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TRANSPORTATION RESEARCH GROUP
CRASH RESEARCH SECTION

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REDESIGNED AIR BAG DEPLOYMENT INVESTIGATION

CASE NO. CA97-036

1998 FORD ESCORT- REDESIGNED AIR BAG

1993 FORD AEROSTAR MINIVAN

LOCATION - STATE OF PENNSYLVANIA

CRASH DATE - SEPTEMBER, 1997

Contract No. DTNH22-94-D-07058

Prepared for:

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National Highway Traffic Safety Administration
Washington, D.C. 20590

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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*

A two vehicle crash involving a 1998 Ford Escort, equipped with dual front redesigned air bags and a 1993 Ford Aerostar minivan occurred in the month of September, 1997 during the late afternoon hours in the State of Pennsylvania. The crash occurred in the intersection of a multi-lane divided roadway which was regulated by traffic control lights. The Ford Escort was struck on the left side plane by the front of the Ford Aerostar which was making a left turn. The Ford Escort sustained a WinSMASH computed total delta V of 13.3 km/h (8.2 mph) while the Ford Aerostar sustained an estimated delta V of 8.0 km/h (5.0 mph). The redesigned dual front air bags deployed during the impact sequence. There were no occupant related injuries or contact detected between the air bags and the front seat occupants.

The driver of the Ford Escort, a 30 year old male who was restrained by the available three point manual lap and shoulder belt, suffered a police reported bleeding wound of the face which was attributed to a rigid component inside the vehicle (e.g., side glazing). The front right occupant, a 23 year old female, was also restrained by the three point lap and shoulder belt. She suffered pain of the neck and back which were attributed to the restraint belt system. A 4 year old male in the left rear seat position and a 11 year old male in the right rear seat position, who were using the available three point manual lap and shoulder belt, were not injured in the crash. All occupants were transported by fire rescue to a local medical treatment facility.

The 16 year old female driver of the Ford Aerostar was transporting three passengers who were listed by police as not injured. The police listed restraint usage as unknown for all occupants in the vehicle. The occupants included a 16 old male seated in the front right seat, a 9 year old male (driver's brother) seated in the second row left, and a 17 year old female in the second row right. The police report indicated that no one in this vehicle was transported to a medical treatment facility.

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FINAL CASE REPORT
CASE NO. CA 97-036
REDESIGNED DUAL AIR BAG DEPLOYMENT
1998 FORD ESCORT
LOCATION - STATE OF PENNSYLVANIA
SEPTEMBER, 1997

BACKGROUND

The National Highway Traffic Safety Administration was notified of a crash involving a redesigned air bag deployment by the Calspan SCI Team after the Calspan Team received notification from the National Automotive Sampling System (NASS). The Crash Investigation Division assigned this task as a remote investigation the following day and requested that the NASS PSU participate in the investigation by obtaining required field data.

SUMMARY

A two vehicle crash involving a 1998 Ford Escort, equipped with dual front redesigned air bags, and a 1993 Ford Aerostar minivan occurred in the month of September, 1997 during the late afternoon hours in the State of Pennsylvania. The weather at the time of the crash was dry with no adverse conditions. The crash occurred in an intersection of a multi-lane divided roadway which was regulated with traffic lights. The Ford Escort was traveling southbound **(Figure 1)** when the northbound Ford Aerostar initiated a left turn and struck the left side plane of the Ford Escort. The intersection boundary was regulated by several traffic control lights. The police reported that the Ford Aerostar violated the red traffic light for the westbound traffic after initiating the left turn.

