TRANSPORTATION SCIENCES
CRASH RESEARCH SECTION

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REDESIGNED AIR BAG SPECIAL STUDY (RABSS)
SCI TECHNICAL SUMMARY REPORT

NASS RABSS CASE NO. 1998-09-805D

RABSS VEHICLE - 1998 FORD WINDSTAR

LOCATION - STATE OF MARYLAND

CRASH DATE - NOVEMBER, 1998

Contract No. DTNH22-94-D-07058

Prepared for:

U.S. Department of Transportation
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.

TECHNICAL REPORT STANDARD TITLE PAGE

1. *Report No.* 98-09-805D	2. *Government Accession No.*	3. *Recipient's Catalog No.*	
4. *Title and Subtitle* Redesigned Air Bag Special Study (RABSS) RABSS Vehicle - 1998 Ford Windstar Location - State of Maryland		5. *Report Date*: October, 1999 6. *Performing Organization Code*	
7. *Author(s)* Crash Research Section		8. *Performing Organization Report No.*	
9. *Performing Organization Name and Address* Transportation Sciences Crash Research Section Veridian Engineering (Calspan Operations) P.O. Box 400 Buffalo, New York 14225		10. *Work Unit No.* C01115.0238.(0000-0009) 11. *Contract or Grant No.* DTNH22-94-D-07058	
12. *Sponsoring Agency Name and Address* U.S. Department of Transportation National Highway Traffic Safety Administration Washington, D.C. 20590		13. *Type of Report and Period Covered* Technical Summary Report Crash Date: November, 1998 14. *Sponsoring Agency Code*	
15. *Supplementary Notes* NASS investigation of a head-on collision that involved a 1998 Ford Windstar with redesigned frontal air bags.			
16. *Abstract* This investigation focused on a two vehicle crash involving a 1998 Ford Windstar minivan (subject vehicle) and a 1988 Chevrolet S-10 pickup truck. The Ford Windstar was equipped with redesigned frontal air bags that deployed as a result of a head-on collision with the Chevrolet pickup truck. The Ford driver was operating the vehicle northbound on a three lane rural roadway when she observed the southbound Chevrolet pickup encroach into her path of travel. As the Chevrolet entered the northbound lane the front left area struck the front left area of the Ford resulting in moderate damage to both vehicles. The 41 year old female driver of the Ford Windstar was restrained by the available 3-point manual lap and shoulder belt system. At impact, she initiated a forward trajectory in response to the 12 o'clock impact force and loaded the manual restraint and deployed redesigned driver air bag. Loading of the manual restraint resulted in multiple soft tissue injuries to the left neck and chest. She also sustained a cervical/lumbar strain which was a result of the sudden forward movement of the head as the body loaded the belt system (flexion). The 12 year old front right passenger was also restrained by the 3-point manual lap and shoulder belt system. At impact, he initiated a forward trajectory in response to the 12 o'clock impact force and loaded the manual restraint and deployed redesigned passenger air bag. Loading of the manual restraint resulted in multiple soft tissue injuries to the right neck and shoulder. He also sustained a cervical strain resulting from the sudden forward movement of the head as it loaded the manual belt system (flexion). Both occupants of the Ford Windstar were transported by ambulance to a local hospital for treatment and released. The 18 year old female driver of the Chevrolet pickup truck was transported by air to a local trauma center for treatment and admitted for one day.			
17. *Key Words* Redesigned frontal air bag system Collision Deformation Classification (CDC): 12-FLEW-1 Proper use of the manual belt system Chest contusion		18. *Distribution Statement* General Public	
19. *Security Classif. (of this report)* Unclassified	20. *Security Classif. (of this page)* Unclassified	21. *No. of Pages* 7	22. *Price*

