TRANSPORTATION SCIENCES
CRASH DATA RESEARCH CENTER

Veridian Engineering
Buffalo, New York 14225

ADVANCED OCCUPANT PROTECTION SYSTEM STUDY
2001 FORD WINDSTAR INVESTIGATION

VERIDIAN CASE NO. CA01-030

LOCATION - MARYLAND

CRASH DATE - MAY 2001

Contract No. DTNH22-94-07058

Prepared for:

U.S. Department of Transportation
National Highway Traffic Safety Administration
Washington, DC 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 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 of the involved vehicle(s) or their safety systems.

TECHNICAL REPORT STANDARD TITLE PAGE

1. *Report No.* CA01-030	2. *Government Accession No.*	3. *Recipient's Catalog No.*	
		4. Weights	
5. *Title and Subtitle* Advanced Occupant Protection System Study Vehicle - 2001 Ford Windstar Location - Maryland		6. *Report Date*: February 2001	
		7. *Performing Organization Code*	
8. *Author(s)* Crash Data Research Center		9. *Performing Organization Report No.*	
10. *Performing Organization Name and Address* Transportation Sciences Crash Data Research Center Veridian Engineering P.O. Box 400 Buffalo, New York 14225		11. *Work Unit No.* CO1115.0339.(0000-9999)	
		12. *Contract or Grant No.* DTNH22-94-D-07058	
13. *Sponsoring Agency Name and Address* U.S. Department of Transportation National Highway Traffic Safety Administration Washington, DC 20590		14. *Type of Report and Period Covered* Technical Report Crash Date: May 2001	
		15. *Sponsoring Agency Code*	
16. *Supplementary Notes*: On-site investigation of a 2001 Ford Windstar equipped with an Advanced Occupant Protection System.			

17. *Abstract*

The subject 2001 Ford Windstar was involved in an intersection crash with a 1997 Ford pick-up truck (model unknown). The frontal air bags in the Ford Windstar did not deploy as a result of the crash. The 39 year old male driver was the sole occupant. He was reportedly restrained and suffered an ankle fracture as a result of the crash. The subject Ford Windstar was owned by a rental car company and during the course of the police investigation allegations surfaced that the rental company was defeating the air bag systems in its vehicles. The investigating police officer informed the Crash Investigations Division of the National Highway Traffic Safety Administration (NHTSA) of the circumstances and NHTSA subsequently assigned an on-site investigation of the crash to the Special Crash Investigations team at Veridian Engineering as part of the Advanced Occupant Protection System Study. This investigation focused on determining the operational state of the vehicle's air bag systems, the crash severity and retrieving the vehicle's Restraint Control Module (RCM). The RCM was removed and the crash data stored within the module was analyzed by Ford's Safety Office. It was determined the vehicle's air bag system was operating properly at the time of the crash and the severity of the crash did not warrant the deployment of the vehicle's safety systems.

18. *Key Words* Advanced Occupant Protection System Frontal air bags Pre-tensioner, Restraint Control Module Ankle fracture		19. *Distribution Statement* General Public	
20. *Security Classif. (of this report)* Unclassified	21. *Security Classif. (of this page)* Unclassified	22. *No. of Pages* 9	23. *Price*

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ADVANCED OCCUPANT PROTECTION SYSTEM STUDY
2001 FORD WINDSTAR
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LOCATION: MARYLAND
CRASH DATE: MAY, 2001

BACKGROUND

This on-site investigation focused on the performance of the Advanced Occupant Protection System in the 2001 Ford Windstar. The Windstar's AOPS consisted of the integrated use of 3-point lap and shoulder belts with retractor-pretensioners, driver seat position sensing, and dual-stage air bag inflation. The driver and front right passenger air bags were designed to deploy at different thresholds of crash severity dependant on restraint use, and driver seat position. The subject 2001 Ford Windstar was involved in an intersection crash with a 1997 Ford pick-up truck (model unknown). The frontal air bags in the Ford Windstar did not deploy as a result of the crash. The 39 year old male driver was the sole occupant . He was reportedly restrained and suffered a left ankle fracture as a result of the crash.