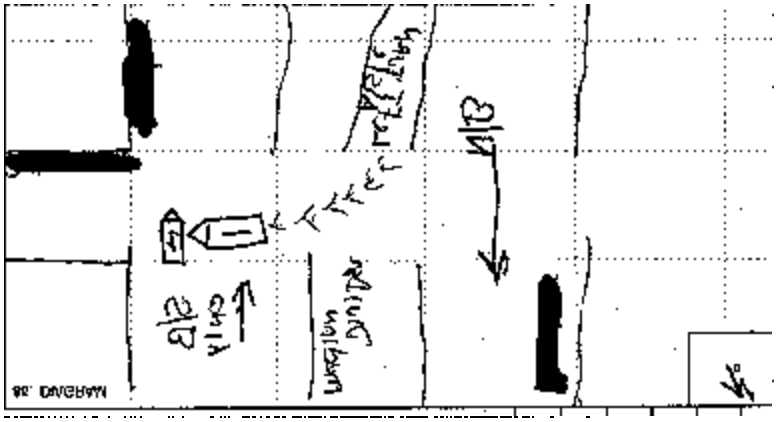

Figure 1 - Police scene diagram, Vehicle #1 (1993 Ford Aerostar), Vehicle #2 (1998 Ford Escort)

The 1998 Ford Escort was a relatively new vehicle with 1,283 km (797 miles) showing on the odometer. It was equipped with redesigned dual front air bags that deployed during the impact sequence. There were no occupant related contact evidence noted along the surfaces of the air bag module covers. However, there were bodily fluid artifacts noted on both air bags which were attributed to a facial lesion suffered by the driver.

The driver of the Ford Escort, a 30 year old male who was restrained by the available three point manual lap and shoulder belt, suffered a police reported bleeding wound of the face. The pattern of the bodily fluid deposits on the driver side air bag suggested that the driver may have contacted a rigid component inside the vehicle (e.g., side glazing) which resulted in a spray pattern of bodily fluid to the air bag. Larger bodily fluid droplets visible on the air bag indicated that his head came to rest over the front left air bag.

The front right occupant in the Ford Escort, a 23 year old female, was also restrained by the three point lap and shoulder belt. She suffered pain of the neck and back. A 4 year old male in the left rear seat position and an 11 year old male in the right rear seat position were using the available three point manual lap and shoulder belt. They were not injured in the crash. All occupants were transported by fire rescue to a local medical treatment facility.

The 16 year old female driver of the Ford Aerostar was transporting three passengers. There was a 16 old male seated in the front right seat, a 9 year old male (driver's brother) seated in the second row left, and a 17 year old female in the second row right. Restraint usage for all occupants in the vehicle was listed as unknown by the police. The police report indicated that no one in this vehicle was injured or transported to a medical treatment facility.

VEHICLE DATA

Exterior -1998 Ford Escort

The Ford Escort sustained direct contact damage along the left side plane from the collision with the Ford Aerostar. Exterior damage to the vehicle involved the front bumper, left front fender, left front wheel, the windshield, left side doors, left side glazing, and B-pillar **(Figure 2)**. Damage began 46.0 cm 18.1") forward of the right front axle and extended 290.0 cm (147.2") rearward. The maximum crush of 12 cm was located on the driver's door **(Figure 3)**. The Ford Escort sustained a WinSMASH computed total delta V of 13.3 km/h (8.2 mph) while the Ford Aerostar sustained an estimated delta V of 8.0 km/h (5.0 mph).

Crush values are contained in the following table:

1998 Ford Escort - Crush			
Impact with the 1993 Ford Aerostar	C_1 = 0 cm	C_2 = 8.0 cm (3.1")	C_3 = 9.0 cm (3.5")
	C_4 = 12.0 cm (4.7")	C_5 = 5.0 cm (2.0")	C6 = 0 cm

Figure 2- Left corner view of the 1998 Ford Escort showing the damage profile

Figure 3- View showing the extend of damage at the driver door

Collision Deformation Classification (CDC)

The Collision Deformation Classification (CDC) assigned to this impact was 11-LYAW-1.

Interior -1998 Ford Escort

Damage to the interior included left side intrusion, bodily fluid transfer evidence to the air bags, and windshield damage from contact by the right air bag module cover. The front left door intruded laterally 4.0 cm (1.6") while the floor pan at the sill sustained a lateral intrusion of 1.0 cm (0.4"). The left B-pillar intruded 7.0 cm (2.75") and the rear left door panel had an intrusion value of 5.0 cm (2.0").