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BACKGROUND

This investigation focused on a two vehicle crash involving a 1998 Ford Windstar minivan (subject vehicle) and a 1988 Chevrolet S-10 pickup truck. The Ford Windstar was equipped with redesigned frontal air bags that deployed as a result of a head-on collision with the Chevrolet pickup truck. The Ford driver was operating the vehicle northbound on a three lane rural roadway when she observed the southbound Chevrolet pickup encroach into her path of travel. As the Chevrolet entered the northbound lane the front left area struck the front left area of the Ford resulting in moderate damage to both vehicles. The 41 year old female driver of the Ford Windstar was restrained by the available 3-point manual lap and shoulder belt system. At impact, she initiated a forward trajectory in response to the 12 o'clock impact force and loaded the manual restraint and deployed redesigned driver air bag. Loading of the manual restraint resulted in multiple soft tissue injuries to the left neck and chest. She also sustained a cervical/lumbar strain which was a result of the sudden forward movement of the head as the body loaded the belt system (flexion). The 12 year old front right passenger was also restrained by the 3-point manual lap and shoulder belt system. At impact, he initiated a forward trajectory in response to the 12 o'clock impact force and loaded the manual restraint and deployed redesigned passenger air bag. Loading of the manual restraint resulted in multiple soft tissue injuries to the right neck and shoulder. He also sustained a cervical strain resulting from the sudden forward movement of the head as it loaded the manual belt system (flexion). Both occupants of the Ford Windstar were transported by ambulance to a local hospital for treatment and released. The 18 year old female driver of the Chevrolet pickup truck was transported by air to a local trauma center for treatment and admitted for one day.

This crash was initially selected for investigation by the National Automotive Sampling System (NASS) as case number 98-09-805D for the Redesigned Air Bag Special Study. The Crash Investigation Division of the National Highway Traffic Safety Administration (NHTSA) assigned the Special Crash Investigation (SCI) team at Veridian/Calspan the task of case review and final report preparation.

SUMMARY

Crash Site

This two vehicle crash occurred during the morning hours of November, 1998. At the time of the crash, it was daylight with rainy conditions as the roads were wet. The crash occurred in the northbound lane of a north/south two lane (straight/level) rural roadway with a center turn lane **(see Figure 7 - page 7)**. The roadside environment included shrubbery and small diameter trees. No traffic controls were present at the scene which had a posted speed limit of 56 km/h (35 mph).

Pre-Crash

The 18 year old female driver of the 1988 Chevrolet S-10 pickup truck was operating the vehicle southbound **(Figure 1)** when she failed to observe southbound traffic stopped ahead. Upon recognition of the impending harmful event, the driver steered left and braked initiating a counterclockwise yaw on the wet pavement (hydroplaned) as she entered the northbound lane. The 41 year old female driver of the 1998 Ford Windstar was operating the vehicle northbound **(Figure 2)** when she observed the Chevrolet S-10 pickup truck encroach into her path of travel. Although no avoidance maneuvers were attempted, she extended her right arm outward to "brace" the child occupant prior to the crash.

Figure 1. Southbound approach for the 1988 Chevrolet S-10 pickup truck.

Figure 2. Northbound approach for the 1998 Ford Windstar.

Crash

As the Chevrolet entered the northbound lane of the two lane rural roadway, the front left area struck the front left area of the Ford resulting in moderate damage to both vehicles. The impact induced deceleration was sufficient to deploy the Ford's redesigned frontal air bag system. The damage algorithm of the WinSMASH program computed velocity changes of 20.8 km/h (12.9 mph) for the subject vehicle and 31.5 km/h (19.6 mph) for the striking Chevrolet. The respective longitudinal components were -20.5 km/h (-12.7 mph) and -27.3 km/h (-17.0 mph). The Collision Deformation Classification (CDC) for this impact to the Ford was 12-FLEW-1 with a principal direction of force of (-)10 degrees. The CDC for this impact to the Chevrolet was 01-FYEW-2 with a principal direction of force of (+)30 degrees. The Ford was re-directed in a northeasterly direction and subsequently departed the right (east) pavement edge where it impacted shrubbery and a small diameter tree resulting in minor frontal damage. The (overlapping) CDC for this second and third impact to the Ford Windstar was 12-FDLW-1. The Ford came to rest against the tree facing northeast. The Chevrolet rotated counterclockwise and came to rest perpendicular to the center turn lane facing east. At this point, a 1988 Buick Century traveling southbound (behind the Ford) struck the Chevrolet pickup resulting in moderate right side damage to the Chevrolet.

Post-Crash

Both occupants of the Ford Windstar (along with the four occupants of the Buick Century) exited the vehicle under their own power. The driver of the Chevrolet pickup truck was removed from the vehicle by rescue personnel with perceived serious injuries. Treatment was rendered at the scene by fire department personnel and emergency medical technicians (EMT). The occupants of the Ford were transported by ambulance to a local hospital for treatment and released. The driver of the Chevrolet

pickup truck was transported by air to a local trauma center and admitted for one day. The driver and occupants of the Buick Century were not reported by police as injured. The Ford Windstar and Chevrolet pickup truck were towed from the scene. The 1988 Buick Century was driven from the scene.