The subject Ford Windstar was owned by a rental car company and during the course of the police investigation allegations surfaced that the rental company was defeating the air bag systems in its vehicles. The investigating police officer informed the Crash Investigations Division of the National Highway Traffic Safety Administration (NHTSA) of the circumstances and NHTSA subsequently assigned an on-site investigation of the crash to the Special Crash Investigations team at Veridian Engineering as part of the Advanced Occupant Protection System study. This investigation focused on determining the operational state of the vehicle's air bag systems, the crash severity and retrieving the vehicle's Restraint Control Module (RCM). The RCM was removed and the crash data stored within the module was analyzed by Ford's Safety Office. It was determined the vehicle's air bag system was operating properly at the time of the crash and the severity of the crash did not warrant the deployment of the vehicle's safety systems.

SUMMARY

Crash Site

This two-vehicle crash occurred during the morning hours in May, 2001. At the time of the crash, it was dawn and the weather was not a factor. The road surfaces were dry. The crash occurred at the intersection of a three-lane north/south divided highway and a two-lane east/west secondary road. The intersection was controlled by a properly operating, overhead (red/amber/green) traffic signal. The speed limit in the area of the crash was 80 km/h (50 mph). **Figure 1** is a northward view of the intersection.

Figure 1: North view of the intersection.

Pre-crash

Immediately prior to the crash, the 2001 Ford Windstar was southbound in the left turn lane approaching the intersection. The Windstar was driven by a 39 year old restrained male. It was the driver's intention to turn left at the intersection and travel east on the intersecting roadway. The southbound traffic signal was illuminated with a green left turn arrow for the left turning traffic. Coincident to the Windstar's travel, 1997 Ford pick-up truck was northbound in the outboard (right) lane driven by a 43 year old male. The traffic signal was red was northbound traffic. The physical nature and extent of the vehicles' damage was relatively minor indicating the impact speeds were well below the speed limit. It was probable the respective drivers recognized the impending crash and applied the brakes. The residual damage to the Windstar indicated an underriding impact configuration, further supporting the application of the brakes pre-crash.

Crash

The crash occurred when the Ford Windstar turned left across the northbound travel lanes and was struck by the Ford pick-up truck. The driver of the Ford pick-up truck had entered the intersection against the red traffic signal. The left frontal region of the Ford pick-up truck impacted the right frontal region of the Windstar in an oblique angular configuration. The directions of force were 01 and 11 o'clock for the Windstar and pick-up truck, respectively. The force of the crash was below the threshold required for deployment of the Windstar's frontal occupant protection system. The barrier equivalent delta V of the Windstar calculated by the WINSMASH model was 13.1 km/h (8.1 mph). The longitudinal and lateral of the delta V were -11.5 km/h (-7.1 mph) and -6.5 km/h (-4.0 mph), respectively. This calculation appeared to underestimate the crash severity based on SCI experience. An estimated delta V in the range of 19.3 km/h (12 mph) was more consistent with the vehicle damage and crash dynamics based on SCI experience.

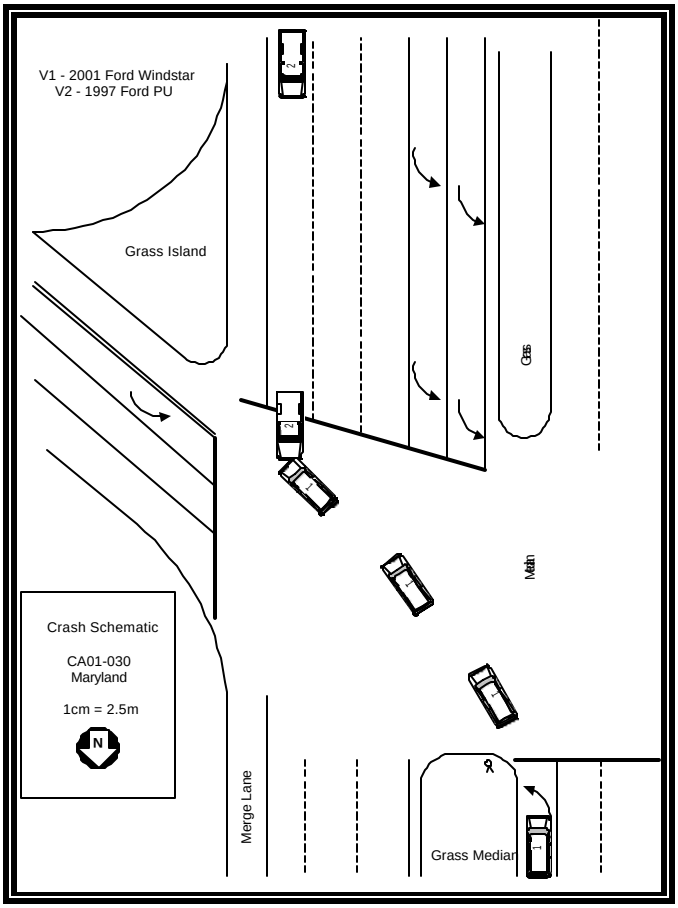

Figure 2: Crash schematic.