The driver's bucket seat was found in the full rear adjusted position with a seat back angle which was reclined at a mid range position **(Figure 4)**. The adjustable head restraint appeared to be near the full up adjusted position. There was no damage noted to the head restraint or seat back support. The front right bucket seat was found in the full rear adjustment position with the adjustable head restraint in a mid range adjustment position. The seat back support appeared to be reclined in a mid rearward position **(Figure 5)**. There was no damage noted to the seat.

Figure 4- View of the rear seat looking toward the left showing the position of the seat back support and the head restraint

Figure 5- View of the rear seat area looking toward the right showing the relative recline position of the seat back support and the adjustment height of the head restraint

The front left door panel exhibited a deformation pattern which was attributed to contact by the driver's hip area. There were no related injuries reported by the police.

The driver's three point manual restraint belt consisted of a continuous loop belt with an adjustable D-ring that was in the full up position. Bodily fluid deposits on the torso belt indicated that the driver was using the restraint belt system at the time of the crash.

The front left air bag exhibited two patterns of bodily fluid transfers. A general scattered transfer field was noted across the entire surface of the air bag and appeared to be a spray dispersion type which continued on to the surface of the front right air bag. This was attributed to the driver striking a hard interior component (e.g., side glazing) resulting in a lesion of his face. The rebound motion and subsequent rotation of his head then resulted in the dispersion pattern. The second artifact on the front left air bag was more of a concentrated bodily fluid transfer which was attributed to position of the driver's face at his final rest position.

The adjustable steering wheel was found in the full up adjusted position. There was no contact evidence to the steering wheel rim. The instrument panel and knee bolster were not damaged.

The windshield sustained a fractured pattern which was located directly forward of the front right air bag module cover **(Figure 6)**. During the supplemental restraint system (SRS) actuation sequence, the air bag module cover rotated upward where the leading edge struck the glazing resulting in a well defined linear fracture pattern.

Figure 6- View of the windshield damage resulting from contact by the air bag module cover

The three point manual restraint belt was a continuous loop design and was used by the front right occupant during the crash. The adjustable D-ring was noted in the full up position. There was no damage observed to the belt system.

The rear seat row was equipped with three point continuous loop manual lap and torso belts in the outboard seat positions and a manual lap belt in the center seat position. The children in the outboard positions were reportedly wearing the restraint belts at the time of the crash. They were not injured in the crash.

SPEED RECONSTRUCTION

The missing vehicle algorithm of the WinSMASH speed reconstruction program was used to compute relative delta V values. The output from the damage routine indicated that the Ford Escort experienced a total delta V of 13.3 km/h (8.2 mph) as shown in the following table. This output value appeared reasonable.

WinSMASH	1998 Ford Escort	1993 Ford Aerostar
Total delta V	13.3 km/h (8.2 mph)	8.0 km/h (5.0 mph)
Longitudinal delta V	-11.5 km/h (-7.1 mph)	-4.0 km/h (-2.5 mph)
Lateral delta V	6.6 km/h (4.1 mph)	-6.9 km/h (-4.3 mph)

WinSMASH	1998 Ford Escort	1993 Ford Aerostar
Energy dissipated	18,265 joules (13,473 ft-lb)	5,611 joules (4,139 ft-lb)
Barrier equivalent speed	17.6 km/h (10.9 mph)	5.1 km/h (3.2 mph)

SUPPLEMENTAL RESTRAINT SYSTEM (SRS)

Front Left Air Bag

The Ford Escort was equipped with redesigned dual front air bags that deployed during the crash sequence. The front left air bag module cover opened in the typical "H" configuration with the vertical height of the upper flap measuring 7.0 cm (2.75") and the lower flap measuring 10 cm (3.9"). The lateral width of the flaps measured 20.5 cm (8.1") along the common seam line **(Figure 7)**. There was no driver related contact evidence noted on the air bag module flaps.

Figure 7 - View of the front right air bag module cover

The front left bag was designed with two tethers and two vent ports located at the 11 o'clock and 1 o'clock sector of the air bag **(Figure 8)**. The diameter of the air bag measured 50.0 cm (19.7") and exhibited two bodily fluid transfer patterns over the front surface. One transfer pattern appeared to be a spray type pattern where several small dot like artifacts were widely scattered over the surface. A second pattern involved a more concentrated artifact located in the lower right quadrant of the air bag **(Figure 9)**. This pattern appeared to be indicative of the driver's post crash head position where bodily fluids from his head/face dripped down onto the air bag.

