about the lap belt. As he engaged the lap belt, the belt folded in half with the fold facing towards the occupant. The thin metal of the buckle may have caused the initial tearing of the skin. The transection began just below the umbilicus. The spine was separated at L2. The ascending aorta was separated at T12. The torso came free and struck the backs of the front seats. The torso then came to rest behind the front right seat, face down. According to the investigating officer, the remainder of this occupant's body remained in place on the seat. The lap belt remained latched throughout the crash. This occupant passed away moments after the crash.

Figure 16. Exemplar view of cloth belt with metal buckle being worn by middle rear occupant

Figure 17. Second row middle seat position with lap belt latched

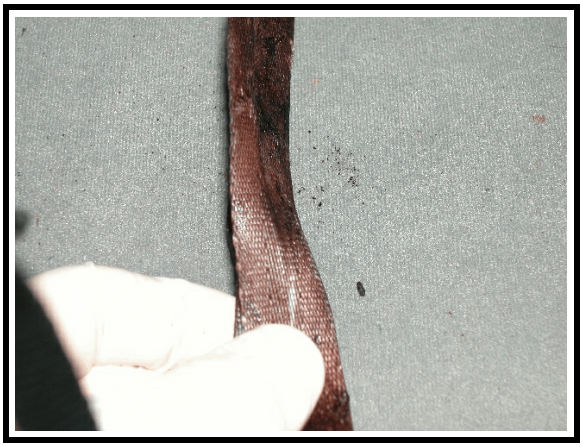

Figure 18. Belt webbing folded over due to loading

Attachment 1. Scene Diagram