Post-crash

The vehicles separated after the impact and came to rest within the confines of the intersection. Both

vehicles sustained disabling damage and were towed. The driver of the Ford Windstar sustained a police reported non-incapacitating injury. The insurer of the Windstar reported the driver sustained an unspecified left ankle fracture. The driver of the Windstar refused to be interviewed by the SCI investigator. The driver of the Ford pick-up truck was not injured.

2001 FORD WINDSTAR

The 2001 Ford Windstar was identified by the Vehicle Identification Number (VIN): 2FMZA51401B (production sequence deleted). The vehicle's power train consisted of a 3.8 liter, V6 engine linked to a 4-speed automatic transmission. The service brakes were a 4-wheel, front disc/rear drum, anti-lock system. The cloth trimmed seating system in the vehicle was configured for seven passengers and consisted of driver and front right captain's chairs, second row two passenger bench seat, and a third row three passenger bench seat.

The vehicle's occupant protection system was Ford's trademarked Personal Safety System. The Personal Safety System (PSS) is an advanced occupant protection system that utilizes 3-point manual lap and shoulder belts with retractor pretensioners for the front occupants, driver seat position sensing, and dual stage frontal air bag inflation. The pretensioners and frontal air bags are designed to deploy with variable thresholds dependant on restraint use, driver's seat position, and crash severity. The vehicle's odometer read 439 km (273 miles) at inspection. The Ford Windstar was owned by a rental agency and was being operated under a rental agreement at the time of the crash.

Exterior Damage

Figures 3 and 4 are the front and left front views of the Windstar. The frontal plane of the Windstar sustained 79 cm (31 in) of direct contact damage that began 5 cm (2 in) left of center and extended to the right corner of the front bumper. The combined direct and induced damage extended across the full 147 cm (58 in) front end width. The nature of the frontal damage was consistent with an under-ride impact configuration. The maximum residual deformation of the bumper reinforcement beam measured 3.8 cm (1.5 in) at C6. The above-bumper damage at C6 was 23 cm (9.0 in) measured at the elevation of the upper radiator support. The profile representing the average residual crush was as follows: C1=0, C2=0, C3=0, C4=0, C5=8.3 cm (3.25 in), C6=13.3 cm (5.3 in). The hood buckled, and was displaced left and rearward fracturing the lower left aspect of the windshield. There was no measurable change in the wheelbase dimensions. The Collision Deformation Classification (CDC) was 01-FZEW-1. The barrier

Figure 3: Front view of the Ford Windstar.

algorithm of the WINSMASH collision model calculated a total delta V of 13.1 km/h (8.1 mph). The longitudinal and lateral of the delta V were -11.5 km/h (-7.1 mph) and -6.5 km/h (-4.0 mph), respectively.

Figure 4: Right lateral view across the front plane.

Interior Damage

Figure 5 is a left view of the driver's interior. There was no interior damage associated with this crash. No points of occupant contact were identified. The lack of interior damage was consistent with the minor severity of the event.
The driver's seat was adjusted to a rear track position at the time of the inspection and measured 2.5 cm (1.0 in) forward of full rear. It could not be verified if this was its adjusted at-crash position.

Figure 5: View of the driver's interior.

The police report indicated the driver was restrained at the time of the crash. The driver's manual 3-point lap and shoulder restraint consisted of a continuous loop webbing and sliding latch plate. The emergency locking retractor was located in the B-pillar and was equipped with a belt pretensioner. The pretensioner did not fire in the below-threshold crash event. The adjustable D-ring was in the full down position. The webbing was stowed within the retractor and the retractor was operational. Examination of the webbing revealed no evidence of loading. However, the lack of belt evidence was consistent with the minor severity of the crash. A determination of driver restraint use, based on examination of the restraint system alone, could not be made. However, assessing driver restraint use holistically, in terms of the crash reconstruction, the driver was most likely restrained by the manual restraint at the time of the crash, given the nature of his injury coupled with the dynamics of the crash and the lack of interior occupant contacts.