RABSS VEHICLE

The 1998 Ford Windstar was identified by the Vehicle Identification Number (VIN): 2FMZA51U8WB (production sequence deleted). The police report listed the driver as the owner of the vehicle. The vehicle was a 4-door minivan equipped with front wheel drive and a 3.0 liter, V-6 engine. The odometer reading was 12,143 km (7,545 miles) at the time of the crash. The seating was configured with front box mounted (van type) bucket seats and rear benches with folding backs. The driver reported no previous crashes or maintenance on the air bag system (original equipment). A portable cell phone was present but not in use at the time of the collision.

VEHICLE DAMAGE

Exterior Damage

Figure 3. Frontal damage to the 1998 Ford Windstar.

The Ford Windstar sustained moderate frontal damage as a result of the impact with the Chevrolet pickup truck **(Figure 3)**. The direct contact damage began at the front left bumper corner and extended 50.0 cm (19.7 in) inboard. The impact deformed the full frontal width resulting in a combined direct and induced damage length (Field L) of 160.0 cm (63.0 in). Six crush measurements were documented at the level of the bumper: C1= 17.0 cm (6.7 in), C2= 10.0 cm (3.9 in), C3= 6.0 cm (2.4 in), C4= 5.0 cm (2.0 in), C5= 4.0 cm (1.6 in), C6= 4.0 cm (1.6 in). Damage was noted to the left fender and wheel/tire from sustained contact between the vehicles during spinout. This damage pattern restricted the left front wheel (not deflated). Superficial contact damage was documented along the front bumper fascia from the shrub impact. The windshield was undamaged in the crash.

Figure 4. Frontal damage to the 1988 Chevrolet pickup truck.

The Chevrolet pickup truck sustained moderate frontal damage as a result of the impact with the Ford Windstar **(Figure 4)**. The direct contact damage began at the front left bumper corner and extended 105.0 cm (41.3 in) inboard. The impact deformed the full frontal width resulting in a combined direct and induced damage length (Field L) of 141.0 cm (55.5 in). The end structure was displaced approximately 5.0 cm (2.0 in) to the left [>10.2 cm (4.0 in) of shift required to increment the principal direction of force]. This end shifting restricted the left front wheel/tire (not deflated). The left side wheelbase was displaced 2.0 cm (0.8 in). The hood was displaced up and rearward from the impact force. Damage was noted to the right door from impact with the 1988 Buick Century. The windshield was undamaged in the crash.

Interior Damage

Interior damage to the Ford Windstar identified through the NASS vehicle inspection was minimal and was attributed to occupant contact. Scuff marks were documented on the left knee bolster (padded type) and glove compartment door. Scuff marks were also documented on the left door panel, A-pillar and center instrument panel area. No deformation was noted to the steering wheel rim (tilt column set to the center position). No intrusions were found in the vehicle.

REDESIGNED AIR BAG SYSTEM

Figure 5. 1998 Ford Windstar redesigned driver air bag.

The 1998 Ford Windstar was equipped with redesigned frontal air bags for the driver and front right passenger positions. The air bags had deployed as a result of the crash. The driver air bag was housed in the center of the steering wheel with a horizontally oriented flap tear seam (H-configuration). The flaps were asymmetrical in shape as the upper flap measured 20.0 cm (7.9 in) in width and 11.0 cm (4.3 in) in height while the lower flap measured 19.0 cm (7.5 in) in width and 6.0 cm (2.4 in) in height. Although no contact evidence was identified on the exterior surface of the module cover flaps, black vinyl transfers were noted on the upper and lower sections of the air bag from expansion within the module. The NASS researcher measured the diameter of the driver air bag at 52.0 cm (20.5 in) in its deflated state **(Figure 5)**. The bag was tethered by two internal straps and vented by two ports located at the 11 o'clock and 1 o'clock sectors on the rear aspect of the air bag.

Figure 6. 1998 Ford Windstar redesigned passenger air bag.

The front right passenger air bag deployed from a mid-mount module in the right instrument panel with a single cover flap design hinged at the top aspect. The cover flap was rectangular in shape and measured 33.0 cm (13.0 in) in width and 18.0 cm (7.1 in) in height. No contact evidence was identified on the air bag or exterior surface of the module cover flaps. The NASS researcher measured the passenger air bag at 50.0 cm (19.7 in) in width and 56.0 cm (22.0 in) in height in its deflated state **(Figure 6)**. No internal tether straps were present. The bag was vented by one port located at the 9 o'clock sector on the side aspect of the air bag. No cutoff switch was available for the front right air bag.