Figure 8 - View of the upper front left air bag vent ports

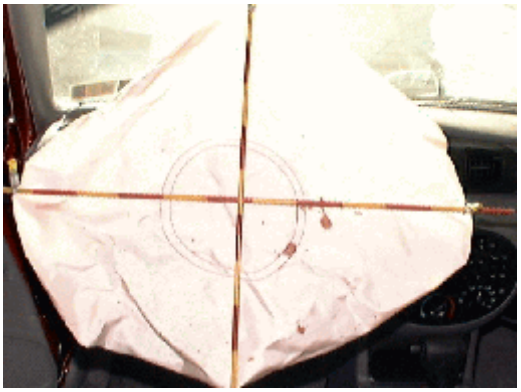

Figure 9 - View of the front left air bag showing the tether related center stitch area and bodily fluid deposits

Front Right Air Bag

The front right air bag module cover was a mid mount design which was hinged along the top surface of the front right instrument panel **(Figure 10)**. During the air bag expansion sequence, the air bag module cover rotated upward and contacted the windshield resulting in a fracture of the glazing area that correlated with the dimensions and location of the module cover. The cover measured 20.5 cm (8.0") wide with a vertical height of 10.0 cm (3.9") and a horizontal dimension of 7.0 cm (2.75").

The untethered front right air bag was designed with two vent ports which were located on the inboard and outboard side panels near the top surface **(Figure 11)**. The vertical surface of the air bag measured 60 cm (23.6") and the width measured 45 cm (17.7"). The top and inboard side surfaces of the air bag exhibited scattered bodily fluid transfers which were attributed to the driver's facial lesion.

Figure 10 - View of the front right mid mounted air bag module

Figure 11 - View of the air bag vent ports along the inboard/outboard side panels of the front right air bag

INJURY DATA

The 30 year old male driver of the Ford Escort suffered a police reported bleeding wound of the face and was transported to a local medical treatment facility. There were no medical records available to further define his lesion. The bodily fluid spray pattern on the both air bags suggested that he struck a hard surface such as the side window which resulted in a bodily fluid dispersion pattern. There was no driver contact evidence detected to the glazing, however, the front left door panel was intruded 4 cm (1.5").

INJURY Driver of the Ford Escort	AIS-90	INJURY SOURCE	
		Component	Certainty
1. Bleeding of the face	29099.1,9	Side surface	Possible

The right front occupant, a 23 year old female, was restrained by the three point lap and shoulder belt and suffered police reported pain of the neck and back. There were no medical records available. A 4 year old male in the left rear seat position and a 11 year old male in the right rear seat position were using the available three point manual lap and shoulder belt. They were not injured in the crash. All occupants were transported by fire rescue to a local medical treatment facility.

OCCUPANT KINEMATICS

The driver's seat in the Ford Escort was found in the full rear track position at the time of inspection. Bodily fluid transfers on the torso belt indicated that the driver was wearing the restraint belt system at the time of the crash. During the impact sequence, the driver moved forward and to the left in response to the 11 o'clock resultant direction of force. Given the lateral intrusion of the door panel and B-pillar, it was hypothesized that the driver's head contacted the front left side glazing resulting in a lesion of the face. As he rebounded, his head rotated rapidly resulting in a widely scattered bodily fluid dispersion which was evident by the bodily fluid artifacts noted to the surface of both air bags. The restraint belt maintained his position in his seat where he momentarily slumped forward at his final rest position. There was no evidence of driver contact on the surface of the front left air bag.

The front right occupant's seat was also found in the full rear track position at the time of inspection. Her upper torso which was restrained by the torso belt may have slipped out of the belt during the impact sequence as she moved forward and to the left in response to the 11 o'clock direction of force. As a result, she suffered police reported pain of the neck and back. There was no physical contact evidence noted on the front right air bag or injuries attributed to air bag interaction with the occupant during the deployment sequence.