The 4-spoke adjustable steering wheel rim was adjusted to a center position. There was no rim deformation. Inspection of the steering column shear capsules determined there was no shear capsule separation.

The driver air bag module was designed in the typical manner and located in the center of the steering wheel. The front right passenger air bag module was a top-mount design located in the right aspect of the instrument panel. The frontal air bags were not deployed. The crash severity was below the threshold required for air bag deployment.

Advanced Occupant Protection System

The Advanced Occupant Protection System in the 2001 Ford Windstar was designated by the manufacturer as the Personal Safety System (PSS). The AOPS consisted of the integrated use of manual 3-point lap and shoulder belts with retractor pre-tensioners, driver seat position sensing, and dual-stage air bag inflation. The driver and front right passenger air bags were designed to deploy at different thresholds of crash severity dependent on restraint use, driver seat position and front right occupant weight. The vehicle was not equipped with side impact air bags. The Restraint Control Module (RCM) located on the vehicle's centerline, under the instrument panel, monitored and controlled the deployment of the vehicle's safety systems. The RCM also recorded the crash acceleration pulse for a duration of 78 milliseconds.

The RCM was removed from the vehicle by a Ford certified mechanic and was forwarded to the Safety Office of the Ford Motor Company for analysis. The preliminary verbal results of that analysis are listed in the table below. A final report of the subject RCM download was not available at the time of this report submission. This report will be amended with the final RCM report if and when it is received from the Ford Safety Office.

Preliminary RCM Stored Crash Data
(Reported Verbally by Ford's Safety Office)

Driver restraint status:	Buckle engaged
Pretensioner fired:	No
Driver air bag deployed	No
Driver seat position forward:	No
Maximum recorded longitudinal delta V at 78 milliseconds after Algorithm Enable	-17.2 km/h (-10.7 mph)

The RCM data indicated the driver's seat belt was buckled and the pre-tensioner had not fired. The driver

air bag had not deployed. The driver seat was not adjusted to a forward track position. The maximum recorded longitudinal delta V was -17.2 km/h (-10.7 mph). The analysis of the RCM data indicated to Ford's Safety Office, the RCM correctly recognized the crash event and correctly assessed that the deployment of the vehicle's supplemental safety systems (pretensioner and air bags) was not warranted, given the driver was restrained by the manual restraint system in this minor crash event.

Figure 6 is a view of the RCM taken during its removal. The module was located under the center aspect of the instrument panel, to the right of the accelerator pedal. The RCM was manufactured by the Takata Corporation and was identified by the following nomenclature:

1F2A-14B321-CD
Bar Code: 861H108100313

Figure 6: View of the Restraint Control Module during removal.

Prior to disconnecting the wiring harness, the vehicle's ignition was cycled to read any fault codes stored within the module. The fault codes could be read via the indicator lamp in the instrument cluster. Upon cycling the key to "ON", the indicator lamp illuminated for approximately 6 seconds, as the RCM performed its diagnostic check of the air bag system. The indicator lamp then went "OFF", indicating the air bag system was operational and that there were no stored fault codes. After disconnecting the wiring harness from the RCM, cycling of the ignition key to "ON" caused the air bag indicator lamp to illuminate and remain on. (This condition was expected because the RCM had been removed from the system.)

OCCUPANT DEMOGRAPHICS

	Ford Windstar Driver
Age/Sex:	39 year old/Male
Height/Weight:	Unknown
Restraint Use:	3-point lap and shoulder
Usage Source:	PAR, RCM
Medical Treatment:	Treated and released

DRIVER INJURY

Injury	Severity (AIS 98 update)	Injury Mechanism
Left ankle fracture, NFS	Moderate (852002.2,2)	Bracing against the floor pan/foot control

Note: the above injury was identified through the insurance company of the Ford Windstar.

DRIVER KINEMATICS

Immediately prior to the crash, the restrained driver was seated in an upright posture with his seat adjusted to a rear track position. The driver was in the process of a left turn when the Ford pick-up entered his path of travel. He realized a crash was imminent and was braking. He probably braced for the impact by extending his left leg against the floor pan or the brake.

The inertial retractor of the seat belt system locked in response to the force of the impact. The driver responded to the 1 o'clock direction of the impact force by exhibiting a forward trajectory. He loaded his left leg due to his forward kinematic pattern resulting in an unspecified left ankle fracture. His upper torso contacted the locked manual belt system minimizing his contact with the interior. He then rebounded rearward into the driver seat where he came to rest.