DRIVER DEMOGRAPHICS

Age/Sex:	41 year old female
Height:	178 cm (70 in)
Weight:	70 kg (154 lb)
Seat Track Position:	Mid-to-rear position
Manual Restraint Use:	3-point lap and shoulder belt
Usage Source:	NASS vehicle inspection, driver interview, medical report
Eyeware:	Prescription glasses
Type of Medical Treatment:	Transported to a local hospital for treatment and released

Driver Injuries

Injury	***Severity (AIS 90)***	***Injury Mechanism***
Abrasion left lateral neck	Minor (390202.1,2)	Shoulder belt webbing
Contusion left lateral neck	Minor (390402.1,2)	Shoulder belt webbing
Cervical strain	Minor (640278.1,6)	Non-contact injury (flexion)
Contusion left shoulder	Minor (790402.1,2)	Shoulder belt webbing
Contusion left anterior chest	Minor (490402.1,2)	Shoulder belt webbing
Lumbar strain	Minor (640678.1,8)	Non-contact injury
Contusion right posterior wrist	Minor (790402.1,1)	Front right air bag
Sprain right wrist	Minor (751420.1,1)	Front right air bag
Abrasion right posterior elbow to wrist	Minor (790202.1,1)	Front right air bag
Bilateral knee contusion	Minor (890402.1,3)	Knee bolster

Driver Kinematics

The 41 year old female driver of the 1998 Ford Windstar was restrained by the available 3-point manual lap and shoulder belt system, seated slightly out-of-position (to the right) with her left hand at the 10 o'clock position on the steering wheel rim and the right arm extended outward to brace the front right child passenger. The seat back was slightly reclined and the seat track was adjusted to the mid-to-rear position. Belt usage was confirmed by the type of injuries sustained and the lack of significant contact points within the vehicle.

At impact with the Chevrolet pickup truck, she initiated a forward trajectory in response to the 12 o'clock impact force and loaded the manual belt which restrained her body as the head flexed

forward resulting in the cervical/lumbar strain. She also sustained multiple soft tissue injuries to the left neck and chest from the shoulder belt webbing, evidenced by the size and location of the injuries relative to the placement of the shoulder harness across the chest. Although no injury was reported as a result of contact by the deployed redesigned *driver air bag*, the expanding *passenger air bag* contacted the posterior aspect of the right arm resulting in abrasions/contusions and a sprained right wrist. This mechanism was evidenced by the driver's attempt to brace the front right child occupant (by extending the arm) in conjunction with the rearward extent of the deployed passenger air bag. The redesigned frontal air bags provided additional restraint against further contact to frontal components. Her knees subsequently loaded the knee bolster which resulted in bilateral contusions as evidenced by the scuff marks documented to this component. At impact with the shrub/tree, she probably remained in a pre-impact posture as these minor impacts offered no significant resistance to the vehicle or produce any resulting kinematic response from the occupant. The driver was transported to a local hospital for treatment and released.

FRONT RIGHT PASSENGER DEMOGRAPHICS

Age/Sex:	12 year old male
Height:	168 cm (66 in)
Weight:	65 kg (143 lb)
Seat Track Position:	Mid-to-forward position
Manual Restraint Use:	3-point lap and shoulder belt system
Usage Source:	NASS vehicle inspection, driver interview, medical report
Eyeware:	None
Type of Medical Treatment:	Transported to a local hospital for treatment and released

Front Right Passenger Injuries

Injury	*Severity (AIS 90)*	*Injury Mechanism*
Abrasion right neck	Minor (390202.1,1)	Shoulder belt webbing
Cervical strain	Minor (640278.1,6)	Non-contact injury (flexion)
Contusion right shoulder	Minor (790402.1,1)	Shoulder belt webbing
Sprain left wrist	Minor (751420.1,2)	Front right air bag
Bilateral knee contusion	Minor (890402.1,3)	Glove compartment door

Front Right Passenger Kinematics

The 12 year old male front right passenger of the 1998 Ford Windstar was restrained by the available 3-point lap and shoulder belt system, seated in an upright posture with the seat back slightly reclined and the seat track adjusted to the mid-to-forward position. Belt usage was confirmed by the type of injuries sustained and the lack of significant interior contact points within the vehicle.

At impact with the Chevrolet pickup truck, he initiated a forward trajectory in response to the 12 o'clock impact force and loaded the manual belt which restrained his body as the head flexed forward resulting in the cervical strain. He also sustained soft tissue injuries to the right neck and shoulder from the shoulder belt webbing, evidenced by the size and location of the injuries relative to the placement of the shoulder harness. Contact by the deployed redesigned passenger air bag resulted in a sprained left wrist. His knees loaded the glove compartment door which resulted in bilateral knee contusions as evidenced by the scuff marks documented to this component. At impact with the shrub/tree, he probably remained in a pre-impact posture as these minor impacts offered no significant resistance to the vehicle or produce any resulting kinematic response from the occupant. The front right passenger was transported to a local hospital for treatment and released.

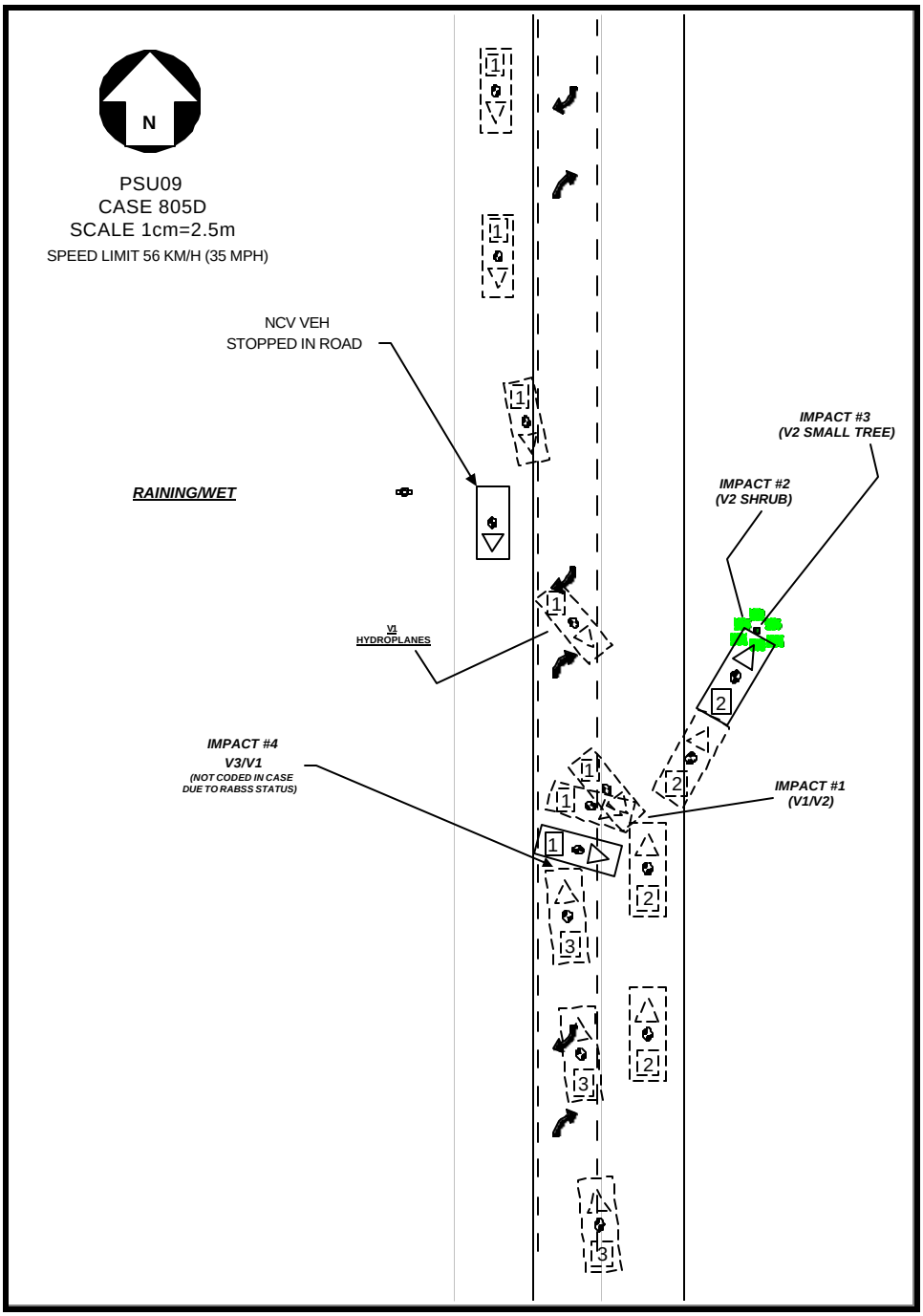

Figure 7. NASS Scene Diagram